

Himanshu Rai · Dalip K. Upreti *Editors*

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# Terricolous Lichens in India

Volume 2: Morphotaxonomic Studies

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*Cladonia fimbriata* taken at 3,170 m, at Gangotri town in Uttarakhand, India on 28 Oct 2010. The sample is preserved in the CSIR-NBRI herbarium with collection no.: 10-0014513 (LWG) by Himanshu Rai and Pramod Nag. Photographed using Fujifilm FinePix S5800 S8000 camera.

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Volume 2: Morphotaxonomic Studies

 Springer

*Editors*

Himanshu Rai  
National Botanical Research Institute  
Council for Scientific and Industrial  
Research  
Lucknow  
Uttar Pradesh  
India

Dalip K. Upreti  
National Botanical Research Institute  
Council for Scientific and Industrial  
Research  
Lucknow  
Uttar Pradesh  
India

ISBN 978-1-4939-0359-7

ISBN 978-1-4939-0360-3 (eBook)

DOI 10.1007/978-1-4939-0360-3

Springer New York Heidelberg Dordrecht London

Library of Congress Control Number: 2013950764

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# Preface

Lichenological investigations now recognize about 2,305 species of lichens in India. The consistent efforts of some dedicated lichenological centres in India, has contributed a lot in discovering new species and new records from the vast and some of the most heterogeneous habitats in Southeast Asia. Although in last 50 years the focus of lichenological investigations in India has been mainly taxonomic, lichen functional groups, such as terricolous lichens, are only mentioned in usual taxonomic enumerations along with other lichen groups. There is no comprehensive monograph available on terricolous lichens for Indian habitats. With increase in the understanding on soil crust lichens, their functional role in maintenance of physical stability, hydrology and nutrient pool of soil crust is well recognized worldwide (Elbert et al. 2012). The investigations on Indian terricolous lichens were initiated at Lichenology Laboratory of CSIR-National Botanical Research Institute (NBRI) as an assessment of their diversity in Western Himalaya and their role in soil stabilization in alpine habitats (Rai 2012). The study revealed a substantial diversity of terricolous lichens and found that soil lichens play a very crucial role in stabilization of soil crust, soil respiration, amelioration of soil temperature and growth of soil microflora. In the course of study, need of a comprehensive taxonomic account of terricolous lichens was realized leading to conceptualization of this volume, which deals with taxonomy of terricolous lichens of India.

With a background of different patterns of diversity and distribution ecology of soil lichens in volume I, this volume II of *Terricolous Lichens in India* intends to describe the taxonomic account of soil lichens of India. The volume is the outcome of extensive field collections and investigation of about 4,500 specimens preserved in various national and international herbaria. The volume is divided into two chapters. The first chapter describes the basics of soil lichen curation from Indian habitats, various morpho-anatomical and chemical techniques for taxonomic identification and introduces the morpho-anatomical features of terricolous lichens. The second chapter deals with the taxonomy of 312 terricolous lichen species, with their detailed identification keys and taxonomic description. The taxonomic diagnostics is complemented with photographs of lichens for visual identification, along with their distribution maps. The book should be of interest to the specialists and also intends to generate interest among ecologists, biologists, naturalists, teachers,

students, protected area managers, policy makers and conservation agencies. We hope that this book will widen the overall understanding of Indian lichens and specifically the terricolous lichens, both for native as well as international workers and would serve as foundation of many more taxonomic as well as applied researches in Indian lichens.

**Acknowledgements** We are thankful to Dr. Roger Rosentreter (BLM , Idaho, USA), Dr. Jayne Belnap (Moab, Utah, USA) and Dr. Christoph Scheidegger (Swiss Federal Research Institute, WSL, Birmensdorf) for their continuous support and advice during the realization of this publication. We are also thankful to Dr. Pradeep K. Divakar (Department of Plant Biology II, College of Pharmacy, Complutense University, Madrid, Spain) for his time-to-time help regarding literature pertaining to various soil lichen genera. We are thankful to Dr. G. P. Sinha (Scientist, Central regional circle, Allahabad) for crucial help regarding lichen samples of Sikkim. Further, we are grateful to all our contributors for the cooperation they extended throughout the project. Finally, we would like to thank the editorial team of Springer—Eric Stannard, Daniel Dominguez and Andy Kwan for their patience and understanding during this project.

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# Contributors

**Teuvo Ahti** Botanical Museum, Finnish Museum of Natural History, University of Helsinki, Helsinki, Finland

**Roshni Khare** Lichenology Laboratory, Plant Diversity, Systematics and Herbarium Division, CSIR-National Botanical Research Institute, Lucknow, Uttar Pradesh, India

**Sanjeeva Nayaka** Lichenology Laboratory, Plant Diversity, Systematics and Herbarium Division, CSIR-National Botanical Research Institute, Lucknow, Uttar Pradesh, India

**Himanshu Rai** Lichenology Laboratory, Plant Diversity, Systematics and Herbarium Division, CSIR-National Botanical Research Institute, Lucknow, Uttar Pradesh, India

**Dalip Kumar Upreti** Lichenology Laboratory, Plant Diversity Systematics and Herbarium Division, CSIR-National Botanical Research Institute, Lucknow, Uttar Pradesh, India

# Chapter 1

## Terricolous Lichens of India: An Introduction to Field Collection and Taxonomic Investigations

Himanshu Rai, Roshni Khare, Dalip Kumar Upreti and Sanjeeva Nayaka

### 1 Introduction

Lichenological investigations in India, although still constrained by unbalanced collections, where some regions are exhaustibly investigated (e.g. Western Himalayas and Palni Hills) and others are still unexplored (e.g. eastern India), have recorded about 2,303 species of lichens (Upreti 1998; Singh and Sinha 2010). In the last 50 years, there has been tremendous advancement in elucidation of lichens from India (Singh 2011); however, there are few publications dealing with specific group (i.e. family/functional group) of Indian lichens (Divakar and Upreti 2005; Singh 2011).

Although soil-inhabiting terricolous lichens have been mentioned in various enumerations and taxonomical records (Chap. 1, Vol. 1), they have not been explored as a functional group (Rai et al. 2012). Lichen biogeographical diversity, when analyzed along species composition similarity, can give an overview of diversity of lichens within a particular geographical setting (Feuerer and Hawksworth 2007). On the basis of updated data after Singh and Sinha 2010 (resulting in 2,368 species) and taking into consideration ten dominant families and genera along with endemism, lichen diversity in India can be divided into eight lichenogeographical regions (Fig. 1.1) (Singh and Sinha 1997; Negi 2003). The distribution of lichens in different lichenogeographical regions shows dominant distribution of terricolous lichen families (e.g. *Cladoniaceae*, *Collemaaceae*) and genera (e.g. *Cladonia*, *Collema*, *Leptogium*) in Himalayan habitats along with their fair presence in other regions (Fig. 1.1).

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H. Rai (✉) · D. K. Upreti  
Lichenology Laboratory, Plant Diversity, Systematics and Herbarium Division,  
CSIR-National Botanical Research Institute,  
Rana Pratap Marg, Lucknow, Uttar Pradesh-226001, India  
e-mail: himanshurai08@yahoo.com

R. Khare · S. Nayaka  
Lichenology Laboratory, Plant Diversity, Systematics and Herbarium Division,  
CSIR-National Botanical Research  
Institute, Rana Pratap Marg, Lucknow-226001, Uttar Pradesh, India

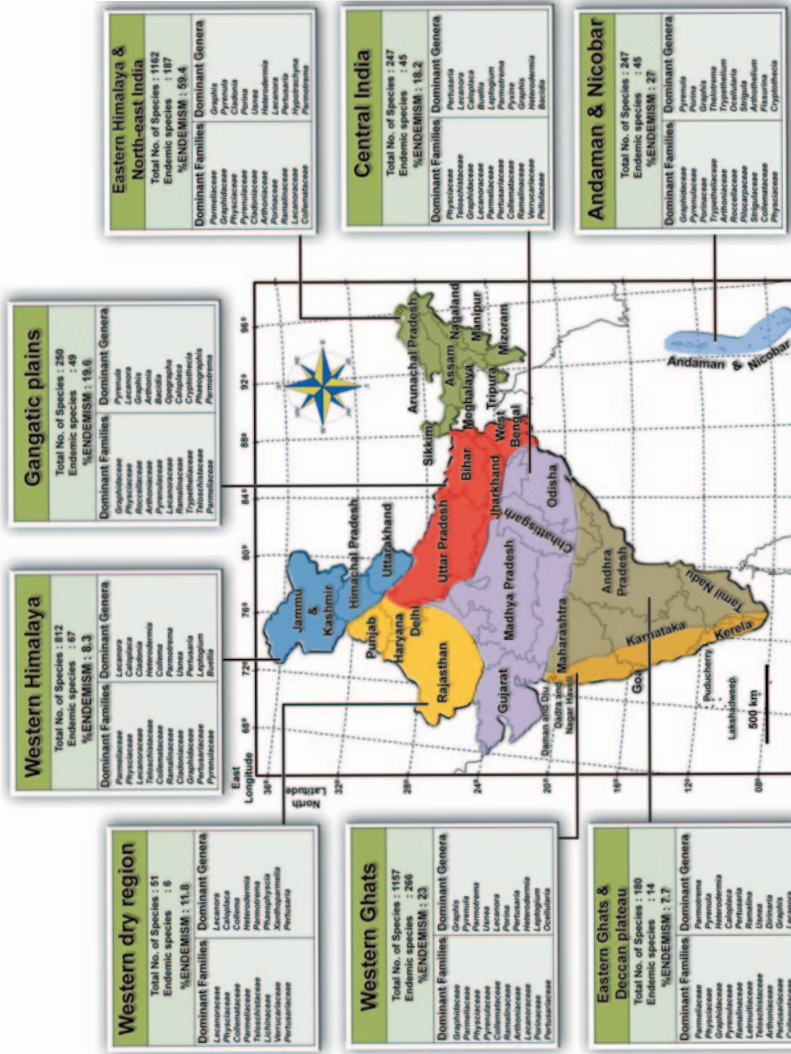


Fig. 1.1 Map of India showing its political boundaries, constituent states/union territories and eight lichenogeographical regions

## 2 Terricolous Lichens: Habitat Differentiation

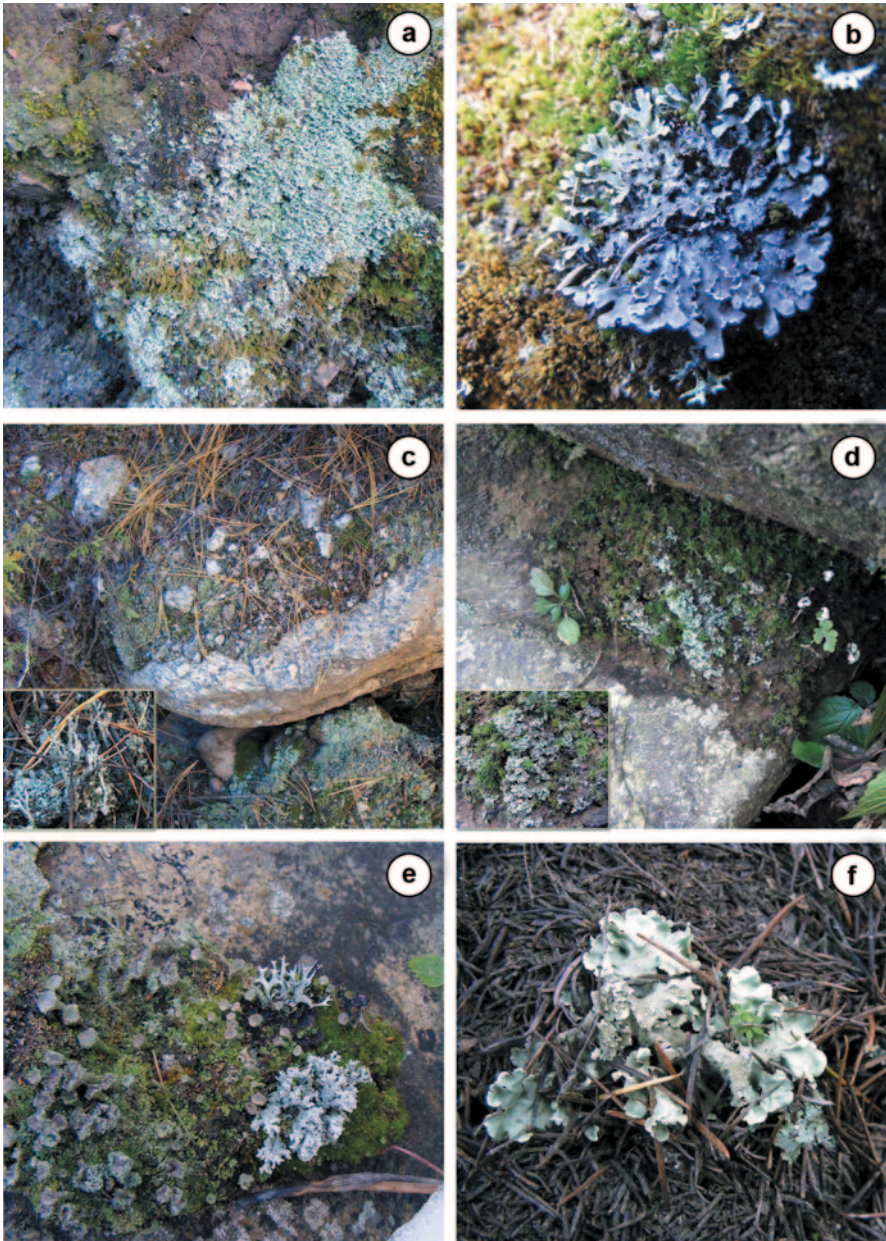
Although soil-crust lichens in India, along with other cryptogams (blue-green algae and mosses), form biological soil crusts in Himalayan habitats (Chap. 2, Vol. 1), their major inhabitation is on soil accumulated over rocks (rupicolous–terricolous habitat) (Chap. 5, Vol. 1). Terricolous lichens, in strict sense, are lichens that inhabit ground directly in soil, sand, peat or humus (Scheidegger and Clerc 2002). Besides this strict habitat delimitation, based on various microhabitat differentiations, following principal types of soil lichens are recognized in India (Scheidegger and Clerc 2002).

1. Species that grow on the ground directly in soil, sand, peat or humus are regarded as *soil-inhabiting (terricolous) lichens* in the narrow sense (Fig. 1.2a).
2. Species that grow on the ground in mosses, which in turn are rooted in earth or sand, are considered as *musciolous–terricolous lichens* (Fig. 1.2b).
3. Species that grow on accumulated soil in rock crevices or on the rough surfaces of rocks are considered as *terricolous–rupicolous lichens* (Fig. 1.2c, d).
4. Species that thrive on mosses, which in turn are rooted directly on rocks (having some accumulated soil or organic debris), are considered as *musciolous–rupicolous lichens* (Fig. 1.2e).
5. Species that grow directly on the ground on plant remains are regarded as *detriticolous–terricolous lichens* (Fig. 1.2f).

## 3 Collection and Curation of Terricolous Lichens in India

The taxonomic studies of terricolous lichens are delimited by poor curation and the resulting lack of good specimens, as the soil substratum becomes very fragile, during specimen removal in the field and during transit to the laboratory. Collection of terricolous lichens requires special attention right from the field. Owing to the fragility and crumbling nature of soil substratum of terricolous lichens, moistening of lichens with a fine sprayer (mister) ensures easy removal of lichens with 1–5 cm of crust (Rosentreter 1988; Awasthi 2000). As the dominant microhabitat of soil lichens in India is soil over rocks or rock crevices, pointing trowel (mason's trowel) is very useful in removing terricolous lichens from the rocky relevés (Fig. 1.3a, b). Soil crusts with soil samples have to be wrapped in several layers of tissue paper (3 ply) and then placed in firm plastic containers for transit to laboratory to reduce the risk of further crumbling of soil crust and specimen destruction (Fig. 1.3c, d) (Rosentreter 1988). The transportation of specimens to laboratory must be done with extra care to avoid fragmentation of samples.

After air drying the specimens, maximum amount of soil is removed from the samples wherever possible, or a fair amount of soil crust (1–2 cm) is retained in order to maintain the integrity of lichen thalli. Terricolous lichen samples with soil crust are dipped into water-based glue, which gradually seeps into the soil from



**Fig. 1.2** Microhabitat differentiation in terricolous lichens of India. **a** Terricolous (soil-inhabiting) lichens. **b** Muscicolous–terricolous (on ground on moss) lichens. **c, d** Terricolous–rupicolous (on accumulated soil on rock surface or rock crevices) lichens, inset (magnified lichen thallus). **e** Muscicolous–rupicolous (on mosses, which are rooted on rocks, having some accumulated soil or organic debris) lichens. **f** Detriticolous–terricolous (grow directly on the ground on plant remains) lichens (after Scheidegger and Clerc 2002)



**Fig. 1.3** Collection and curation of terricolous lichens from field. **a, b** Collection of terricolous lichens along with their substratum, using pointing trowel (mason’s trowel). **c** Placing terricolous lichens in firm plastic containers for transportation to laboratory. **d** Soil lumps with terricolous lichens in laboratory (before mounting). **e** Terricolous lichens mounted (glued) to archival quality cardboard (samples having maximum of soil removed). **f** Terricolous lichens mounted on cards with styrofoam packing material at the perimeter (samples with their soil substratum intact)

below, and dried to prevent the crumbling of the soil and retain the lichen in its position (Rosentreter 1988; Awasthi 2000). The prepared terricolous lichen samples are either mounted on cards directly (sample having maximum soil removed) (Fig. 1.3e) or on cards with glued strips of styrofoam (thicker than the mounted specimen so that the surrounding packet rests on them rather than on specimen) packing material around the perimeter to help eliminate breakage of the crusted samples when filed or stacked (Fig. 1.3f) (Rosentreter 1988). Additional protection is achieved by covering the specimen with a piece of tissue paper.

## 4 Taxonomic Identification of Terricolous Lichen Specimens

Taxonomic investigation of terricolous lichen samples is done by usual microscopic morphoanatomical observations and lichenological chemical tests (i.e. spot tests, thin-layer chromatography (TLC), microcrystallization and ultraviolet (UV) reactions).

### 4.1 Morphoanatomical Examination

External morphology is examined by stereomicroscopes, at magnifications enough for proper identification of characteristic morphological features. Thin hand-cut sections of apothecia and thalli are mounted in plain water, lactophenol cotton blue, 5% KOH and iodine solution and observed under a compound microscope.

The external morphology is generally examined in dry conditions, but dark brown to bluish specimens of *Leptogium* and *Collema* are studied in wet conditions. The colours of medulla, epithecium, hypothecium and ascus are recorded. The asci and ascospores are taken from the sections, and their shapes and sizes are recorded when mounted in water.

### 4.2 Chemical Examinations

Chemistry of the specimens includes colour tests, TLC and microcrystallization.

#### 4.2.1 Colour Tests

Specific chemical reagents having tendency to give diagnostic colours when applied to lichen thallus and medulla, resulting in change in colour, are used for colour tests. In taxonomic descriptions, the results of the colour tests are reported as positive change, denoted by a positive symbol (+), or no change, denoted by a negative symbol (-). The chemical reagents used are as follows (Orange et al. 2001):

**K test** Aqueous solution of potassium hydroxide (10%, 10 g KOH pellets + 100 ml distilled water) is applied to the cortex, the medulla and a part of apothecia. This aqueous solution of KOH is used as a clearing agent for sections of fruiting bodies and thalli, as it often dissolves the crystalline lichen substances and removes some mucilage that may obscure the details of the sections.

**Pd test** A stable solution of *para*-phenylenediamine, termed Steiner's Pd, is prepared by dissolving 1.0 g of *para*-phenylenediamine and 10 g of sodium sulphite in 100 ml of distilled water with 0.5 ml of a liquid detergent. This reagent remains usable for about a month.

**C test** Freshly prepared aqueous solution of calcium hypochlorite or bleaching powder or modern commercial bleaching fluid containing active chlorine is prepared by dissolving calcium hypochlorite in distilled water.

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

**Iodine reaction** Iodine forms coloured complexes with some of the classes of polysaccharides (rarely with other lichen substances), which are formed in hyphal walls and in extracellular gels; these reactions are valuable at taxonomic levels. Lugol's solution (0.5 g of iodine is dissolved in 100 ml of water containing 0.5 g of potassium iodide) is used in routine I reactions (Hawksworth et al. 1995). The reagent is usable for several days and should be renewed when colour fades.

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

#### 4.2.2 Microcrystallization

Introduced by Asahina (1936 and 1938), the microcrystallization method relies on the characteristic crystal forms assumed by lichen substances when recrystallized in a suitable solvent. Although largely superseded by the more sensitive and reliable method of TLC, this technique is still useful for a small number of lichen compounds. The method is of most use when a small number of taxa of known chemistry are to be separated.

A small fragment of lichen to be investigated is placed on the middle part of a microscopic glass slide and one or two drops of acetone are dripped on the fragment by means of a dropper. Following the evaporation of acetone, lichen substances, if present, get extracted on the slide as residue in the form of a ring around the fragment. The thallus fragment is then removed. A micro cover glass is placed over the residue and a drop of one of the crystallizing fluids (detailed later) is placed at the edge of the cover glass. The fluid gradually seeps in. The slide is then heated gently



over a spirit lamp. The residue dissolves in the fluid and lichen substances gradually crystallize into their characteristic shapes on cooling. These crystals are observed under low-power microscope and identified by comparison with the photographs or line diagrams published by Huneck and Yoshimura (1996), Hale (1974) and Orange et al. (2001). Identification of depsides, depsidones and dibenzofurans is usually confirmed by this method. The crystallizing fluids used are as follows:

- a. G.E.—glycerol:acetic acid, 1:3
- b. G.A.W.—glycerol:ethanol:water, 1:1:1
- c. An—*aniline*:glycerol:ethanol, 1:2:2
- d. *oT*—*o*-toluidine:glycerol:ethanol, 1:2:2
- e. Py—pyridine:glycerol:water, 1:1:3
- f. Q—quinoline:ethanol:glycerol, 1:2:2
- g. KK- potassium hydroxide: potassium carbonate: water, 1:4:20

#### 4.2.3 Thin-Layer Chromatography (TLC)

We performed TLC mainly in solvent system A containing toluene, 1, 4-dioxane, and acetic acid in the ratio 180:45:5 (Culberson and Ammann 1979). The chemical substances are extracted in acetone and loaded on TLC plates of size 20 × 20 cm, made of aluminium and coated with a layer of silica (MERCK™ TLC Silica gel 60 F<sub>254</sub>). These plates contain an indicator which fluoresces under short UV wavelength. The samples are loaded on loading front, drawn with a soft pencil, 20 mm from the base of the plate. Samples are loaded at 10 mm intervals on the loading line. Solvent system is run up to 130 mm from the base, marked as finishing line of solvent front. *Parmelinella wallichiana* (Taylor) Elix & Hale, having salazinic acid (R<sub>f</sub> class 2) and atranorin (R<sub>f</sub> class 7), is used as reference/control (Awasthi 2000). After running in the solvent system, the TLC plates are sprayed with distilled water for the presence of fatty acids, and are examined under UV light of short (254 nm) or long (366 nm) wavelength. Any fluorescence observed is marked or noted at the place of occurrence. Later, the plates are sprayed with freshly prepared 10% H<sub>2</sub>SO<sub>4</sub> solution and heated in hot air oven at 110 °C until (5–10 min) the colour spots are developed because of charring. The plate is taken out and allowed to cool. The distance travelled in a particular solvent is characteristic for each substance, which can be expressed as the R<sub>f</sub> value (retention value). The colours of the spots and the position for each extract are noted; the plate is again observed under UV light and finally the R<sub>f</sub> value is calculated. Absolute values may vary considerably with a slight variation in experimental setup. One common method to overcome this variation is to divide the TLC plates into classes of R<sub>f</sub> values, i.e. R<sub>f</sub> classes.

$$R_f = \frac{\text{distance travelled by lichen substance (indicated by spot)}}{\text{distance travelled by solvent (solven front)}}$$

Control specimens which contain substances with well-known R<sub>f</sub> values like norstictic acid (R<sub>f</sub> class 4) and atranorin (R<sub>f</sub> class 7) are used to “calibrate” the plates.

Another way to overcome experimental variation is the calculation of relative rather than absolute  $R_f$  values.

Identification of lichen substances is made on the basis of the comparison of position and colour of the spots by charts and data published in relevant references (Elix and Ernst-Russel 1993; Orange et al. 2001). The guidelines of Orange et al. (2001) were followed for TLC. Lichen substance identification in TLC was further confirmed using the software WINTABOLITES, which has library records of 711 lichen substances from the study of Orange et al. 2001 (Mietzsch et al. 1994).

**UV test** A number of secondary metabolites in lichens exhibit a characteristic fluorescence under UV light. The response of presence and absence of these metabolites in the form of fluorescence against UV light plays a vital role in the lichen identification.

Morphoanatomical investigation along with chemical studies forms an essential component of taxonomic determination of lichens species. Following is a brief description of various morphological features (growth forms, vegetative propagules, and other surface structures), anatomical features (thallus anatomy), fruiting bodies (apothecia) and spore types, which are essential for proper delimitation of Indian terricolous lichen species.

## 5 Terricolous Lichen Morphology

Unlike other lichens (epiphytic or rock dwelling), terricolous lichens are often covered with soil debris; therefore, proper removal of soil and associated debris is essential for morphological analysis. Blue-green algae containing cyanolichens need moistening of thallus for the proper morphological examination.

### 5.1 Growth Forms

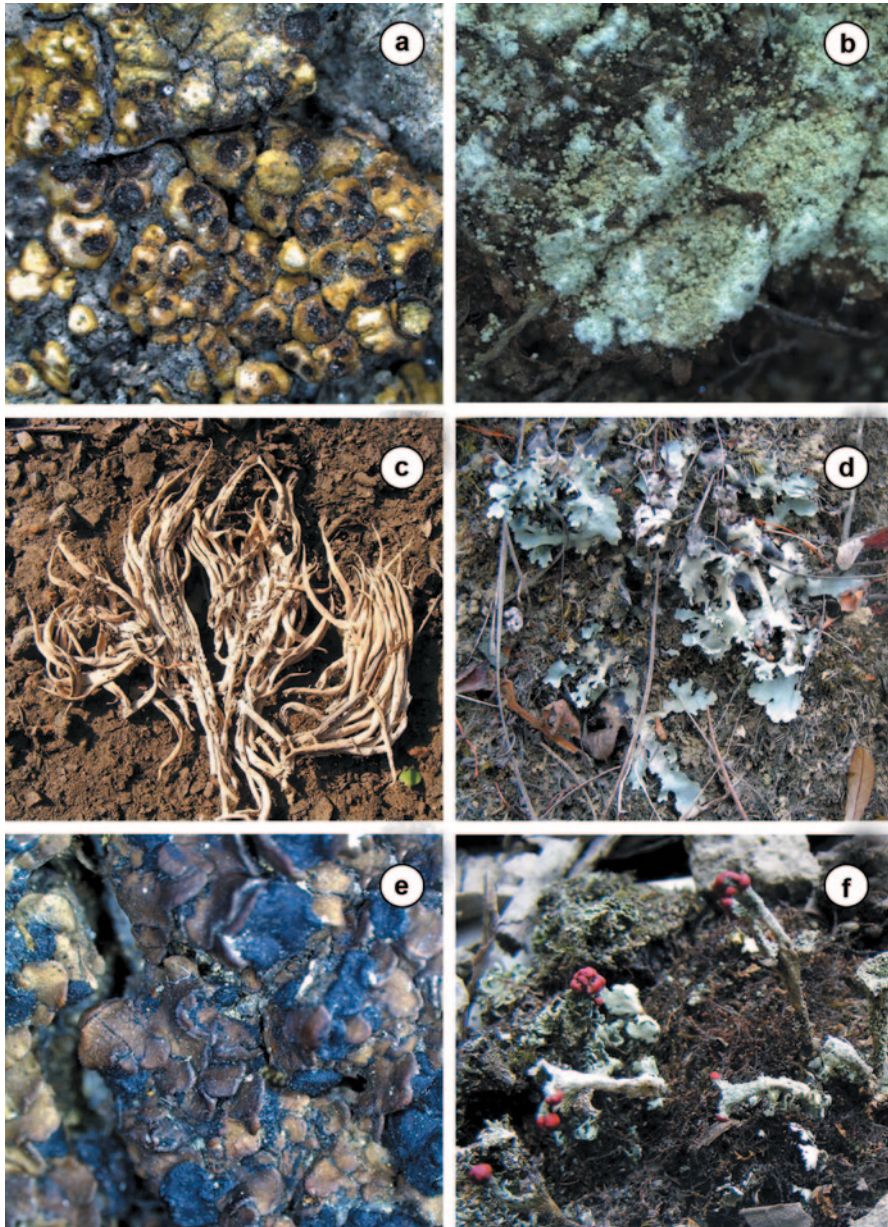
The morphology of terricolous lichens like other lichens groups can be categorized into three main growth forms (Nash III et al. 2002) (Fig. 1.4):

1. **Crustose** (crust-like) lichens consist of an adherent crust within or on the substrate and lack cortex and rhizines at the lower surface. Among crustose lichens, many growth forms are distinguished:

*Areolate* thalli are characterized by small broken independent crustose areoles, e.g. *Acarospora* (Fig. 1.4a).

*Leprose* lichens represent the least organized crustose form in which thallus is in the form of a powder or finely granular mass of algal cells and fungal hyphae and are never delimited by cortical layers, e.g. *Lepraria* spp. (Fig. 1.4b).

*Bullate* thalli are composed of inflated, swollen areoles, e.g. *Toninia* spp..



**Fig. 1.4** Growth form diversity in terricolous lichens. **a** Crustose, **b** Leprose, **c** Fruticose, **d** Foliose, **e** Squamulose, **f** Compound

*Squamules* have irregularly scattered areoles, which become minutely lobed and scale-like, e.g. *Endocarpon* spp., *Heppia* spp., *Catapyrenium* spp., *Placidium* spp. (Fig. 1.4e).

2. **Foliose** (leaf-like) are usually dorsiventrally differentiated with a distinct upper and lower surface and are commonly attached to substratum by structures like rhizines or umbilicus, e.g. *Peltigera*, *Hypogymnia*, *Sticta*, *Umbilicaria*, *Parmotrema*, *Dermatocarpon* (Fig. 1.4d)
3. **Fruticose** (shrub or beard-like) are bushy shrub-like and are either erect or pendulous, e.g. *Thamnolia* spp., *Ramalina* spp. (Fig. 1.4c).

Besides these forms, many intermediate forms are observed, e.g. subfruticose and subfoliose.

4. **Dimorphic/compound**: There are two terricolous lichens, *Cladonia* and *Stereocaulon*, in which more than one growth forms combine to form thallus, called as *cladoniiform* (Fig. 1.4f). These lichens have a basal granular or squamulose *primary thallus*, which extends horizontally on substrate and gives rise to erect stalks or branches referred to as *secondary thallus*. In *Cladonia*, these stalks are called *podetia*, which are hollow and are modifications/extensions of reproductive structures like apothecia or pycnidia. In *Stereocaulon*, the upright stack known as *pseudopodetia* are thalline in origin and solid throughout. Conventionally, termed as *dimorphic* thalli (Ahti 2000), these thalli are also reported as *compound*, as the so-called secondary thallus is just a modification of fruiting structures (Rai et al. 2012).

## 5.2 Vegetative Propagules

Vegetative propagules in terricolous lichens, like other lichens, usually integrate both mycobiont and photobiont cells and are among the most common mode of asexual reproduction (Nash III et al. 2002). Some of the most encountered vegetative propagules in terricolous lichens are soredia, isidia and schizidia.

*Soredia* are dispersal units of photobiont cells aggregated with loosely interwoven hyphae. Their morphology varies from fine (*farinose*) to coarse, grain-like (*granular*) or occasionally aggregate in large clusters (*consoredia*). Soredia are produced in well-defined structures, called *soralia*, which may be laminal or marginal. The region of thallus where soredia are formed, cortex breaks and the powdery mass of soredia comes out, giving the thallus surface a granular appearance.

*Isidia* are minute out growths with similar organization as the lichen thallus. Covered by cortical layers, isidia often has an internal differentiated photobiont layer. Isidial morphology varies, which ranges from simple to branched, coralloid, globose, and flattened. Isidia function as vegetative dispersal units, as they are loosely attached to the thallus surface. They are either distributed all over the thallus or to margins or ridges. Flattened isidia develop into small scale-like lobes, which are often referred to as *phyllidia*, observed in *Nephroma*, *Peltigera* and *Sticta*. Phyllidia develop along the margins or cracks.

*Schizidia* resemble phyllidia having flattened structures, but are formed by small parts flaking off the thallus surface. Therefore, their lower surface is not covered

by a thallus cortex and the remains of the thallus medulla are usually attached as residue. Schizidia are relatively rare and can be observed in terricolous lichens, e.g. *Baeomyces*, and within the cups of *Cladonia pyxidata*.

### 5.3 Other Surface Structures

Surface morphology of lichens varies considerably among species or even across individual thallus of the same species. Surface structures correlate with internal differentiation of the thallus, especially of the upper, cortical layers (Nash III et al. 2002).

*Shiny* surface is usually the result of highly gelatinized cortical hyphae. Some thalli have frosted appearance because of white granular deposits on the thallus surface, which is referred as *pruina*, and such thalli are described as *pruinose*. Pruina is usually crystallized calcium oxalate, crystallized lichen substances or the remains of dead partially disintegrated surface cells.

*Pulverulent* lichens have a powdery surface. *Pubescent* lichens have very fine hair (much finer than cilia or isidia) on their thallus surface. *Glabrous* lichens are without hair. The thallus surface texture can be *plane* ( $\pm$ flattened) or *undulate* (wavy). *Rugose* thallus has evenly thickened rounded wrinkles, called *rugae*. *Veins* are irregular net-like pattern, typical for the lower surface of foliose lichen species belonging to the genus *Peltigera*. Some lichens (e.g. *Nephroma*, *Peltigera*, *Sticta* and *Leptogium*) have a thick mat of hair-like hyphae, particularly on the lower surface, known as *tomentum*.

Mottled appearance of the thallus surface, found in *Parmelia*, *Parmotrema* and *Physcia* refer to as *maculae*, which are small rounded to irregularly elongated, pale spots caused by uneven thickening of the cortex and irregular distribution of photobiont cells below.

*Cyphelloids* are larger breaks in the thallus cortex, which are usually paler or more brightly coloured than the surrounding thallus and facilitate gas exchange. Two types of cyphelloids can generally be distinguished: (i) *cyphellae*, which only occur on the lower surface, e.g. *Sticta*, and are often imbedded in a tomentum; they are distinct recesses, sharply delimited, rounded or ovate, lined with a pseudocortex and surrounded by a pale ring and (ii) *pseudocyphellae*, which are more widely distributed and characteristic for several different terricolous genera (e.g. *Allocetraria*, *Bryoria*, *Cetraria*, *Flavocetraria*, *Melanelia*, *Parmelia*, *Pseudocyphellaria* and *Ramalina*); they are plane to slightly convex structures where medullary hyphae break through the thallus cortex. Pseudocyphellae occur in various shapes and can be found on the upper surface (e.g. *Parmelia*, *Melanelia*, *Melanelixia*), marginal (e.g. *Allocetraria*, *Cetraria*, *Ramalina*), on the lower surface (e.g. *Flavocetraria*) and on the thallus surface of fruticose lichens (e.g. *Bryoria*).

Raised surface features vary from rounded *papillae* (e.g. *Allocetraria*, *Melanelia*) (<0.3 mm in diameter) to *pustules* (e.g. *Collema*, *Flavoparmelia*, *Hypotrachyna*), which are larger (up several millimetre wide) than papillae and are convex, blister-like bulges on the upper side of foliose lichens, each with a corresponding

depression on the lower surface. *Verrucose* thallus surface is characterized by *tubercles* or *verrucae*, which are relatively large ( $\pm 1$  mm), conspicuous, rounded, wart-like outgrowths (e.g. *Collema*, *Cladonia*, *Lempholemma*, *Stereocaulon*, *Umbilicaria*).

Lichen thallus develops pits, depressions, channels and furrows without causing breaking of the thallus surface. A shallower and coarser pattern is called *scrobiculate* (e.g. *Nephroma*, *Peltigera*). Shallowly grooved or channelled depressions are called *sulcae* (e.g. *Parmelia sulcata*).

*Cephalodia* are unique, small, gall-like (0.5-1 mm wide) surface structures, which occur in tripartite lichen symbioses where the lichen fungus associates with both green algae (as primary photobiont) and cyanobacteria (as secondary photobiont). Sometimes they are externally formed as warty, squamulose or shrubby outgrowths of the thallus surface (e.g. *Nephroma*, *Peltigera*, *Stereocaulon*). However, in other lichens, they form internally and can only be noticed as a discoloration or when viewed in thallus cross sections (e.g. *Peltigera*).

## 6 Anatomy of the Lichen Thallus

Thallus anatomy of terricolous lichens varies extensively from highly differentiated thalli with several distinct layers of hyphae to thalli with virtually no internal differentiation. Thalli can be classified into two types. (i) *Homoiomorous*, in which the photobiont and the mycobiont are loosely interwoven with uniform dispersal of photobiont cells, throughout the thallus (e.g. *Collema*, *Leptogium*). Homoiomorous thalli are most commonly formed with cyanobacteria, and some of these lichens swell enormously if wetted with water. More frequently, lichen thalli are (ii) *Heteromorous*, where their thallus anatomy is stratified into distinct layers, especially an algal layer which may be distinguished from one or more *cortical* layers and a *medulla* (e.g. *Allocetraria*, *Bryoria*, *Bulbothrix*, *Cladia*, *Coccocarpia*, *Evernia*, *Heterodermia*, *Hypogymnia*, *Melanelixia*, *Nephroma*, *Peltigera*, *Phaeophyscia*, *Physcia* and *Sticta*).

## 7 Fruiting Bodies

Sexual reproduction in terricolous lichens occurs through ascospores, which are produced in fruiting bodies (ascocarps). Following ascocarps are reported from Indian terricolous lichens (Nash III et al. 2002).

### 7.1 Apothecia

They are disc-shaped structures formed by the lichen fungus on the thallus surface. Two important parts of an apothecium are the margin and the disc. The margin of an apothecium forms a ring around the disc of the apothecium. The disc is the

layer in the fruiting body where fungal spores are produced. The margin can appear similar in structure and colour to the thallus or to the disc. If the margin is similar to the thallus, it is called thalline margin and the whole apothecium is referred to as *Lecanorine apothecium* (named after *Lecanora*), whereas when the margin appears strongly blackened and rather similar to the disc, it is referred to as *Lecideine apothecia* (named after *Lecidea*). *Biatorine apothecia* (named after *Biatora*) have similar margins to the disc, but not strongly blackened.

## 7.2 *Perithecia*

They are flask-shaped fruiting bodies containing the asci. At maturity, an opening at the top, the ostiole, allows release of the spores. Perithecia are fully or partially immersed in the thallus or in the substrate, are rarely more than 1 mm in diameter, and occur in small numbers. They may be scattered or grouped, sometimes in clusters or in discrete areas of blackened tissue, a stroma. The walls of the perithecium, commonly black or darkened, form the exciple (or excipulum), which may be partly covered by a shield-like structure—the *involucrellum*. Lichens having perithecium are termed “pyrenocarpous” and common examples are *Agonimia*, *Catapyrenium*, *Dermatocarpon*, *Endocarpon*, *Placidium*. Their identification commonly requires a vertical section of the perithecium to elucidate the structure of the exciple, the involucrellum (if any), and the arrangement of the tissues within, as well as details of the asci and spores.

## 7.3 *Pycnoconidia*

Conidium is a specialized, non-motile fungal spore, which develops externally from specialized conidiogenous cells, in pycnidia in some terricolous lichens (e.g. *Flavoparmelia*, *Flavopunctelia*, *Hypogymnia*, *Melanelixia*, *Parmelinella*, *Rhizoplaca*, *Umbilicaria*). These spores (pycnoconidia) are often believed to be the male spermatia of the lichens, but some can also germinate and form new lichens.

## 8 Ascospores (Spores)

Ascospores vary in size, shape and structure and may be colourless or brown. Spore shape and size are important taxonomic characters for generic segregation in terricolous lichens. There are usually eight spores in each ascus; however, in some genera, the number of spores can be in 100s or in multiples of eight (16, 32 etc). Terricolous lichens show a wide range of sexually formed ascospore forms, from simple spores (without any septa) to spores with a single septa or with several septa (*pluriseptate*). Pluriseptate spores are formed in genera *Peltigera*, *Stereocaulon* etc. Simple spores also show diversity in forms, such as clavate, oblong, ovoid, bacilliform, globose, subglobose, ellipsoid, and are found in large number of families like *Acarosporaceae*, *Cladoniaceae*, *Lichinaceae* and *Parmeliaceae*. Spores become *submuriform* if

longitudinal septa are occasionally formed between the transverse septa. *Muriform* spores always have several transverse as well as longitudinal septa. Submuriform to muriform spores are represented by some genera like *Collema*, *Leptogium* and *Diploschistes*. Some other types of spores are also formed in terricolous lichens, like *polaribilocular* spores, which have a thick median cross wall formed by “isthmus” and are hyaline and characteristic of the genus *Teloschistes*, *Pachysporaria*-type (spores with strongly thickened walls around rounded cell lumina), *Physcia*-type and *Physconia*-type spores are characteristic of the family *Physciaceae*.

## 9 Conservation Status of Terricolous Lichens in India

Terricolous lichens face the same threats as other lichen groups, which range from natural climate change, unsustainable utilization for commercial purposes, zoo-anthropogenic pressures and unsustainable management of lichen-rich habitats (Upreti 1995; Scheidegger and Clerc 2002). As growth of soil lichens is intimately linked with stability of soil crust, any change/pressure on the terrestrial niches is exemplified by soil lichens, which are very sensitive to zoo-anthropogenic pressures (Rai et al. 2012). Terricolous lichens in India are the most vulnerable group of lichens, and substrate shift is very evident in this group which perishes on onset of even a slight disturbance. As the largest diversity of terricolous lichens in India occurs in Himalayan habitats, mainly in temperate–alpine grasslands (Bugyals), these habitats must be managed in sustainable way for healthy survival of soil lichens. The major threat to soil lichens is grazing and cattle-induced trampling, which can be minimized by decreasing the annual frequency of grazing in specific area and checks on period of grazing and number of cattle. The alpine grasslands are also faced with pilgrimage-based tourism in India, as these regions have some of the major temples of Hindu belief (e.g. Tungnath, Badrinath, Jageshwar), which induce pressures on soil crust because of tourist movements. The pressures can be reduced by construction of approach pathways for tourist movement. The terricolous lichens can only flourish in habitats where there is minimal competition with other ground vegetation (Scheidegger and Clerc 2002); therefore, agricultural practices like manure addition in areas of terricolous lichens, which increase the flourishing of other vascular plants and thus increase competition, can result in decrease in soil lichens.

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# Chapter 2

## Terricolous Lichens of India: Taxonomic Keys and Description

Himanshu Rai, Roshni Khare, Dalip Kumar Upreti and Teuvo Ahti

### 1 Introduction

The current taxonomic account of terricolous lichens is based on investigations of specimens preserved in CSIR-National Botanical Research Institute herbarium (LWG); Lucknow University, Lucknow herbarium (LWG-LWU) and personal collection of Dr D. D. Awasthi (LWG-AWAS) preserved in LWG; lichen herbarium of Botanical Survey of India, Sikkim Himalayan circle, Gangtok, Sikkim (BSHC) and eastern circle, Shilong, Meghalaya (ASSAM); herbarium of National Museum of Nature and Science, Tsukuba, Ibaraki Prefecture, Japan (TNS); herbarium of University of Helsinki (H) and terricolous lichens taxa reported so far in different literature within the present political boundaries of India.

Lichen samples were examined morpho-anatomically using thin hand-cut sections of apothecia and thalli mounted in plain water, lactophenol cotton blue, 5% KOH and iodine solution and observed under a compound microscope. The specimens were examined with a LEICA™ S8 APO stereomicroscope fitted with camera attachment (LEICA™ 10445929 0.5X) and LEICA™ DM 500 optical microscope. Photographs were taken by using FUJIFILM™ Fine Pix S5800 S800 camera and camera attachment of stereomicroscope. The external morphology was examined generally in dry conditions but dark brown to bluish specimens of cyanolichens *Lep-togium* and *Collema* were studied in wet conditions. The colours of medulla, epithecium, hypothecium and ascus were recorded. The asci and ascospores were taken from the sections when mounted in water, and their shapes and sizes were recorded. The

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Teuvo Ahti has contributed only for genus *Cladonia*

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H. Rai (✉) · R. Khare · D. K. Upreti  
Lichenology Laboratory, Plant Diversity, Systematics and Herbarium Division,  
CSIR-National Botanical Research Institute,  
Rana Pratap Marg, Lucknow-226001, Uttar Pradesh, India  
e-mail: himanshurai08@yahoo.com

T. Ahti  
Botanical Museum, Finnish Museum of Natural History, University of Helsinki,  
P.O. Box 47, 00140 Helsinki, Finland

H. Rai, D. K. Upreti (eds.), *Terricolous Lichens in India*,  
DOI 10.1007/978-1-4939-0360-3\_2, © Springer Science+Business Media New York 2014

chemistry of lichens was studied using spot tests, thin layer chromatography (TLC), microcrystallography and ultraviolet (UV) reaction of lichen thallus (Chap. 1, Vol. 2). All the lichen taxa thus studied were compared with relevant literature (i.e. checklist, revisionary studies, flora and monographs), in order to identify lichen samples up to species level (Singh and Upreti 1984; Purvis et al. 1992; Goward et al. 1994; Goward 1999; Ahti 2000; Divakar and Upreti 2005; Awasthi 2007; McCune and Rosentreter 2007; Rosentreter et al. 2007; Saag et al. 2009; Upreti et al. 2010; Singh and Sinha 2010; Upreti and Divakar 2010). New records of terricolous lichen species were recorded against the annotated checklist by Singh and Sinha (2010).

## 2 Present Status of Terricolous Lichen Diversity in India

The present study concludes occurrence of 312 species of terricolous lichens belonging to 79 genera and 28 families (Table 2.1). Out of these, about 19 species (6.1%) are endemic. Species diversity at family level shows that *Parmeliaceae* (70 species) dominates, followed by *Cladoniaceae* (61 species) and *Collemaaceae* (38 species) (Table 2.2). Similarly, at generic level, maximum diversity is shown by *Cladonia* (59 species), followed by *Leptogium* (20 species), *Collema* (18 species), *Peltigera* (17 species) and *Heterodermia* (11 species) (Table 2.2).

Considering diversity of terricolous lichens in different Lichenogeographic regions, it may be concluded that Western Himalaya are the most diverse in terricolous lichens, holding 225 species, followed by Eastern Himalaya and Northeast India (164 species), Eastern Ghats and Deccan plateau (51 species), and Western Ghats (21 species) (Fig. 2.36). Andaman and Nicobar region is devoid of any records of terricolous lichen. Maximum endemism of terricolous lichens were found in Central India (50%), followed by Western Dry Regions (20%).

The study elucidated seven species as new records for India.

1. *Bryoria nepalensis* D. D. Awasthi
2. *Umbilicaria leiocarpa* DC
3. *Pertusaria puffina* A. W. Archer and Elix
4. *Buellia asterella* Poelt and Sulzer
5. *Peltigera lepidophora* (Nyl.) Bitter
6. *Leptogium teretiusculum* (Flörke in Wallr.) Arnold
7. *Pseudocyphellaria ceylonensis* H. Magn

## 3 Taxonomic Description

All the identified lichens are artificially keyed out first in genera and ultimately identified species are keyed under their respective genera. Genera under each family and species under each genus are arranged alphabetically. Data regarding the total number of species in the world under each genus is taken from latest references (Singh and Sinha 2010; Nash et al. 2002). Outline classification of Ascomycota is

**Table 2.1** A conspectus of families, genera and species of terricolous lichens in India

Sr. No.	Name of family	Names of genera	No. of genera	No. of species
1.	<i>Acarosporaceae</i>	ACAROSPORIA A. Massal.	1	3
2.	<i>Baeomycetaceae</i>	BAEOMYCES Pers.	1	2
3.	<i>Caliciaceae</i>	ACROSCYPHUS Lév. BUELLIA De Not.	2	1 1
4.	<i>Candelariaceae</i>	CANDELARIELLA Müll. Arg.	1	1
5.	<i>Catillariaceae</i>	TONINIA A. Massal.	1	3
6.	<i>Cladoniaceae</i>	CLADIA Nyl CLADONIA P. Browne GYMNODERMA Nyl.	3	1 59 1
7.	<i>Coccocarpiaceae</i>	COCCOCARPIA Pers.	1	3
8.	<i>Collemataceae</i>	COLLEMA Weber ex F.H. Wigg. LEPTOGIUM (Ach.) Gray	2	18 20
9.	<i>Icmadophilaceae</i>	DIBAEIS Clem. ICMADOPHILA Trevis. SIPHULA Fr. THAMNOLIA Ach. ex Schaer.	4	2 1 1 1
10.	<i>Lecanoraceae</i>	LECANORA Ach. RHIZOPLACA Zopf	2	2 2
11.	<i>Lecideaceae</i>	LECIDOMA G. Schneider and Hertel	1	1
12.	<i>Lichinaceae</i>	HEPPIA Nägeli ex A. Massal. LEMPHOLEMMA Körb. PECCANIA A. Massal. ex Arnold	3	1 1 3
13.	<i>Lobariaceae</i>	LOBARIA (Schreb.) Hoffm. PSEUDOCYPHELLARIA Vain. STICTA (Schreb.) Ach.	3	4 1 10
14.	<i>Megasporaceae</i>	LOBOTHALLIA (Clauzade and Cl. Roux) Hafellner	1	1
15.	<i>Nephromataceae</i>	NEPHROMA Ach.	1	4
16.	<i>Pannariaceae</i>	FUSCOPANNARIA P.M. Jørg.	1	2
17.	<i>Parmeliaceae</i>	ALECTORIA Ach. ALLOCETRARIA Kurok. and M.J. Lai BRYORIA Brodo and D. Hawksw. BULBOTHRIX Hale CETRARIA Ach. CETRELIA W.L. Culb. and C.F. Culb. EVERNIA Ach. EVERNIASTRUM Hale ex Sipman FLAVOCETRARIA Kärnefelt and A. Thell FLAVOCETRARIELLA D.D. Awasthi FLAVOPARMELIA Hale FLAVOPUNCTELIA (Krog) Hale HYPOGYMNIA (Nyl.) Nyl. HYPOTRACHYNA (Vain.) Hale LETHARIELLA (Motyka) Krog MELANELIA Essl. MELANELIXIA O. Blanco and al.	26	1 4 8 2 6 2 1 3 2 2 1 4 1 4 2 2 1 4 2

**Table 2.1** (continued)

Sr. No.	Name of family	Names of genera	No. of genera	No. of species
		MELANOHALEA O. Blanco and al.		1
		NEPHROMOPSIS Müll. Arg.		2
		PARMELIA Ach.		2
		PARMELINELLA Elix and Hale		1
		PARMOTREMA A. Massal.		9
		PUNCTELIA Krog		2
		TUCKNERARIA Randlane and A. Thell		1
		USNEA Dill. ex Adans.		1
		XANTHOPARMELIA (Vain.) Hale		4
18.	<i>Peltigeraceae</i>	PELTIGERA Willd.	2	17
		SOLORINA Ach.		3
19.	<i>Pertusariaceae</i>	PERTUSARIA DC.	1	1
20.	<i>Physciaceae</i>	ANAPTYCHIA Körb.	6	2
		HETERODERMIA Trevis. em. Poelt		11
		PHAEOPHYSCIA Moberg		4
		PHYSCIA (Schreb.) Mich.		4
		PHYSCONIA Poelt		3
		RINODINA (Ach.) Gray		2
21.	<i>Psoraceae</i>	PSORA Hoffm.	1	2
22.	<i>Ramalinaceae</i>	FRUTIDELLA Kalb	2	1
		RAMALINA Ach.		4
23.	<i>Stereocaulaceae</i>	LEPRARIA Ach.	3	5
		SQUAMARINA Poelt		1
		STEREOCAULON (Schreb.) Hoffm.		13
24.	<i>Teloschistaceae</i>	TELOSCHISTES Norman	1	1
25.	<i>Thelotremataceae</i>	DIPLOSCHISTES Norman	1	4
26.	<i>Umbilicariaceae</i>	UMBILICARIA Hoffm.	1	4
27.	<i>Verrucariaceae</i>	AGONIMIA Zahlbr.	5	1
		CATAPYRENIUM Flot.		1
		DERMATOCARPON Eschw.		1
		ENDOCARPON Hedw.		1
		PLACIDIUM A. Massal.		2
28.	<i>Lecanorales</i> <sup>a</sup>	LEPROCAULON Nyl. ex Lamy	2	2
		MYCOBILIMBIA Rehm		2
		<b>Total</b>	<b>79</b>	<b>312</b>

<sup>a</sup> The genera and species included in this order are with uncertain families

followed as given by Lumbsch and Huhndorf (2009), and current name of species was validated using the study by Singh and Sinha (2010). Citation of relevant literature for taxonomic nomenclature are followed that from Awasthi (2007) and Singh and Sinha (2010). Each species is described with respect to its morphological, anatomical and chemical characters if any. Ecology of the species is described with reference to their habitat differentiation assigned according to Scheidegger and Clerc (2002) (Chap. 1). Besides the reported distribution of the taxa within Indian states,

**Table 2.2** Dominant families and genera of terricolous lichens in India

Dominant families		Dominant genera	
Family	No. of species	Genus	No. of species
<i>Parmeliaceae</i>	70	<i>Cladonia</i>	59
<i>Cladoniaceae</i>	61	<i>Leptogium</i>	20
<i>Collemataceae</i>	38	<i>Collema</i>	18
<i>Physciaceae</i>	28	<i>Peltigera</i>	17
<i>Peltigeraceae</i>	20	<i>Heterodermia</i>	11
<i>Stereocaulaceae</i>	19	<i>Stereocaulon</i>	13
<i>Lobariaceae</i>	15	<i>Sticta</i>	10
<i>Verrucariaceae</i>	6	<i>Parmotrema</i>	9
<i>Icmadophilaceae</i>	5	<i>Bryoria</i>	8
<i>Lichinaceae</i>	5	<i>Cetraria</i>	6
<i>Ramalinaceae</i>	5	<i>Lepraria</i>	5
<i>Lecanoraceae</i>	4	<i>Alloctraria</i>	4
<i>Nephromataceae</i>	4	<i>Diploschistes</i>	4
<i>Acarosporaceae</i>	3	<i>Hypogymnia</i>	4
<i>Catillariaceae</i>	3	<i>Hypotrachyna</i>	4
<i>Coccocarpaceae</i>	3	<i>Lobaria</i>	4
<i>Caliciaceae</i>	2	<i>Nephroma</i>	4
<i>Pannariaceae</i>	2	<i>Phaeophyscia</i>	4
<i>Baeomycetaceae</i>	2	<i>Physcia</i>	4
<i>Psoraceae</i>	2	<i>Ramalina</i>	4
<i>Lecidiaceae</i>	1	<i>Umbilicaria</i>	4
<i>Pertusariaceae</i>	1	<i>Xathoparmelia</i>	4
<i>Megasporaceae</i>	1		
<i>Teloschistaceae</i>	1		

their distribution outside India is provided as far as possible. Distribution of a taxon begins with India, comprising Indian states within paranthesis, then followed by other countries, regions, continents and general remarks if any. These are arranged in alphabetical order and separated by semicolon (;). The taxa with limited distribution within India, which include several recently described species as well, are treated as endemic until reported from elsewhere. Illustrative distribution maps and photographs of species are also given to facilitate identification.

**Key to the terricolous lichen genera of India:**

1.	Thallus foliose, fruticose, subfruticose or dimorphic .....	2
1a.	Thallus leprose, crustose or squamulose, subfoliose-squamulose, subcrustose-squamulose .....	67
2.	Thallus foliose, fruticose or subfruticose.....	3
2a.	Thallus dimorphic .....	61
3.	Thallus foliose.....	4
3a.	Thallus fruticose to subfruticose.....	45
4.	Thallus with blue green alga as photobiont .....	5
4a.	Thallus with green alga as photobiont .....	14

5.	Thallus homoiomerous.....	6
5a.	Thallus heteromerous.....	7
6.	Thallus ecorticated or with pseudocortex, rhizinate or erhizinate, photobiont <i>Nostoc</i> , spores transversely septate or muriform.....	<i>Collema</i>
6a.	Thallus corticated on one or both sides.....	<i>Leptogium</i>
7.	Thallus corticated only on upper side (rarely cortex present below apothecia).....	8
7a.	Thallus corticated on both sides.....	10
8.	Thallus large lobed, lower side $\pm$ distinctly veined, spores colourless or brown, usually 3-septate.....	<i>Peltigera</i>
8a.	Thallus medium sized, corticated only below apothecia, spores brown, 2-celled.....	<i>Solorina</i>
10.	Apothecia marginal, nephromoid.....	<i>Nephroma</i>
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**ACAROSPORA** A. Massal. (*Acarosporaceae*)

Ric. Auton. Lich. Crost.: 27. 1852.

**Thallus:** crustose, ± areolate, stellate-radiate, subsquamulose to squamulose at margins; **photobiont:** a green protoocoid alga. Both surfaces and only the upper surface paraplectenchymatously corticated with small cells. **Apothecia:** initially sunken, later sessile, lecanorine; **paraphyses:** simple, swollen or moniliform at apices; **asci:** multispored; **spores:** small, colourless, simple, thin walled, subglobose to ellipsoid.

Out of 128 species known in the world, 9 species are known from India, of which 3 are terricolous.

**Key to the terricolous species of *Acarospora*:**

1.	Thallus K+ red or rusty red (norstictic acid).....	<i>A. smaragdula</i>
1a.	Thallus K- .....	2
2.	Thallus greenish yellow to dark yellow .....	<i>A. schleicheri</i>
2a.	Thallus bluish white, squamules with pruina.....	<i>A. strigata</i>

***Acarospora schleicheri*** (Ach.) A. Massal. (Fig. 2.1a; Fig. 2.37)

Ric. Auton. Lich. Crost.: 27, 3. 1852.

Basionym: *Urceolaria schleicheri* Ach., Lichenogr. Universalis: 332. 1810.

**Thallus:** squamulose, indeterminate; **squamules:** 1–5 mm large, 0.2–0.4 mm thick, at first small, discrete and round, then more or less contiguous and often angular, crenate or sublobate; **upper surface:** pale greenish yellow to dark; **lower surface:** usually brownish red. **Apothecia:** 0.5–1.0 mm in diam., reddish brown, mostly solitary or occasionally 2–3 in the areola, immersed; **disc:** 0.5–1 mm, more or less dark reddish brown, plane or often convex; **asci:** 65–85 × (10–)14–17 μm, not numerous, often rather narrowly clavate; **spores:** about 100 per ascus, 3–4 × 2–2.5 μm, ellipsoid to subglobose.

**Chemistry:** Rhizocarpic (major), acarenoic (trace) acids (Galloway 2007, p. 11).

**Ecology and distribution:** *Microhabitat occupied:* Terricolous. In India, the species is exclusively terricolous and is widely distributed in Western Himalaya and known from Himachal Pradesh (Awasthi 2007) and Uttarakhand. Outside India, the species is also reported from China and is widely distributed in Europe and North America.

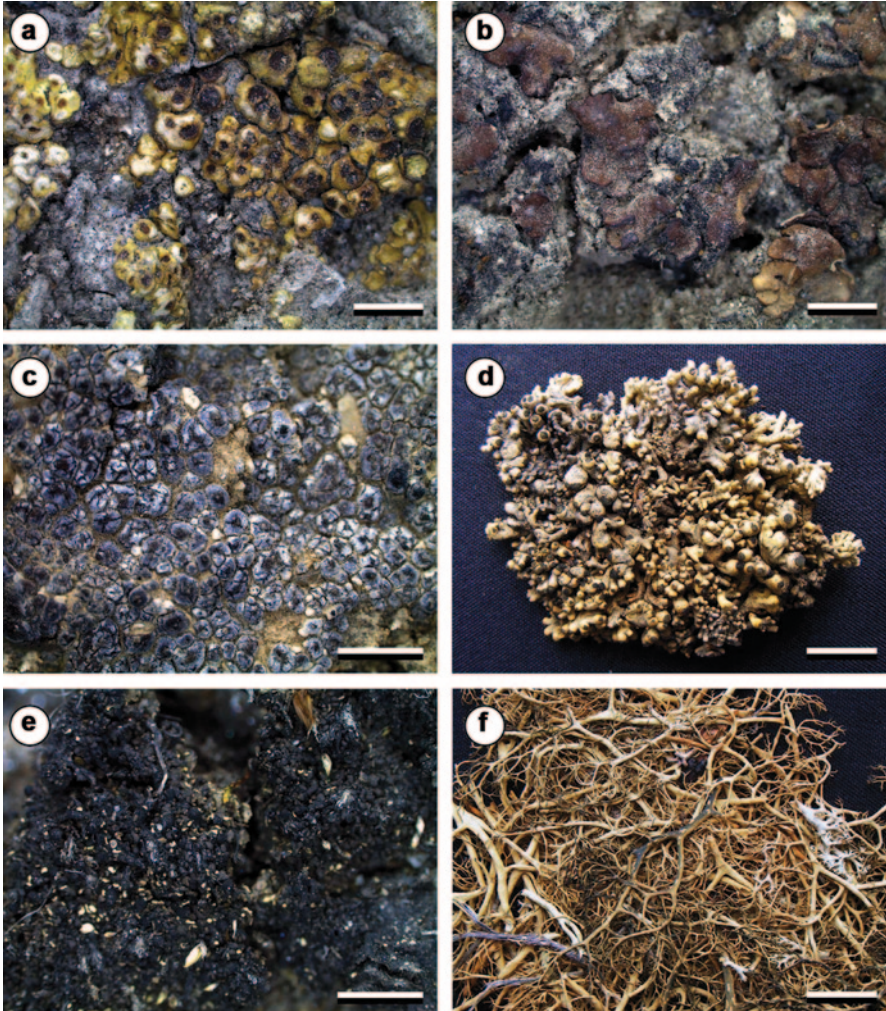
**SPECIMENS EXAMINED: INDIA: UTTARAKHAND, UTTARKASHI DISTRICT,** Gangotri, Gomukh area, right bank 2nd moraine, alt. 3,901 m, on rocky soil, D. D. Awasthi and S. R. Singh 8394 (LWG-AWAS); Gangotri, Gomukh area, right bank 3rd and 4th moraine, alt. 3,871 m, on soil, D. D. Awasthi and S. R. Singh 8455 (LWG-AWAS); Gangotri, Gomukh area, Devwasa, alt. 3,200 m, on soil, S. Chatterje and P. K. Divakar 02-000267 (LWG).

***Acarospora smaragdula*** (Wahlenb.) A. Massal. (Fig. 2.1b; Fig. 2.37)

Massalongo Ric. Auton. Lich. Crost.: 29.1852.

Basionym: *Endocarpon smaragdulum* Wahlenb. in Ach., Methodus: 129. 1803.

**Thallus:** indeterminate, squamulose or occasionally subareolate; **squamules:** 1–2 mm large, 0.3–0.4 mm thick, dispersed or usually few grouped, mostly rounded or subcrenate, shiny when dark; **upper surface:** yellowish or pale brown; **lower**



**Fig. 2.1** **a** *Acarospora schleicheri* (Ach.) A. Massal., **b** *A. smaragdula* (Wahlenb.) A. Massal., **c** *A. strigata* (Nyl.) Jatta, **d** *Acrosyphus sphaerophoroides* Lév., **e** *Agonimia tristicula* (Nyl.) Zahlbr., **f** *Alectoria ochroleuca* (Hoffm.) A. Massal. Scale in **a**, **b**, **c**, **e**=2 mm, in **d**, **f**=10 mm

**surface:** pale in colour. **Apothecia:** generally 3–7 per areola, immersed; **disc:** 0.2–0.4 mm across, dark brown or blackish, plane; **asci:** numerous, 70–135 × 17–25 μm, swollen clavate or cylindric clavate, sometimes with narrower apex; **spores:** several 100 per ascus, 3–4(–4.5) × 1–1.5 μm, narrowly ellipsoid or subcylindric.

**Chemistry:** Norstictic acid.

**Ecology and distribution:** *Microhabitat occupied:* Terricolous. In India, the species growing on soil is known from a single locality of Himachal Pradesh. Outside India, the species is also reported from Brazil, Nepal, Japan, Europe and North America.

**SPECIMEN EXAMINED: INDIA: HIMACHAL PRADESH, LAHAUL SPITI DISTRICT,** Lahaul valley, 6 km before Chhatru from Koksar, alt. 3,900 m, on soil, Upreti and Divakar 02-000161 C (LWG).

***Acarospora strigata* (Nyl.) Jatta (Fig. 2.1c; Fig. 2.37)**

Jatta, *Malpighia* 20: 10. 1906.

Basionym: *Lecanora strigata* Nyl., *Ann. Sci. Nat. Bot.*, ser. 4, 3: 155. 1855.

**Thallus:** indeterminate, squamulose or squamulose-areolate; **squamules:** (0.6–) 1–1.5 mm long, 0.3–0.7 mm thick, either scattered or crowded in small groups, thick pruinose; **upper surface:** plane or somewhat uneven, with numerous deep and narrow fissures; **lower surface:** paler than upper surface. **Apothecia:** sometimes scanty and sometimes frequent, solitary, immersed; **disc:** 0.2–0.5 mm in diam., often irregular in shape, black or very dark reddish brown, plane or subconcave, slightly rough or concave, impressed; **asci:** 70–110 × 15–20 μm, narrowly or broadly clavate; **spores:** 100–200 per ascus, 3–4.5 × 2–2.5 μm, mostly broadly ellipsoid.

**Chemistry:** Thallus K–, C–, KC–, P–; no secondary metabolites in TLC.

**Ecology and distribution:** *Microhabitat occupied:* Terricolous-rupicolous. In India, the species is widely distributed in Himachal Pradesh and Jammu and Kashmir, whereas the species growing on soil is reported from a single locality of Himachal Pradesh. Outside India, the species is also reported from Iran, Siberia and South America.

**SPECIMEN EXAMINED: INDIA: HIMACHAL PRADESH, KINNAUR DISTRICT,** in and around Yangthang, alt. 3,800 m, on soil over rock, Upreti, Srivastava and Prakash 03-002638 (LWG).

**ACROSCYPHUS** Lév. (*Caliciaceae*)

Léveillé, *Ann. Sci. Nat. Bot.* ser. 3, 5: 262. 1846.

**Thallus:** pulvinate-fruticose, branched; **branches:** cylindrical, podetiid, corticated on all surfaces; **photobiont:** a green alga (*Trebouxia*); **medulla:** solid. **Apothecia:** terminal on ± globular branches, adnate to sunken, cupuliform with a proper margin; **asci:** cylindrical, soon gelatinized; **spores:** in mazaedium, brown to dark brown, two-celled, constricted at the septum, thick walled. **Pycnidia:** on tips of branches; **pycnoconidia:** straight, elongate.

The genus is monotypic widespread.

***Acrosyphus sphaerophoroides* Lév. (Fig. 2.1d; Fig. 2.37)**

Léveillé, *Ann. Sci. Nat. Bot.* sér. 3, 5: 262. 1846.

**Thallus:** spreading in large patches, pulvinate, with grey-brown to basally darker, rigid, dactyliform podetiid branches; **podetia:** crowded, cylindrical to clavate, repeatedly dichotomously branched, to 5 mm tall; **podetial surface:** verrucose; **medulla:** yellowish orange, solid. **Apothecia:** terminal, black; **hymenium:** mazaedial, black, not protruding; **spores:** ovoid, (12) 20–30 × 9–16 μm, thick walled.

**Chemistry:** Medulla K+ red, I+ bluish, C+ red, P+ red. Calycin, gyrophoric acid, zeorin and two unknown substances, fide: Pant and Awasthi (1989); and atranorin, gyrophoric acid, usnic acid, chrysophenol, rugulosin, skyrin, zeorin and calycin, fide: Culbertson (1970, p. 222).

**Ecology and distribution:** *Microhabitat occupied:* Terricolous; terricolous-rupicolous. In India the species is exclusive terricolous and widely distributed in Eastern Himalaya and known from Arunachal Pradesh and Sikkim. Outside India, the species is also reported from Bhutan, British Colombia, China, Japan, Mexico, Nepal, Patagonia, Peru and South Africa; North America. It is abundant in alpine areas and grows on soil and on rocks over soil in association with some fruticose lichen species like *Cetraria*.

**SPECIMENS EXAMINED:** **INDIA:** ARUNACHAL PRADESH, WEST-KAMENG DISTRICT, Tawang, alt.4,000 m, on soil, Jaishree Rout s.n. (LWG); **SIKKIM,** NORTH SIKKIM, Yangdi, above Thangu, alt. 4,250 m, on soil, D. K. Upreti, S. Chatterjee and P. K. Divakar 04-003961 (LWG); Chubuk, alt. 4,100 m, on soil over rock, D. K. Upreti, S. Chatterjee and P. K. Divakar 04-003940 (LWG); **WEST SIKKIM,** Dzongri, alt. 4,000 m, on soil, G. P. Sinha 760 (BSHC).

**AGONIMIA** Zahlbr. (*Verrucariaceae*)

Österr. bot. Z. 59: 350. 1909.

**Thallus:** smooth or granular to finely digitate or minutely squamulose; **upper surface:** green, grayish green, olivaceous; **photobiont:** chlorococcoid alga. **Perithecia:** subglobose or pyriform to barrel-shaped, often between squamules or granules, superficial to half-immersed; **exciple:** thick, paraplectenchymatous, ± distinctly three-layered; **periphyses:** simple or sparingly branched; **hymenial gel:** I + blue or orange-red; **asci:** clavate, 1-, thin-walled, (1-) 2- or (4-) eight-spored; **spores:** strongly muriform, hyaline to pale brownish, ellipsoid to elongate-ellipsoid.

Out of 13 species known from the world, 1 terricolous species is known from India.

*Agonimia tristicula* (Nyl.) Zahlbr. (Fig. 2.1e; Fig. 2.37)

Österr. bot. Z. 59: 351. 1909.

Basionym: *Verrucaria tristicula* Nyl., Flora 48: 356. 1865.

**Thallus:** delicately squamulose, forming small, aggregates; **squamules:** 0.1–0.5 mm wide, ± crowded, adnate to ascending, flat or convex, roundish to elongate, more rarely digitiform or divided into coarsely subgranular segments; **upper surface:** grayish brown or green brown to fawn, green when wet, dull; **lower surface:** pale. **Perithecia:** prominent, black, barrel shaped, up to 0.5 mm broad, surface rough and wrinkled; **asci:** clavate, two-spored; **spores:** strongly muriform, elongate-ellipsoid, hyaline to pale yellow brown, 80–120 × 30–50 µm.

**Chemistry:** Medulla K-, C-, KC-, P-; no secondary metabolites in TLC.

**Ecology and distribution:** *Microhabitat occupied:* Muscicolous-terricolous. In India the species is exclusive terricolous and exhibits restricted distribution to Eastern Himalaya and known only from single locality of Arunachal Pradesh. Outside India, the species is also reported from Europe, Macaronesia, North America and Pacific Island.

**SPECIMEN EXAMINED:** **INDIA:** ARUNACHAL PRADESH, WEST KAMENG DISTRICT, Sela Pass, alt. 4,221 m, on mosses over soil, D. K. Upreti, U. Dubey, R. Khare and G. Mishra 08-009421 (LWG).

**ALECTORIA** Ach. (*Parmeliaceae*)

Acharius in Luyken, Tent. Hist. Lich.: 95. 1809.

**Thallus:** fruticose, erect, decumbent to pendulous, greenish yellow; **lobes:** dichotomously branched; pseudocyphellate; with or without isidia and soredia; corticated all round; **photobiont:** a green alga; **medulla:** solid. **Apothecia:** lateral, geniculate, lecanorine; **asci:** arrested bitunicate, 2–4-spored; **spores:** brown at maturity, simple.

Out of 8 species known from the world, 1 terricolous species is known from India.

**Alectoria ochroleuca** (Hoffm.) A. Massal. (Fig. 2.1f, Fig. 2.37)

Massalongo, Sched. Crit. Lich. Ital.: 47. 1855.

Basionym: *Usnea ochroleuca* Hoffm., Descr. Adumbr. Pl. Lich. 2(1): 7. 1791.

**Thallus:** terricolous, to 8 cm long, erect to decumbent; **branches:** to 2 mm in diam., pseudocyphellate; **pseudocyphellae:** sparse to dense, white, flat or raised, elongate-fusiform; **surface:** matt, ± pitted at base; lacking isidia and soredia; **medulla:** hollow in middle part. **Apothecia:** not seen.

**Chemistry:** Cortex K– or K+ reddish, C–, KC+ yellow, P–; medulla K– C–, KC+ red, P–. Usnic, alectoronic and diffractaic acids present.

**Ecology and distribution:** *Microhabitat occupied:* Terricolous; terricolous-rupicolous. In India the terricolous species is reported from Sikkim. In world, the species is also reported from China, Japan, Nepal and New Zealand; Europe, North America.

**SPECIMENS EXAMINED:** **INDIA:** SIKKIM, NORTH SIKKIM, Lashar, alt. 4,500 m, on rock over soil, Sinha 1187 (BSHC); Llonakh valley, Llonakh chu surroundings, alt. 4,500 m, on soil, Sinha 1610, 1669 (BSHC).

**ALLOCTRARIA** Kurok. and M. J. Lai (*Parmeliaceae*)

Bull. Nat. Sci. Mus. Tokyo, B, 17: 60. 1991.

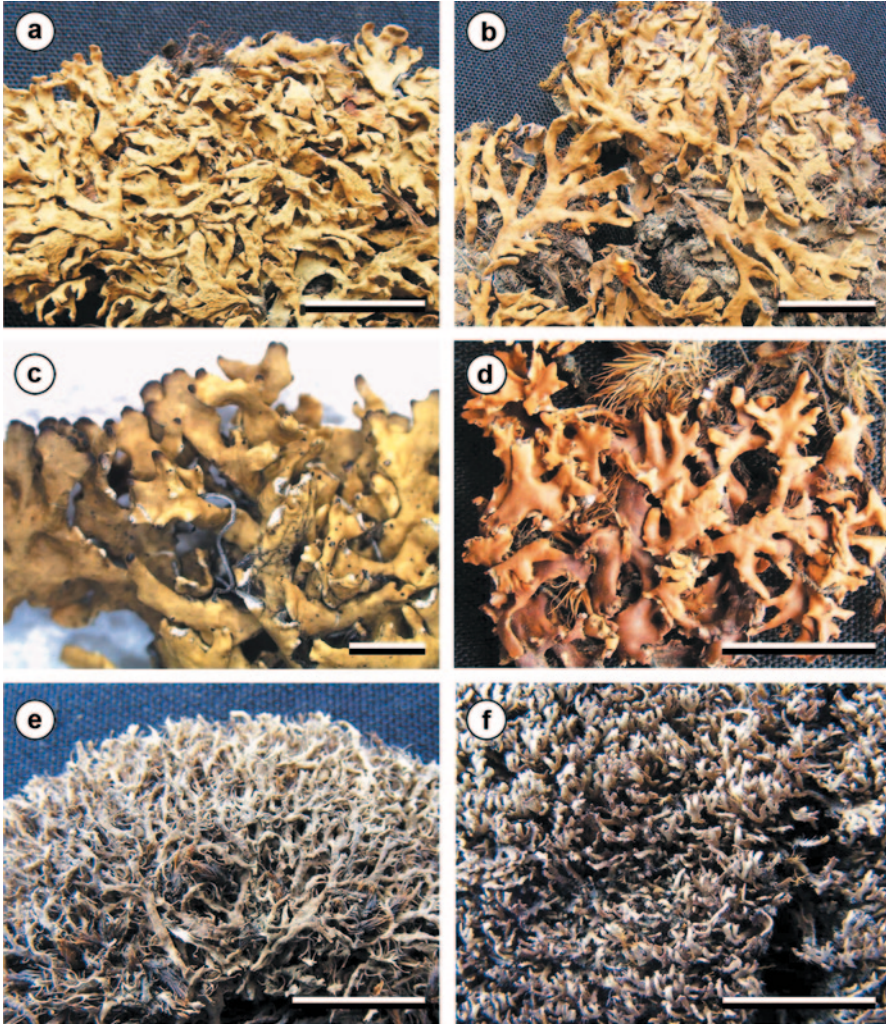
**Thallus:** foliose to fruticose, prostrate to erect, dorsiventral, unbranched or dichotomously branched; **lobes:** 1–2 mm wide, bearing marginal pycnidial projections; **upper surface:** yellow to brownish, concave or convex, lacking pseudocyphellae; **lower surface:** with punctiform to linear pseudocyphellae; **photobiont:** a green alga; **medulla:** white to ochraceous. Thallus heteromerous, corticated on both surfaces. **Apothecia:** usually marginal; **disc:** brown; **exciple:** two-layered; **spores:** hyaline, simple.

Out of 11 species known from world, 5 species are known from India, of which 4 are terricolous.

**Key to the terricolous species of *Allocetraria*:**

1.	Medulla white, P+ orange.....	<i>A. flavonigrescens</i>
1a.	Medulla white or yellow-orange, P–.....	2
2.	Thallus dorsiventral, convex on upper surface to partially radially symmetrical, medulla white to ochraceous.....	<i>A. stracheyi</i>
2a.	Thallus always dorsiventral.....	3
3.	Thallus erect, medulla white to yellow.....	<i>A. globulans</i>
3a.	Thallus forming 2–3 cm tussocks, lobes concave, prostrate, medulla white, lower surface pale yellow.....	<i>A. ambigua</i>





**Fig. 2.2** **a** *Allocetraria ambigua* (C. Bab.) Kurok. and M. J. Lai, **b** *A. flavonigrescens* A. Thell and Randlane, **c** *A. globulans* (Nyl.) A. Thell and Randlane, **d** *A. stracheyi* (C. Bab.) Kurok. and M. J. Lai, **e** *Anaptychia kaspica* Gyeln., **f** *A. pseudoroemeri* D. D. Awasthi and S. R. Singh. Scale in **c**=2 mm, in **a, b, d, e, f**=10 mm

*Allocetraria ambigua* (C. Bab.) Kurok. and M. J. Lai (Fig. 2.2a; Fig. 2.37)

Kurokawa and Lai, Bull. Nat. Sci. Mus. Tokyo, ser. B, 17: 62. 1991.

Basionym: *Cetraria ambigua* C. Bab., Hooker's J. Bot. Kew Gard. Misc. 4: 244. 1852.

Synonym: *Platysma ambiguum* (Bab.) Nyl., Mém. Soc. Sci. Nat. Cherbourg, 5:100. 1857.

**Thallus:** foliose, prostrate, subdichotomously divided, forming 2–3 cm high tussocks; **lobes:** to 3 cm long, 2–3 mm wide, yellow ochraceous, plane to concave on upper surface; **margins:** with black pycnidial papillae; **upper surface:** yellowish plane, smooth to faintly lacunose; **medulla:** white; **lower surface:** ± reticulately lacunose, with marginal punctate-pseudocyphellae.

**Chemistry:** Cortex and medulla K–, C–, KC–, P–. Usnic acid in cortex and lichesterinic and protolichesterinic acids in medulla; secalonic acid A and/or C may also be present.

**Ecology and distribution:** *Microhabitat occupied:* Terricolous. In India the species is exclusively terricolous and distributed in Sikkim and Uttarakhand. The species is endemic to Himalayas. Outside India, the species is also reported from China and Nepal.

**SPECIMENS EXAMINED: INDIA: SIKKIM, NORTH SIKKIM,** Yangdi, above Thangu, alt. 4,250 m, on soil, D. K. Upreti, S. Chatterjee and P. K. Divakar 04-003981 A (LWG); **UTTARAKHAND, UTTARKASHI DISTRICT,** Gangotri, Gomukh area, right bank 5th moraine, alt. 3,840 m, on soil, D. D. Awasthi and S. R. Singh 8521, 8473 Dup. (LWG-AWAS).

*Alloctetraria flavonigrescens* A. Thell and Randlane (Fig. 2.2b; Fig. 2.37)

In Daniels and al. (eds.), Flechten Follmann: 359. 1995.

**Thallus:** foliose to subfruticose, dorsiventral, loosely attached, cushion forming, to 4 cm tall; **lobes:** subdichotomously branched, linear-laciniate, to 3 mm wide; **upper surface:** dull, yellowish with black spots, faintly lacunose, with reticulate lamellae; **medulla:** white; **lower surface:** brown-black, wrinkled, lamellate rugose, lacking pseudocyphellae, erhizinate. **Apothecia:** not known. **Pycnidia:** emergent, black, marginal to submarginal, fibrils not conspicuous.

**Chemistry:** Cortex K–; medulla P+ orange-red. Usnic acid in cortex; fumarprotocetraric acid, unknown fatty acid and a violet pigment in medulla.

**Ecology and distribution:** *Microhabitat occupied:* Terricolous. In India, the species growing on soil is distributed in different localities of Sikkim and Uttarakhand. Outside India, the species is also reported from China and Nepal.

**SPECIMENS EXAMINED: INDIA: SIKKIM, NORTH SIKKIM,** Llonakh valley, Muguthang to Naku La track, alt. 4,500 m, on ground, Sinha 1575 (BSHC); **UTTARAKHAND, UTTARKASHI DISTRICT,** Gangotri, Gomukh area, right bank, 3rd and 4th moraine, alt. 3,810 m, on ground, D. D. Awasthi and S. R. Singh 8438 (LWG-AWAS); Gangotri, Bhojwasa, alt. 3,700 m, on soil, S. Chatterjee and P. K. Divakar 02-000205 (LWG).

*Alloctetraria globulans* (Nyl.) A. Thell and Randlane (Fig. 2.2c; Fig. 2.37)

In Daniels and al. (eds) Flechten Follmann: 360. 1995.

Basionym: *Platysma globulans* Nyl., Flora 70: 134. 1887.

**Thallus:** foliose, branched; **lobes:** to 8 mm wide, plane to concave, with narrow secondary lobes; **upper surface:** plane to concave, yellow-brown; **lower surface:** brown with sparse concolorous rhizines; **medulla:** white to yellow. **Apothecia:** to 8 mm in diam.; **spores:** globose to subglobose, 6.5–9 × 5–6.5 µm.

**Chemistry:** Cortex and medulla K–, P–. Usnic acid in cortex; lichesterinic, protolichesterinic acids, with or without secalonic acid A and C in medulla.

**Ecology and distribution:** *Microhabitat occupied:* Terricolous. In India, the species is restricted to Eastern Himalaya and known only from Sikkim. Outside India, the species is also reported from China and Nepal. *Alloctraria globulans* is very close to *A. stracheyi*; the latter is distinguished by pale yellow and convex upper surface, somewhat narrower lobes and medulla yellow ochraceous.

**SPECIMEN EXAMINED: INDIA: SIKKIM, NORTH SIKKIM,** Giagaon, above Thangu, alt. 4,600 m, on soil, D. K. Upreti, S. Chatterjee and P. K. Divakar 04-0044008 (LWG).

*Alloctraria stracheyi* (C. Bab.) Kurok. and M. J. Lai (Fig. 2.2d; Fig. 2.37)

Kurokawa and Lai, Bull. Nat. Sci. Mus. Tokyo, ser. B, 17:62.1991.

**Basionym:** *Evernia stracheyi* C. Bab., Hooker's J. Bot. Kew Gard. Misc. 4:244. 1852.

**Synonyms:** *Cetraria everniella* (Nyl.) Kremp., Verh. K. K. Zool.-Bot. Ges. Wien. 18:315. 1868. *-Cetraria potaninii* Oksner, Zhurn. Bio.-Bot. Tsyklu Vseukräins'k. Akad. Nauk 7-8: 169. 1933. *-Alloctraria potaninii* (Oksner) Randle and Saag, Mycotaxon 44: 492. 1992.

**Thallus:** prostrate to erect, caespitose, to 5 cm tall, branched; **lobes:** to 3 mm wide, sometimes apically almost radially symmetrical; **upper surface:** yellow to brownish, convex; **lower surface:** yellow to brownish, concave, lacunose; **medulla:** white to ochraceous. **Apothecia:** rare, marginal to submarginal, to 10 mm in diam.; **spores:**  $7 \times 4.5 \mu\text{m}$ .

**Chemistry:** Cortex and medulla K-, C-, KC-, P-. Usnic acid in cortex; lich-esterinic, protolichesterinic acids, secalonic acid A and C and pigment endocrocin in medulla.

**Ecology and distribution:** *Microhabitat occupied:* Terricolous; terricolous-rupicolous. In India, the species is widely distributed in Jammu and Kashmir, Sikkim and Uttarakhand while species growing on soil is known from localities of Sikkim and Uttarakhand. The species is also reported from China and Nepal.

**SPECIMENS EXAMINED: INDIA: SIKKIM, NORTH SIKKIM DISTRICT,** Yangdi after Thangu, alt. 4,250 m, on soil over rocks, D. K. Upreti, S. Chatterjee and P. K. Divakar 04-003953 (LWG); Giagaon, above Thangu, alt. 4,600 m, on soil, D. K. Upreti, S. Chatterjee and P. K. Divakar 04-004005 (LWG); **UTTARAKHAND, BAGESHWAR DISTRICT,** Phurkiya, en route Pindari glacier, alt. 3,505 m, on ground among mosses, D. D. Awasthi and A. M. Awasthi 81 (LWG-AWAS); **UTTARKASHI DISTRICT,** Gangotri, Gomukh area, right bank 5th moraine, alt. 3,840 m, on soil, D. D. Awasthi and S. R. Singh 8527 (LWG-AWAS).

**ANAPTYCHIA** Körb. em. Poelt (*Physciaceae*)

Körber, Grundr. Krypt.-Kunde: 197. 1848 em. Poelt, Nova Hedwigia 9: 31. 1965.

**Thallus:** foliose, adnate to ascending into  $\pm$  shrubby form; **lobes:** repeatedly branched, elongate; heteromerous; **upper surface:** grey to grey-brown, corticated by thick walled longitudinally oriented hyphae; **lower surface:** grey-brown, corticated and rhizinate or ecorticated with marginal rhizines; **photobiont:** a green alga; **medulla:** white. **Apothecia:** laminal, lecanorine; **hypothecium:** colourless or yellowish brown; **asci:** eight-spored; **spores:** brown, two-celled, *Physconia*-type.

Out of 11 species known from the world, 3 species are known from India, of which 2 are terricolous.

**Key to the terricolous species of *Anaptychia*:**

- 
- |     |  |                         |
|-----|--|-------------------------|
| 1.  | Lobes more or less adpressed, lobes compact, irregularly branched, 0.4–1 mm wide, not articulate, red brown to dark brown, corticated on both the surfaces ..... | <i>A. pseudoroemeri</i> |
| 1a. | Lobes ascendent apically, not corticated on lower surface, receptacle of apothecium with spinules .....  | <i>A. kaspica</i>       |
- 

***Anaptychia kaspica*** Gyeln. (Fig. 2.2e; Fig. 2.37)

Gyelnik, Ann. Cryptog. Exot. 4: 166. 1931.

Synonym: *Anaptychia ciliaris* var. *angustata* (Tuck.) Zahlbr., fide: Kurokawa 1962: 15.

**Thallus:** repeatedly branched; **lobes:** to 1.5 mm wide; **upper surface:** grey-brown to brown; **lower surface:** pale, canaliculate, ecorticate. **Apothecia:** subterminal, to 4 mm in diam., pruinose, marginally spinulate; **spores:** 30–42(–48) × 12–18(–24) µm.

**Chemistry:** Thallus K–, C–, KC–, P–; no secondary metabolites in TLC.

**Ecology and distribution:** *Microhabitat occupied:* Terricolous-muscicolous; muscicolous-rupicolous. In India, the species growing on soil and restricted to Western Himalaya. It is reported from single locality of Jammu and Kashmir. Outside India, the species is also reported from Iran, Europe and North America.

**SPECIMEN EXAMINED:** **INDIA: JAMMU AND KASHMIR, SRINAGAR DISTRICT,** Shankaracharya hill alt. 1,676 m, over stones and ground among mosses, D. D. Awasthi 2638 A, B, C, D (LWG-AWAS).

***Anaptychia pseudoroemeri*** D. D. Awasthi and S. R. Singh (Fig. 2.2f; Fig. 2.37)

D. Awasthi and S. Singh. Indian J. Forestry 1 (2): 139. 1978.

**Thallus:** in dense tufts; **lobes:** imbricate, ascending, to 1 mm wide; **upper surface:** reddish brown; **medulla:** very thin to insignificant; **lower surface:** pale brown, sparsely rhizinate; thickly prosoplectenchymatously corticated. **Apothecia:** not known.

**Chemistry:** Thallus K–, C–, KC–, P–; no secondary metabolites in TLC.

**Ecology and distribution:** *Microhabitat occupied:* Terricolous. In India, the species is exclusive terricolous and distributed in Jammu and Kashmir (Singh and Sinha 2010) and Uttarakhand. The species is endemic to India. The specimen observed only belongs to Type specimen.

**SPECIMEN EXAMINED:** **INDIA: UTTARAKHAND, UTTARKASHI DISTRICT,** Gangotri, Gomukh area, right bank 5th moraine, alt. 3,840 m, on soil, D. D. Awasthi and S. R. Singh 8501 (Holotype: LWG-AWAS).

**BAEOMYCES** Pers. (*Baeomycetaceae*)

Persoon, Ann. Bot. (Usteri) 1(7): 19. 1794.

**Thallus:** dimorphic; **primary thallus:** crustose, squamulose to subfoliose in rosettes, attached by rhizohyphae, whitish grey to greenish, heteromerous, corticated on upper side; **photobiont:** a green alga; **secondary thallus:** podetiid stipe bearing terminal apothecia; usually corticated. **Apothecia:** biatorine; **disc:** red-brown

to dark brown, eventually contorted undulate; **asci**: not amyloid at apex, with  $\pm$  concave tholus, eight-spored; **spores**: colourless, simple, 2(–4)-celled, thin walled.

Out of about 9 species known from the world, 2 terricolous species are known from India.

**Key to the terricolous species of *Baeomyces*:**

1.	Primary thallus squamulose, lobed at periphery; podetioid stipes corticated .....	<i>B. pachypus</i>
1a.	Primary thallus granulose-verrucose and sorediate .....	<i>B. soreidiifer</i>

***Baeomyces pachypus*** Nyl. (Fig. 2.3a; Fig. 2.38)

Nylander, Syn. Lich. 1(2):182. 1860.

**Primary thallus:** squamulose, yellowish grey, lobed at periphery, lacking soredia; **podetia:** to 12 mm tall, 4 mm in diam. at base, grey, simple, cylindrical to compressed, corticated, often furrowed in upper part. **Apothecia:** brown black, terminal, glomerulose, 3–4 confluent, to 4 mm in diam.; **disc:** K–, convex; **epithecium:** 9–13  $\mu$ m; **hymenium:** 80–165  $\mu$ m, I+ blue; **spores:** 7–12(–26)  $\times$  3–7  $\mu$ m. **Schizidia:** formed in primary thallus.

**Chemistry:** Primary thallus and podetioid stipes K+ yellow, C–, P+ yellow or P–. Stictic acid and an undetermined substance present or absent.

**Ecology and Distribution:** *Microhabitat occupied:* Terricolous. In India, the species is exclusively terricolous and exhibits its restricted distribution to Eastern Himalayas and known only from Sikkim and West Bengal hills. Outside India, the species is also reported from Nepal.

**SPECIMENS EXAMINED:** INDIA: SIKKIM, RATHONG GLACIER, on soil, Bose 60–147 (LWG-AWAS); WEST BENGAL, DARJEELING DISTRICT, near Sandakhpoo, alt. 3,510 m, on soil by roadside, Awasthi and Agarwal 67–360 (LWG-LWU); on way from Sandakhpoo to Phalut, alt. 3,600 m, on ground by roadside, Awasthi and Agarwal 67–473 (LWG-LWU); near Tonglu, on hard soil, Awasthi 107 (LWG-AWAS); Batasi to Palmajua, alt. 1,800 m, on soil, Bose 60–58 (LWG-AWAS).

***Baeomyces soreidiifer*** Nyl. (Fig. 2.3b; Fig. 2.38)

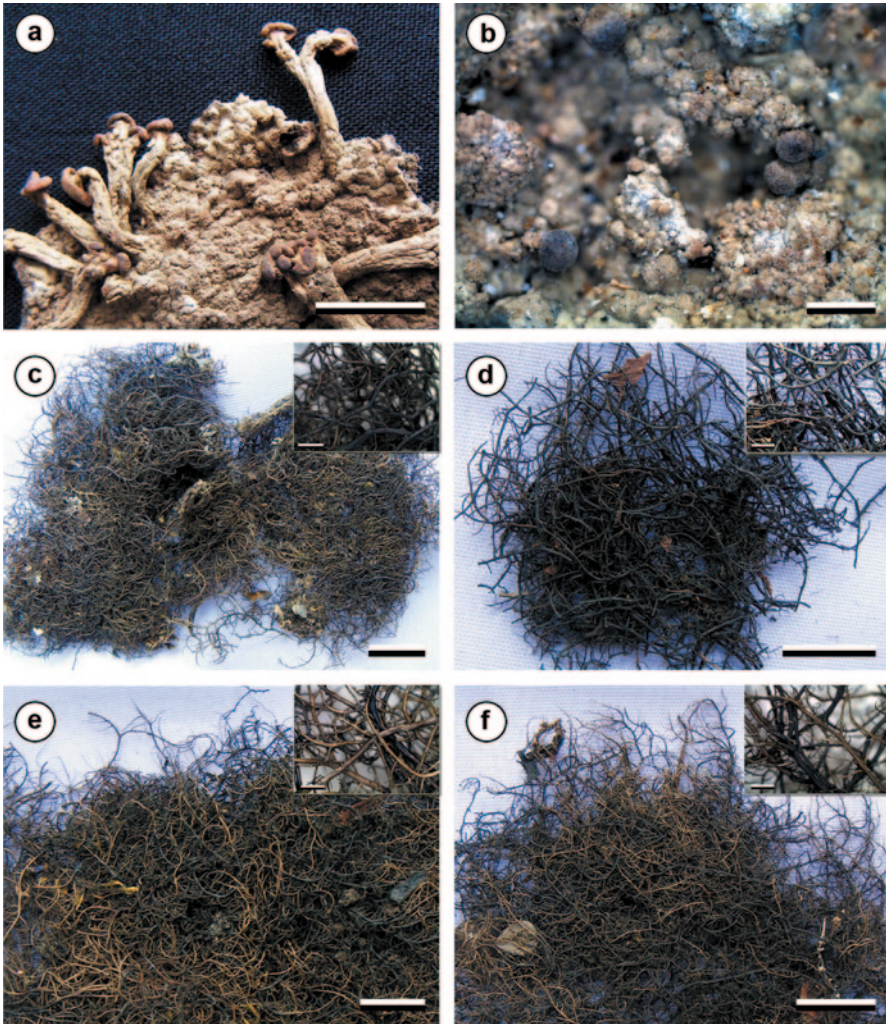
Nylander, Acta Soc. Sci. Fenn. 26(10): 5.1900.

**Primary thallus:** on soil or on soft sandy stones, crustose to verrucose, sorediate; **soredia:** granular, marginal or laminal; **podetia:** to 1.5 mm tall, 1 mm in diam., grey, simple, cylindrical, opaque, ecorticated. **Apothecia:** flesh coloured to brownish, peltate, less than 0.5 mm in diam.; **disc:** convex, K+ yellow; **epithecium:** 7–13  $\mu$ m; **hymenium:** 40–100  $\mu$ m; **asci:** immature.

**Chemistry:** Primary thallus and podetioid stipes K+ yellow, C–, P+ yellow. Baeomycesic and stictic acids and an unknown substance present.

**Ecology and Distribution:** *Microhabitat occupied:* Terricolous. In India, the species is exclusively terricolous and exhibits its restricted distribution to Eastern Ghats and Deccan Plateau and known only from Tamil Nadu. Outside India, it is also reported from Sri Lanka.

**SPECIMEN EXAMINED:** INDIA: TAMIL NADU, MADURAI DISTRICT, Shambaganur, below S. H. College, along old ghat road, alt. 1,710–1,800 m, on soft sandy stone, Awasthi 4379 (LWG-AWAS).



**Fig. 2.3** **a** *Baeomyces pachypus* Nyl., **b** *B. sorediifer* Nyl., **c** *Bryoria asiatica* (Du Rietz) Brodo and D. Hawksw., **d** *B. bicolor* (Ehrh.) Brodo and D. Hawksw., **e** *B. confusa* (D. D. Awasthi) Brodo and D. Hawksw., **f** *B. himalayana* (Mot.) Brodo and D. Hawksw. Scale in **b**=0.5 mm, in **a, c, d, e, f**=10 mm; inset images, scale 1 mm

### **BRYORIA** Brodo and D. Hawksw. (*Parmeliaceae*)

Brodo and Hawksworth, *Opera Bot.* 42: 78. 1977.

**Thallus:** fruticose, erect caespitose to decumbent or pendulous, grey, grey-brown to brown-black, dichotomously to irregularly branched; **branches:** cylindrical, tapering, with or without lateral spinules, isidia, soredia and pseudocyphellae; **photo-biont:** a green alga; **medulla:** white. Thallus heteromerous, corticated. **Apothecia:** lateral to geniculate, lecanorine; **disc:** reddish brown to dark brown; **paraphyses:** anastomosing; **asci:** arrested bitunicate, eight-spored; **spores:** hyaline, simple.

Out of 81 species known from world, 11 species are known from India, of which 8 terricolous.

**Key to the terricolous species of *Bryoria*:**

1.	Thallus sorediate, soralia often with tufts of isidioid spinules.....	2
1a.	Thallus lacking soredia .....	3
2.	Medulla P+ yellow to orange-red, thallus pale yellow to brown, soralia occasionally broader than the branch.....	<i>B. implexa</i>
2a.	Medulla P-, soralia white, thallus erect, main branches ca. 1 mm in diam., sterile.....	<i>B. smithii</i>
3.	Medulla P+ orange-red .....	4
3a.	Medulla P-.....	5
4.	Thallus erect, up to 5(-8) cm tall.....	<i>B. bicolor</i>
4a.	Thallus pendulous, more than 10 cm long.....	<i>B. himalayana</i>
5.	Thallus pseudocypheolate.....	6
5a.	Thallus lacking pseudocypheolate.....	7
6.	Thallus erect, dark brown to black, main branches ca. 0.3 mm in diam., sterile.....	<i>B. tenuis</i>
6a.	Thallus pendulous, greenish brown, main branches ca. 0.7 mm in diam., fertile.....	<i>B. nepalensis</i>
7.	Thallus erect to decumbent, brown-black, with longitudinal depressions on surface.....	<i>B. confusa</i>
7a.	Thallus elongate, pendulous, brown-black, lacking longitudinal depressions on surface, smooth.....	<i>B. asiatica</i>

***Bryoria asiatica*** (Du Rietz) Brodo and D. Hawksw. (Fig. 2.3c; Fig. 2.38)

Brodo and Hawksworth, Opera Bot. 42: 155. 1977.

Basionym: *Alectoria asiatica* Du Rietz, Ark. Bot. 20A (II): 11.1926.

**Thallus:** pendulous, to 35 cm long; **main branch:** ca. 0.5 mm in diam., flexuose; **lateral spinules:** present; pseudocypheolate, isidia and soralia absent. **Apothecia:** not known.

**Chemistry:** Thallus K-, C-, KC-, P-; no secondary metabolites in TLC.

**Ecology and Distribution:** *Microhabitat occupied:* Terricolous. In India, the species distributed in Himalayas (Singh and Sinha 2010) while the species growing on soil is reported from different localities of Arunachal Pradesh and Uttarakhand. Outside India, the species is also reported from China.

**SPECIMENS EXAMINED: INDIA: ARUNACHAL PRADESH, WEST KAMENG DISTRICT,** Sela Pass, alt. 4,221 m, on soil, D. K. Upreti, U. Dubey, R. Khare and G. Mishra 04-009739 (LWG); **UTTARAKHAND, CHAMOLI DISTRICT,** on way from Mana to Vasudhara falls, alt. 3,340 m, on soil, D. K. Upreti and S. Nayaka 08-010935 (LWG).

***Bryoria bicolor*** (Ehrh.) Brodo and D. Hawksw. (Fig. 2.3d; Fig. 2.38)

Brodo and Hawksworth, Opera Bot. 42: 99. 1977.

Basionym: *Lichen bicolor* Ehrh., Beit. Naturk.3: 82. 1788.

Synonym: *Alectoria bicolor* (Ehrh.) Nyl., Actes Soc. Linn. Bordeaux 21: 291. 1856.

**Thallus:** erect, caespitose, 2-4(-7) cm tall, black in lower part and pale brown in upper part, branched, branching dichotomous to anisotomic dichotomous, di-

vergent; **lateral spinules**: perpendicular on branches; **pseudocyphellae**: slit like, sparse, distinct towards apices. Isidia, soredia, pycnidia and apothecia absent.

**Chemistry**: Medulla K<sup>-</sup>, P<sup>+</sup> red, at least in parts. Fumarprotocetraric acid present.

**Ecology and Distribution**: *Microhabitat occupied*: Detriticolous-terricolous. In India, the species is distributed in Sikkim, Uttarakhand and West Bengal hills while the species growing on soil is known from single locality of Sikkim. Outside India, the species is also reported from Nepal and widely distributed in Northern Hemisphere. *Bryoria bicolor* is close to *B. nitidula*, but differs in pale brown colour in upper branches. *B. tenuis* is also close, but lacks fumarprotocetraric acid in medulla.

**SPECIMEN EXAMINED**: **INDIA**: **SIKKIM, WEST SIKKIM, JONGRI**, alt. 3,352 m, on decaying pinus needles over soil, alt. 3,962 m, M. N. Bose 6333 (LWG-AWAS).

*Bryoria confusa* (D. D. Awasthi) Brodo and D. Hawksw. (Fig. 2.3e; Fig. 2.38)

Brodo and Hawksworth. Opera Bot. 42: 155. 1977.

Basionym: *Alectoria confusa* D. D. Awasthi, Proc. Indian Acad. Sci., B, 72: 152. 1970.

**Thallus**: fruticose, erect to procumbent, to 10 cm long, branched, dark brown to black at base, pale brown towards apices; **main branch**: 1(–1.2) mm in diameter; **lateral spinules**: present; **thallus surface**: with narrow depressions (medulla not exposed); isidia, soredia and pseudocyphellae absent. **Apothecia**: absent.

**Chemistry**: Thallus K<sup>-</sup>, C<sup>-</sup>, KC<sup>-</sup>, P<sup>-</sup>; no secondary metabolites in TLC.

**Ecology and distribution**: *Microhabitat occupied*: Terricolous; muscicolous-rupicolous; terricolous-rupicolous. In India, the species is widely distributed in Arunachal Pradesh, Himachal Pradesh, Sikkim, Uttarakhand and West Bengal hills while species growing on soil is known from different localities of Arunachal Pradesh, Sikkim and Uttarakhand. Outside India, the species is also reported from China and Nepal.

**SPECIMENS EXAMINED**: **INDIA**: **ARUNACHAL PRADESH, WEST KAMENG DISTRICT**, Tawang, alt. 4,145 m, on soil, Ashish Kar 04-009739 (LWG); **SIKKIM, NORTH SIKKIM**, Yangdi, above Thangu, alt. 4,250 m, on soil, D. K. Upreti, S. Chatterjee and P. K. Divakar 04-003958, 04-003960 (LWG); Kalep before Thangu, alt. 3,900 m, on soil over rocks, D. K. Upreti, S. Chatterjee and P. K. Divakar 04-003874 (LWG); Singhbo Rhododendron Sanctuary, near Yumthang, alt. 3,500 m, on soil, D. K. Upreti, S. Chatterjee and P. K. Divakar 04-004121 (LWG); Chubuk, above Thangu, alt. 4,100 m, on rocks over soil among mosses, D. K. Upreti, S. Chatterjee and P. K. Divakar 04-003913 (LWG); **UTTARAKHAND, RUDRAPRAYAG DISTRICT**, Chopta, en route from Chopta to Tungnath, alt. 3,000 m, on soil over rock on mosses, Himanshu Rai and Pramod Nag 08-0012227 (LWG).

*Bryoria himalayana* (Mot.) Brodo and D. Hawksw. (Fig. 2.3f; Fig. 2.38)

Brodo and Hawksworth, Opera Bot. 42: 155. 1977.

Basionym: *Alectoria himalayana* Motyka, Fragm. Florist. Geobot. 6: 450. 1960.

**Thallus**: pendulous, to 20 cm long, grey-brown to black, branched; **main branch**: to 0.8 mm in diam.; **lateral spinules**: present, sparse; **pseudocyphellae**: narrow, streak-like; isidia and soredia absent. **Apothecia**: not known.

**Chemistry**: Medulla K<sup>-</sup>, C<sup>-</sup>, KC<sup>-</sup>, P<sup>+</sup> orange-red. Fumarprotocetraric acid and an unknown substance present.



**Ecology and distribution:** *Microhabitat occupied:* Terricolous. In India, the species is distributed in Himachal Pradesh, Nagaland, Sikkim and West Bengal hills while the species growing on soil reported from single locality of Sikkim. The species seems to be endemic in the Himalayas. Outside India, the species is also reported from Bhutan and Nepal.

**SPECIMEN EXAMINED:** **INDIA: SIKKIM, NORTH SIKKIM,** 2 km before, near Yumthang, Singhbo Rhododendron Sanctuary, alt. 3,300 m, on soil, D. K. Upreti, S. Chatterjee and P. K. Divakar 04-004071 (LWG).

*Bryoria implexa* (Hoffm.) Brodo and D. Hawksw. (Fig. 2.4a; Fig. 2.38)

Brodo and Hawksworth, Opera Bot. 42: 121. 1977.

Basionym: *Usnea implexa* Hoffm., Deutschl. Fl. 2: 134. 1796.—*Alectoria implexa* (Hoffm.) Nyl., Lich. Scand.: 72. 186 l.

Synonym: *Alectoria catharinae* Räsänen, Lich. Fenn. Exs. No. 729. 1943.

**Thallus:** erect to pendent, to 6 cm long, pale brown to dark brown, branched; **main branch:** 0.3 mm in diam., lateral spinules present; **soralia:** fissural, elongate slit-like, sometimes broader than the branch; **pseudocyphellae:** absent. **Apothecia:** not known.

**Chemistry:** Medulla K<sup>-</sup>, C<sup>-</sup>, P<sup>+</sup> yellow. Psoromic and thamnolic acids present.

**Ecology and distribution:** *Microhabitat occupied:* Terricolous. In India, the species is exclusively terricolous and distributed in different localities of Sikkim and Uttarakhand. Outside India, the species is also reported from China and Nepal, Europe and North America.

**SPECIMENS EXAMINED:** **INDIA: SIKKIM, NORTH SIKKIM,** Above Lachen, alt. 3,000 m, on soil, D. K. Upreti, S. Chatterjee and P. K. Divakar 04-003827 (LWG); **UTTARAKHAND, UTTARAKASHI DISTRICT,** Gomukh area, right bank, 5th moraine, alt. 3,840 m, on soil, D. D. Awasthi and S. R. Singh 8531 B (LWG-AWAS).

*Bryoria nepalensis* D. D. Awasthi (Fig. 2.4b; Fig. 2.38)

In G. Awasthi and D. Awasthi, Candollea 40: 312. 1985.

**Thallus:** pendulous, to 15 cm long, black near base and brown upwards, branched; **main branch:** to 0.7 mm in diam.; **lateral spinules:** rarely present; **pseudocyphellae:** slit-like, narrow, elongate; isidia and soredia absent. **Apothecia:** lateral, 1 mm in diam.; **spores:** 6–8 × 4 μm.

**Chemistry:** Thallus K<sup>-</sup>, C<sup>-</sup>, KC<sup>-</sup>, P<sup>-</sup>; no secondary metabolites in TLC.

**Ecology and distribution:** *Microhabitat occupied:* Terricolous. Earlier the species was only known from type locality in Nepal and for the first time it is reported outside the type locality. It is a new record for Indian lichen flora and known only from Sikkim. The species is endemic to Himalayas (Awasthi, 2007).

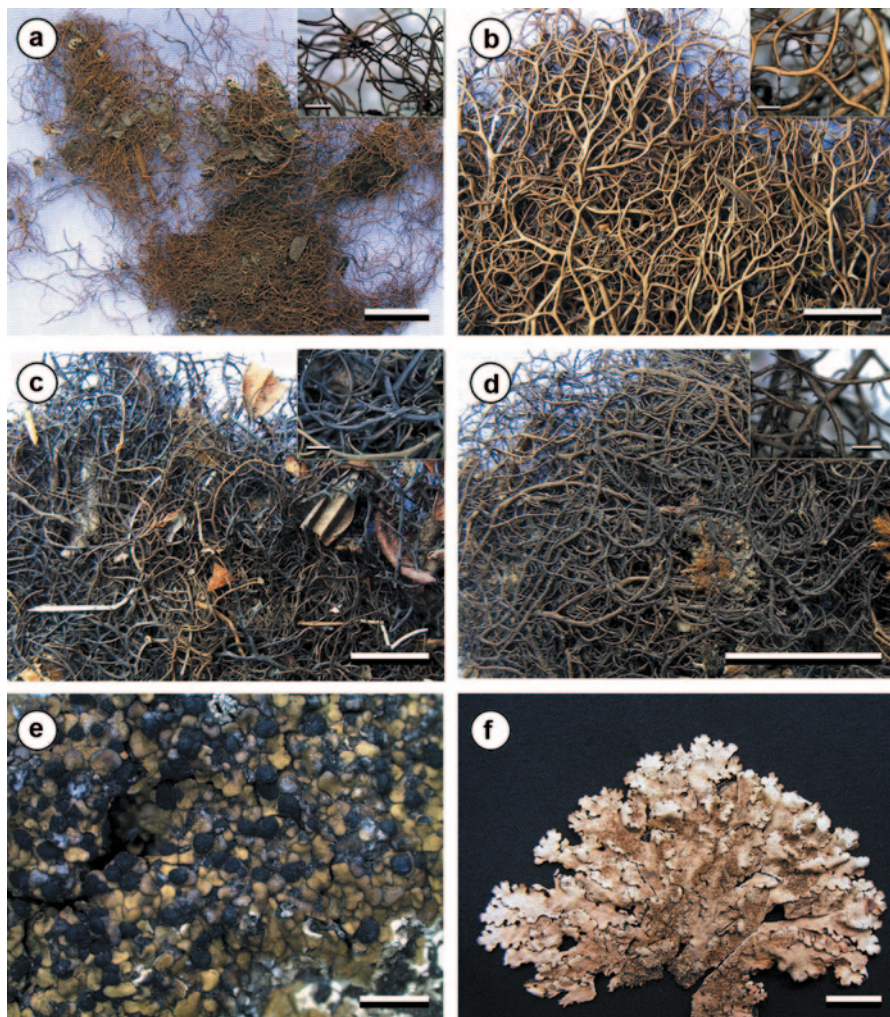
**SPECIMEN EXAMINED:** **INDIA: SIKKIM, NORTH SIKKIM,** Above Lachen, alt. 3,000 m, on soil, D. K. Upreti, S. Chatterjee and P. K. Divakar 04-003778, 003827 (LWG).

*Bryoria smithii* (Du Rietz) Brodo and D. Hawksw. (Fig. 2.4c; Fig. 2.38)

Brodo and Hawksworth, Opera Bot. 42: 152. 1977.

Basionym: *Alectoria smithii* Du Rietz, Ark. Bot. 20A (11): 15. 1926.

**Thallus:** erect, to 7 cm tall, blackish brown to black at base, paler upwards, branched; **main branch:** to 1 mm in diam.; **lateral spinules:** present; **pseudocy-**



**Fig. 2.4** **a** *Bryoria implexa* (Hoffm.) Brodo and D. Hawksw., **b** *B. nepalensis* D. D. Awasthi, **c** *B. smithii* (Du Rietz) Brodo and D. Hawksw., **d** *B. tenuis* (A. E. Dahl) Brodo and D. Hawksw., **e** *Buellia asterella* Poelt and Sulzer, **f** *Bulbothrix isidiza* (Nyl.) Hale. Scale in **e**=2 mm, in **a, b, c, d, f**=10 mm; inset images, scale 1 mm

**phellae:** as cracks in cortex; **soralia:** cupuliform,  $\pm$  elongate, narrower than the branch, with tufts of isidioid spinules in mature condition. **Apothecia:** absent.

**Chemistry:** Cortex, medulla and soralia K<sup>-</sup>, C<sup>-</sup>, KC<sup>-</sup>, P<sup>-</sup>; no secondary metabolites in TLC.

**Ecology and distribution:** *Microhabitat occupied:* Terricolous in higher altitudes of Himalayas. In India, the species is widely distributed in Himachal Pradesh, Uttarakhand and West Bengal hills while species growing on soil is known from different localities of Uttarakhand and West Bengal hills. Outside India, the spe-

cies is also reported from Bhutan, China, Hawaiian Islands, Malaysia and Nepal; Europe. *Bryoria smithii* though typically corticolous has been found to be terricolous at higher altitudes in the Himalayas. It is close to *B. variabilis*, but the latter is distinguished by pendulous habit of thallus, soralia turning brown-black later and presence of apothecia. *B. furcellata* and *B. poeltii* are subsimilar to *B. smithii* in general habit of thallus, but are distinguished by presence of fumarprotocetraric acid in medulla.

**SPECIMENS EXAMINED:** **INDIA:** **UTTARAKHAND, CHAMOLI DISTRICT,** Nanda Devi Biosphere Reserve, Srenikhal, alt. 3,700 m, on soil, S. Rawat and D. Rawat 08-010935 (LWG); **UTTARKASHI DISTRICT,** Gomukh area, right bank, 6th moraine, alt. 3,800 m, on ground, D. D. Awasthi and S. R. Singh 8589, 8594 (LWG-AWAS); 5th moraine, alt. 3,840 m, on soil, D. D. Awasthi and S. R. Singh 8531A (LWG-AWAS); **WEST BENGAL, DARJEELING DISTRICT,** Tiger Hill, Senchal lake area, alt. 2,438 m, on ground, D. D. Awasthi 64.129 (LWG-AWAS).

*Bryoria tenuis* (E. Dahl) Brodo and D. Hawksw. (Fig. 2.4d; Fig. 2.38)

Brodo and Hawksworth, Opera Bot.42: 112. 1977.

Basionym: *Alectoria tenuis* E. Dahl, Meddl. Groenl. 150(2): 144. 1950.

**Thallus:** mossy rocks, erect to decumbent, to 8 cm long, often dying at base, dark brown to black in basal region, paler brown towards apices, branched; **main branch:** to 0.5 mm in diam.; **lateral spinules:** present; **pseudocypbellae:** fissural, usually dark; isidia, soredia and isidioid spinules absent. **Apothecia:** not observed.

**Chemistry:** Cortex and medulla K-, C-, KC-, P-; no secondary metabolites in TLC. Brodo and Hawksworth (1977, p. 112) reported medulla P+ red in American specimens.

**Ecology and distribution:** *Microhabitat occupied:* Terricolous. In India, the species is widely distributed in Sikkim, Uttarakhand and West Bengal hills while species growing on soil is known from different localities of Uttarakhand and West Bengal hills. The species is widely distributed in boreal and arctic regions of Europe and North America.

**SPECIMENS EXAMINED:** **INDIA:** **UTTARAKHAND, UTTARKASHI DISTRICT,** Gomukh area, right bank, 6th moraine, alt. 3,800 m, on ground, D. D. Awasthi and S. R. Singh 8593 (LWG-AWAS); **WEST BENGAL, DARJEELING DISTRICT,** on way from Batasi to Palmajua, alt. 2,400 m, on ground, M. N. Bose 60.71 (LWG-AWAS).

**BUELLIA** De Not. (*Caliciaceae*)

Giorn. Bot. Ital. 2(1, 1): 195. 1846.

**Thallus:** crustose, smooth to granulose-verrucose, rimose-areolate or truly areolate, hypothallus rarely present; **photobiont:** *Trebouxia*. **Apothecia:** dark brown to black, round, rarely irregular in outline, sessile, adnate to immersed, lecidine; **exciple:** indistinctly or distinctly cellular; **epihymenium:** brown to olive-brown; **hymenium:** with or without oil globules; **hypothecium:** brown; **paraphyses:** septate, simple to apically branched, capitate, brownish black at apices, conglutinate; **asci:** usually eight-spored; **spores:** pale brown to dark-brown, one-septate to submuriform, wall uniformly thickened or unevenly thickened (mischoblastiomorphic or placodiomorphic), surface smooth or ornamented.

Out of 455 species known from the world, 41 species are known from India, of which 1 is terricolous.

***Buellia asterella*** Poelt and Sulzer (Fig. 2.4e; Fig. 2.38)

Poelt and Sulzer, *Nova Hedwigia* 25(1–2): 182. 1974.

**Thallus:** white, matt, containing numerous crystals; **lobes:** short, marginal, to 2 mm long and 0.4–1 mm wide, forming rosettes when young but often becoming irregular and fragmented when older; **medulla:** I–. **Apothecia:** 0.4–0.8 mm diam., at first immersed with a thalline collar, later superficial; **disc:** flat to strongly convex, ± pruinose when young; **true exciple:** narrow or excluded; **hymenium:** 50–70 µm tall, without oil droplets; **asci:** four-spored, (rarely more); **spores:** 10–17 × 5–8 µm, one-septate, finely warted, apices rounded.

**Chemistry:** Thallus P+ yellow-orange or -, K+ yellowish red or K-, C- (± norstictic acid)

**Ecology and distribution:** *Microhabitat occupied:* Terricolous. Earlier the species is reported from England, Norway, France, Germany, and Switzerland. In the present study, the species extends its distribution to India and known only from Uttarakhand, found to be growing on soil at an altitude of 3,304 m. It is a new record for lichen flora of India.

**SPECIMEN EXAMINED:** **INDIA:** UTTARAKHAND, CHAMOLI DISTRICT, near Badrinath, on way from Mana to Vasudhara, alt. 3,304 m, on soil, D. K. Upreti and S. Nayaka 07-010151 (LWG).

**BULBOTHRIX** Hale (*Parmeliaceae*)

Hale, *Phytologia* 28: 480. 1974.

**Thallus:** foliose, closely adnate, irregularly lobate; **lobe:** margins with bulbate cilia; **upper surface:** grey; **lower surface:** pale brown to black with simple or dichotomously branched rhizines; **photobiont:** a green alga; **medulla:** usually white. Thallus heteromerous, corticated on both surfaces. **Apothecia:** laminal, lecanorine, imperforate; **asci:** 8-spored; **spores:** colourless, simple. Atranorin always present in upper cortex.

Out of 45 species known from the world, 7 species are known from India, of which 2 are terricolous.

**Key to the terricolous species of *Bulbothrix*:**

- 
- |     |   |                      |
|-----|---|----------------------|
| 1.  | Thallus isidiate, isidia simple to coralloid branched, lower surface pale brown to brown..... | <i>B. isidiza</i>    |
| 1a. | Thallus not isidiate, lobes subrotund, lower surface jet black, marginal zone brown.....      | <i>B. meizospora</i> |
- 

***Bulbothrix isidiza*** (Nyl.) Hale (Fig. 2.4f; Fig. 2.38)

Hale, *Phytologia* 28: 480. 1974.

Basionym: *Parmelia isidiza* Nyl. in Henriques, *Bol. Soc. Brot. Coimbra Lichenes* 3: 130. 1884.

**Thallus:** closely to loosely adnate, to 8 cm across; **lobes:** to 8 mm wide, sparse, bulbate cilia along margins; lobe margins densely to sparsely ciliate; **cilia:** bulbate, 0.5–1 mm long; **upper surface:** mineral grey to lightly brownish, sometimes faintly maculate, isidiate; **isidia:** dense, laminal, cylindrical, simple to rarely coralloid branched, tips brown; **medulla:** white; **lower surface:** pale brown to

brown, rhizinate; **rhizines**: short, simple, brown to black. **Apothecia**: common, adnate, to 4 mm in diameter; **disc**: dark brown; **asci**: clavate, 8-spored; **spores**: 9–14(–19) × 6–8 μm. **Pycnidia**: absent.

**Chemistry**: Cortex K<sup>+</sup> yellow; medulla: K<sup>+</sup> yellow turning red, C<sup>-</sup>, KC<sup>-</sup>, P<sup>+</sup> orange-red; Atranorin and salazinic acid present.

**Ecology and distribution**: *Microhabitat occupied*: Terricolous; terricolous-rupicolous. In India, the species is widely distributed in tropical, subtropical and subtemperate zones of Arunachal Pradesh, Karnataka, Kerala, Madhya Pradesh, Manipur, Meghalaya, Maharashtra, Nagaland, Sikkim, Tamil Nadu, Uttar Pradesh, Uttarakhand and West Bengal foot hills while the species growing on soil is known from different localities of Meghalaya and Sikkim. The species is pantropical in distribution and reported from Australia, China, Japan, Nepal, Papua New Guinea, Brazil, Indonesia, Kenya, Mexico, Philippines, Central and South America; South Africa, Tanzania, Taiwan and Nepal.

**SPECIMENS EXAMINED**: **INDIA**: **MEGHALAYA**, SHILLONG, near Mawlai in Pinus forest, alt. 1,500 m, on hard soil, D. D. Awasthi 7906 B (LWG-AWAS); **SIKKIM**, **SOUTH SIKKIM**, Namchi, 10 km towards Jorhang, alt. 1,200 m, on rock over soil, Upreti and Chatterjee 219550 (LWG).

***Bulbothrix meizospora* (Nyl.) Hale (Fig. 2.5a; Fig. 2.39)**

Hale, Phytologia 28: 480. 1974.

Basionym: *Parmelia tiliacea* var. *meizospora* Nyl., Syn. Lich.l: 383. 1860.

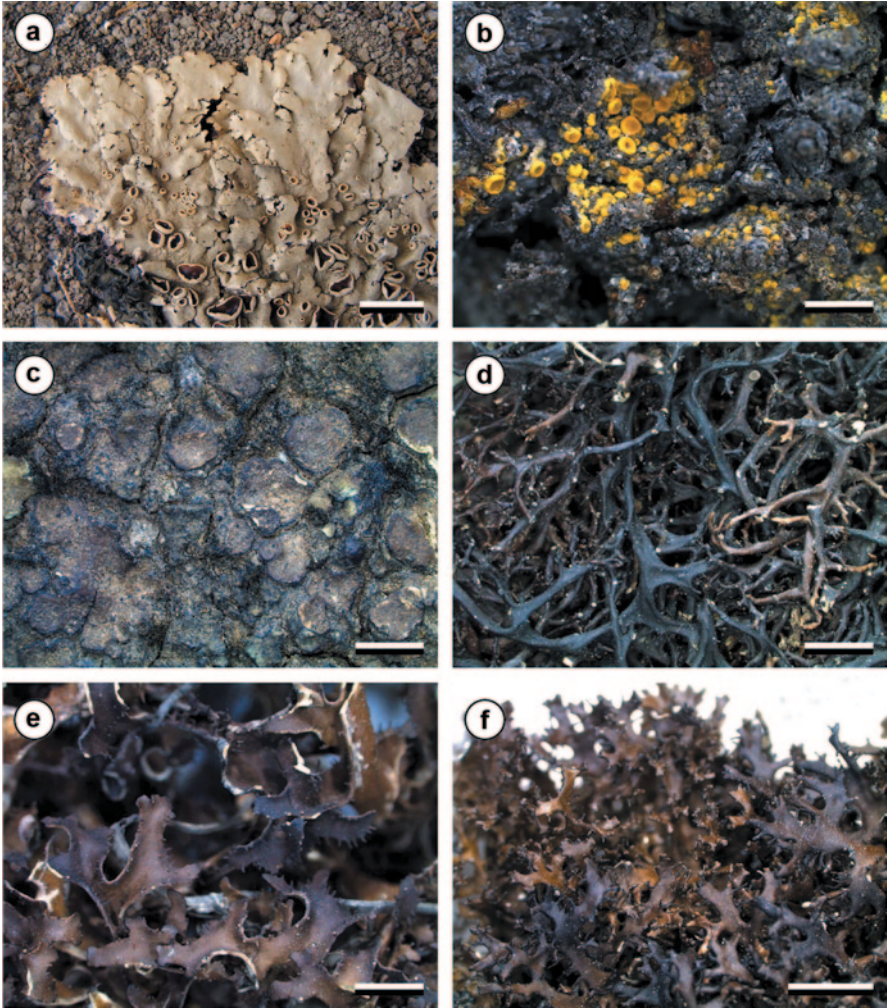
Synonyms: *Parmelia meizospora* (Nyl.) Nyl., Flora 52: 292. 1869.

**Thallus**: foliose, closely adnate to the substratum, to 12 cm across; **lobes**: subdichotomously branched, to 5(–8) mm wide, bulbate cilia mostly in axils; **cilia**: bulbate, mostly in notches, simple to furcated at apices; **upper surface**: ashy grey to dark grey, plane, sometimes wrinkled rugose, faintly maculate or emaculate; isidia and soredia absent; **medulla**: usually white; **lower surface**: black, with narrow papillate marginal zone, densely rhizinate; **rhizines**: simple, brown black to black. **Apothecia**: numerous, to 10 mm in diam.; **disc**: concave, brown, imperforate; **margins**: inflexed; **asci**: cylindrical to clavate, 8-spored; **spores**: 12–20 × (6–) 8–12 μm. **Pycnidia**: immersed, confine to peripheral zone of lobes, black; **conidia**: colourless, weakly bifusiform.

**Chemistry**: K<sup>+</sup> yellow; medulla K<sup>+</sup> yellow turning red, C<sup>-</sup>, KC<sup>-</sup>, P<sup>+</sup> orange-red. Atranorin and salazinic acid present.

**Ecology and distribution**: *Microhabitat occupied*: Terricolous; terricolous-rupicolous. In India, the species is widely distributed in the regions of Arunachal Pradesh, Himachal Pradesh, Meghalaya, Nagaland, Sikkim, Tamil Nadu and Uttarakhand while the species growing on soil is reported from Himachal Pradesh and Uttarakhand. This is an Asian species and known only from Africa, India, Nepal and Pakistan.

**SPECIMENS EXAMINED**: **INDIA**: **HIMACHAL PRADESH**, SHIMLA DISTRICT, alt. 2,100 m, on soil, P. Chandra s.n. (LWG); **UTTARAKHAND**, ALMORA DISTRICT, 1 km before Loharkhet, alt. 1,676 m, on stone over soil, D. D. Awasthi 533 (LWG); **DEHRADUN DISTRICT**, Mussoorie, Landour, along the road between Kellogg Church and GB Hospital, alt. 2,019 m, on rock and ground, O. A. Höeg 1441 (LWG-AWAS).



**Fig. 2.5** **a** *Bulbothrix meizospora* (Nyl.) Hale, **b** *Candelariella grimmiae* Poelt and Reddi, **c** *Catsbyrenium cinereum* (Pers.) Körb., **d** *Cetraria aculeata* (Schreb.) Fr., **e** *C. islandica* (L) Ach., **f** *C. laevigata* Rass. Scale in **b**=1 mm, in **c, d, e, f**=2 mm, in **a**=10 mm

### CANDELARIELLA Müll. Arg. (*Candelariaceae*)

Bull. Herb. Boissier 2, appendix 1, p. 11. 1894.

**Thallus:** crustose, squamulose or effigurate-lobate; **upper surface:** grey-white to yellow, K<sup>-</sup>, corticated; **lower surface:** erhizinate; **photobiont:** protococcoid green alga. **Apothecia:** sessile, K<sup>-</sup>, lecanorine; **hypothecium:** colourless, with algal cells below it; **paraphyses:** simple or apically branched; **asci:** 8-many spored; **spores:** colourless, simple or rarely 1-septate, thin walled.

Out of 48 species known from the world, 3 species are known from India, of which 1 is terricolous.

***Candelariella grimmiae*** Poelt and Reddi (Fig. 2.5b; Fig. 2.39)

Poelt and Reddi, *Khumbu Himal* 6(1): 7. 1969.

**Thallus:** squamulose, distinctly effigurate; **marginal squamules:** 0.7–1.0 mm long and 0.1–0.4 mm wide; **upper surface:** yellow to reddish yellow. **Apothecia:** 1–1.5 mm in diameter, when mature often lobed; **hymenium:** 55–60  $\mu\text{m}$  high; **spores:** 15–18.5  $\times$  5–6.5  $\mu\text{m}$ .

**Chemistry:** K+ yellow; medulla K+ yellow turning red, C–, KC–, P+ orange-red. Atranorin and salazinic acid present.

**Ecology and distribution:** *Microhabitat occupied:* Terricolous. In India, the species is exclusively terricolous and exhibits restricted distribution to Jammu and Kashmir and Sikkim. The species is also reported from Nepal and North America.

**SPECIMENS EXAMINED:** **INDIA:** JAMMU AND KASHMIR, LEH DISTRICT, Ganglas area, alt. 4,000 m, on soil, D. K. Upreti and S. Chatterjee 03-001822 (LWG); **SIKKIM, NORTH SIKKIM,** Giagaon, above Thangu, alt. 4,600 m, on soil among mosses, D. K. Upreti, S. Chatterjee and P. K. Divakar 04-00399 (LWG).

**CATAPYRENIUM** Flot. (*Verrucariaceae*)

*Bot. Zeitung* 8: 361. 1850 em. O. Breuss, *Stapfia* 23: 34. 1990.

**Thallus:** crustose to squamulose; **squamules:** scattered, contiguous or imbricate, loosely or closely attached, rounded, lobed or finely incised, corticate above, with or without a lower cortex, anchored by a mat of rhizohyphae; **photobiont:** a green alga. **Perithecia:** immersed in the thallus, broadly pyriform to subglobose, to 0.3 mm diameter, without an involucrellum; **peridium:** pale or darker composed of rectangular cells; **paraphyses:** absent; **periphyses:** extending into perithecial cavity; **asci:** clavate, 8-spored; **spores:** biseriolate, simple, colourless. **Pycnoconidia:** short, cylindrical.

Out of 60 species known from the world, 1 exclusively terricolous species is known from India.

***Catapyrenium cinereum*** (Pers.) Korb. (Fig. 2.5c; Fig. 2.39)

Korber, *Syst. Lich. Germ.*: 325. 1855.

Basionym: *Endocarpon cinereum* Pers., *Ann. Bot. (Usteri)* 1: 28. 1794.

Synonyms: *Endocarpon hepaticum* Ach., *Kongl. Vetensk. Acad. Nya Handl.* 1809: 156. 1809. -*Dermatocarpon cinereum* (Pers.) Th. Fr., *Nova Acta Reg. Soc. Sci. Upsal.*, ser. 3, 3: 355. 1861.

**Thallus:** squamulose; **squamules:** small,  $\pm$  densely aggregated, up to 0.3 mm thick, closely appressed, finely incised, especially at the periphery, sometimes subgranular in central parts of the thallus, usually whitish pruinose, often with a darker margin; **lower cortex:** paraplectenchymatous, blackish; **hypothallus:** blackish, spongy, of intricate, rhizoidal hyphae. **Perithecia:** numerous, immersed in the thallus, ostioles sometimes slightly elevated; **true exciple:** pale when young, soon becoming brown or blackish through out; **asci:** clavate, 8-spored; **spores:** 17–23  $\times$  7–8  $\mu\text{m}$ , biseriolate.

**Chemistry:** Thallus K<sup>-</sup>, C<sup>-</sup>, KC<sup>-</sup>, P<sup>-</sup>; no secondary metabolites in TLC.

**Ecology and distribution:** *Microhabitat occupied:* Terricolous. In India, the species is exclusively terricolous, restricted its distribution to Central India and known from region of Maharashtra. It is also reported from Australia, Japan, Nepal and New Zealand; Africa, Europe, North and South America.

**SPECIMEN EXAMINED:** **INDIA:** MAHARASHTRA, PUNE DISTRICT, Pune University Campus, on soil, P. G. Patwardhan and A. V. Prabhu 74.323 (LWG).

### CETRARIA Ach. (*Parmeliaceae*)

Acharius, Methodus: 292. 1803.

**Thallus:** fruticose, pale brown to dark brown, sometimes reddish at base, more or less dorsiventral, due to colour difference; **lobes:** canaliculated to subtubular, apically expanded; **upper surface:** usually smooth; **margins:** ciliate; **lower surface:** with marginal to laminal pseudocyphellae. Thallus heteromerous, corticated on both surfaces; cortices with an outer paraplectenchymatous and an inner prosoplectenchymatous tissue; **photobiont:** a green alga; **medulla:** white. **Apothecia:** marginal; **asci:** with large tholus and an apical ring structure, 8-spored; **spores:** colourless, simple. **Pycnidia:** on marginal projections or fibrils.

Out of 21 species known from the world, 6 species are known from India, of which 6 are terricolous.

#### Key to the terricolous species of *Cetraria*:

1.	Medulla K <sup>+</sup> yellow then red, P <sup>+</sup> reddish (fumarprotocetraric acid).....	2
1a.	Medulla K <sup>-</sup> , P <sup>-</sup> .....	3
2.	Lobes 1–3 mm wide, smooth, pseudocyphellae marginal in distinct continuous line.....	<i>C. laevigata</i>
2a.	Lobes 3–6(–16) mm wide, smooth to pitted or ridged, pseudocyphellae marginal or laminal.....	<i>C. islandica</i>
3.	Pseudocyphellae distinct or indistinct, marginal cilia long distinct.....	4
3a.	Pseudocyphellae usually distinct, marginal cilia rare.....	5
4.	Pseudocyphellae concave, lobes in distinct tufts.....	<i>C. nigricans</i>
4a.	Pseudocyphellae plane, indistinct, upper part pale red.....	<i>C. odontella</i>
5.	Branches often irregularly flattened, open, foveolate, hollow.....	<i>C. aculeata</i>
5a.	Branches terete to slightly flattened, dense, solid, pseudocyphellae flat.....	<i>C. muricata</i>

#### *Cetraria aculeata* (Schreb.) Fr. (Fig. 2.5d; Fig. 2.39)

Fries, Nov. Sched. Crit. Lich. 4: 32. 1826.

Basionym: *Lichen aculeatus* Schreb., Spic. Fl. Lips.: 125. 1771.

Synonyms: *Cornicularia aculeata* (Schreb.) Ach., Syn. Meth. Lich. 300. 1814.-*Coelocaulon aculeatum* (Schreb.) Link, Handb. Erk. Gew. 3: 165. 1833.

**Thallus:** fruticose, in 4(–6) cm tall tufts; **branches:** olive-black with concave pseudocyphellae; **medulla:** hollow; isidia and soredia absent. **Apothecia:** absent.

**Chemistry:** Medulla K<sup>-</sup>, C<sup>-</sup>, P<sup>-</sup>. Protolichesterinic acid present.

**Ecology and distribution:** *Microhabitat occupied:* Terricolous. In India the species is exclusively terricolous and exhibits restricted distribution to Western Himalaya and known only from single locality of Uttarakhand. Outside India, the species is also reported from boreal regions of Asia, Europe and North America.



**SPECIMENS EXAMINED:** **INDIA:** **UTTARAKHAND, UTTARKASHI DISTRICT,** Gangotri, Gomukh area, right bank, 5th moraine, alt. 3,840 m, on soil, D. D. Awasthi and S. R. Singh 8474, 8474 B (LWG-AWAS).

***Cetraria islandica* (L) Ach.** (Fig. 2.5e; Fig. 2.39)

Acharius, Methodus: 29. 1803.

Basionym: *Lichen islandicus* L., Sp. Pl.: 1145. 1753.

**Thallus:** fruticose, to 3.5(–5) cm tall, suberect to erect, coriaceous, divaricately branched; **lobes:** to 3 (–5) mm wide, involute, subcanaliculate, basally blackened; **margins:** with pycnidial brown-black fibrils (projections); **upper surface:** light to chestnut brown, smooth; **lower surface:** yellow-brown, pseudocyphellate; **pseudocyphellae:** laminal and submarginal, ± continuous, whitish; isidia and soredia absent. **Apothecia:** absent.

**Chemistry:** Medulla K–, C+, P+ red. Fumarprotocetraric, protocetraric and protolichesterinic acids present.

**Ecology and distribution:** *Microhabitat occupied:* Terricolous; muscicolous-terricolous. In India, the species is exclusively terricolous and widely distributed in Sikkim and Uttarakhand. Outside India, the species is also reported from Australia, Nepal and New Zealand; boreal Asia, Europe, North America, cooler South America.

**SPECIMENS EXAMINED:** **INDIA:** **SIKKIM, NORTH SIKKIM,** Sebu La base camp, east side, alt. 4,960 m, on ground, Sinha 1236 (BSHC); **UTTARAKHAND, BAGESHWAR DISTRICT,** Phurkiya, en route to Pindari glacier, alt. 3,505 m, on ground among mosses, D. D. Awasthi 781 B (LWG-AWAS); above Phurkiya to Mirtoli, alt. 3,505 m, on ground under shrub, D. D. Awasthi 7792 (LWG-AWAS); ridge of moraine above Pindari glacier, near zero mile, alt. 3,658 m, on ground, D. D. Awasthi 7782 (LWG-AWAS); **UTTARKASHI DISTRICT,** Gangotri, Gomukh area, right bank, 3rd and 4th moraine, alt. 3,871m, on ground, D.D. Awasthi and SR Singh 8458 (LWG-AWAS).

***Cetraria laevigata* Rass.** (Fig. 2.5f; Fig. 2.39)

Rassadina, Bot. Mater. Otd. Sporov. Rast. Bot. Inst. Komarova Akad Nauk S.S.S.R. 5:133. 1945.

Synonym: *Cetraria crispa* var. *japonica* Asahina in Sato, J. Jap. Bot. 14: 787. 1938.

**Thallus:** fruticose, to 6 cm tall, suberect to erect, light brown to chestnut brown, coriaceous, lacinate, sparsely branched; **lobes:** to 3 mm wide, canaliculate to sub-tubular; **margins:** with pycnidial brown-black fibrils (projections); **upper surface:** brown, smooth, pseudocyphellate; **pseudocyphellae:** marginal in a continuous line; **lower surface:** light brown, marginal projections abundant. **Apothecia:** absent.

**Chemistry:** Medulla K+ yellowish or K–, P+ red. Fumarprotocetraric, lichesterinic and protolichesterinic acids present.

**Ecology and distribution:** *Microhabitat occupied:* Terricolous; terricolous-rupicolous. In India the species is exclusively terricolous. Earlier the species was reported from Sikkim, in the present study it extends its distribution to Western Himalaya, Uttarakhand. Outside India, the species is also reported from Bhutan and Nepal; Northern boreal regions of Asia and North America.

**SPECIMENS EXAMINED:** **INDIA:** SIKKIM, NORTH SIKKIM, Llonakh valley, Chhaber lake below Luna La, alt. 4,600 m, on soil, Sinha 1607 (BSHC); **UTTARAKHAND, CHAMOLI DISTRICT,** on way from Mana to Vasudhara, alt. 3,340 m, on soil over rock, D.K. Upreti and S Nayaka 07-010132 (LWG).

***Cetraria muricata*** (Ach.) Eckfeldt (Fig. 2.6a; Fig. 2.39)

Eckfeldt, Bull. Torrey Bot. Club 22: 240. 1895.

Basionym: *Lichen muricatus* Ach., Lichenogr. Suec. Prodr.: 214.1798.

Synonym: *Cornicularia muricata* (Ach.) Ach., Methodus: 302.1803.

**Thallus:** forming shrubby tufts, densely branched, 1–2 cm tall, matt to glossy brown; **branches:** terete, dense to spinulose, main branches rounded to somewhat flattened, to 1.5 mm thick, usually with small lateral spinules; marginal cilia sparse; **surface:** even, brown, pseudocyphellate; **pseudocyphellae:** flat, circular, not pitted, oval-elliptic, plane, white; **medulla:** solid, white. **Apothecia:** not seen.

**Chemistry:** Medulla K<sup>-</sup>, C<sup>-</sup>, P<sup>-</sup>. Protolichesterinic and rangiformic acids present.

**Ecology and distribution:** *Microhabitat occupied:* Terricolous-rupicolous. In India the species is distributed in Karnataka, Sikkim, Tamil Nadu and Uttarakhand while species growing on soil is reported from single locality of Sikkim. Outside the India, the species is also reported from boreal and temperate regions, widespread in N. hemisphere, mountains in Africa and South America, extending to Antarctica.

**SPECIMEN EXAMINED:** **INDIA:** SIKKIM, NORTH SIKKIM, Theu La base camp, south side, alt. 4,500 m, on soil over rock, Sinha 1697 (BSHC).

***Cetraria nigricans*** Nyl. (Fig. 2.6b; Fig. 2.39)

Nylander, Herb. Musei Fenn.: 109. 1859.

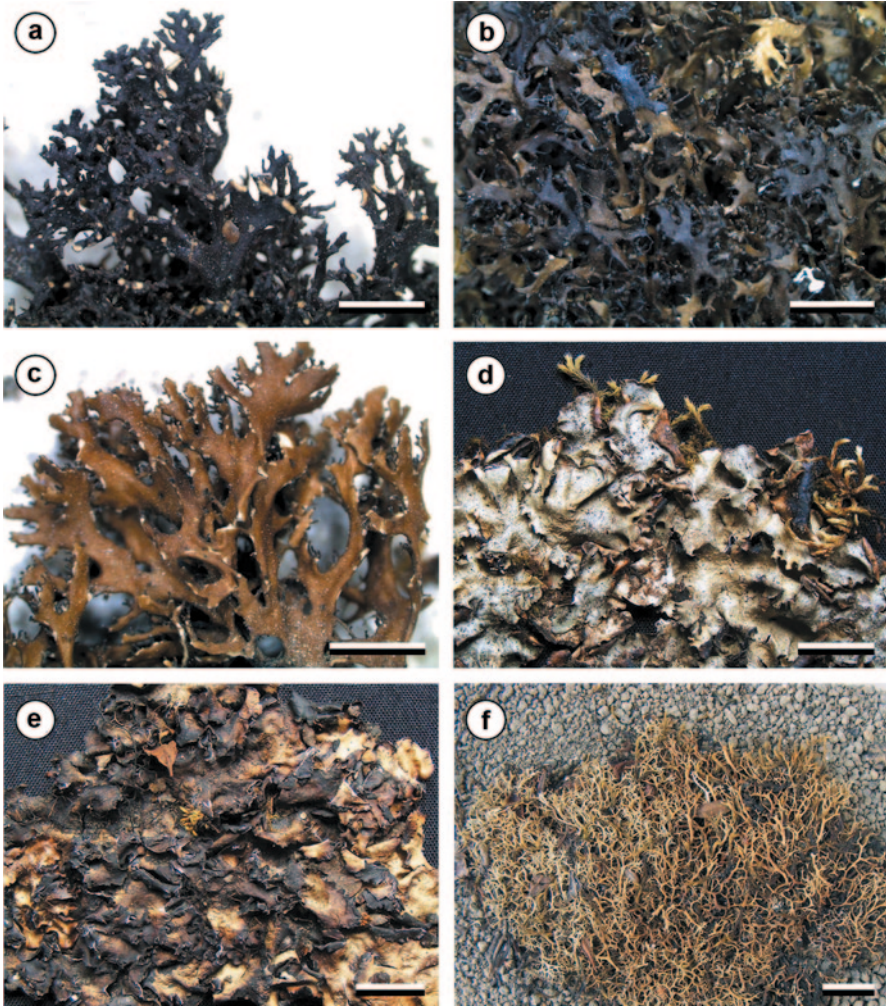
Synonym: *Cetraria nigricans* var. *himalayana* Asah. in Kihara (ed.) Fauna Flora Nepal Himalaya Lichens: 55. 1955.

**Thallus:** fruticose, to 1.5(–3) cm tall, branched; **lobes:** to 1.5(–3) mm wide, weakly canaliculated; **upper surface:** dark brown to black, rarely sorediate, marginal projections sparse; **pseudocyphellae:** marginal very narrow to indistinct; **lower surface:** pale brown to brown. **Apothecia:** to 10 mm in diameter; **spores:** 5 × 2.5 μm.

**Chemistry:** Medulla K<sup>-</sup>, C<sup>-</sup>, KC<sup>-</sup>, P<sup>-</sup>. Lichesterinic and protolichesterinic acids present.

**Ecology and distribution:** *Microhabitat occupied:* Terricolous; terricolous-rupicolous; musicolous-terricolous. In India the species is exclusively terricolous. Earlier the species was reported from Sikkim, in the present study it extends its distribution to Western Himalaya, Uttarakhand. Outside India, the species is also reported from Nepal and New Guinea; boreal to circumpolar regions.

**SPECIMENS EXAMINED:** **INDIA:** SIKKIM, NORTH SIKKIM, Sebu La, base camp area, west side, alt. 4,500–4,800 m, on soil over rocks among mosses, Sinha 1224 (BSHC); **WEST SIKKIM,** Dzongri, alt. 4,000 m, Sinha 70 A (BSHC); **UTTARAKHAND, BAGESHWAR DISTRICT,** above Phurkiya to Mirtoli, alt. 3,505 m, over boulders with mosses on soil, D. D. Awasthi 7799 (LWG-AWAS); **CHAMOLI DISTRICT,** near Badrinath, on way from Mana to Vasudhara,



**Fig. 2.6** **a** *Cetraria muricata* (Ach.) Eckfeldt, **b** *C. nigricans* Nyl., **c** *C. odontella* (Ach.) Ach., **d** *Cetraria olivetorum* (Nyl.) W. L. Culb. and C. F. Culb., **e** *C. sinensis* W. L. Culb. and C. F. Culb., **f** *Cladia aggregata* (Sw.) Nyl. Scale in **a**, **b**, **c** = 2 mm, in **d**, **e**, **f** = 10 mm

alt. 3,350 m, on soil over rocks, D. K. Upreti and S Nayaka, 07-010128 (LWG); UTTAR-KASHI DISTRICT, Gangotri, Gomukh area, right bank 3rd and 4th moraine, alt. 3,871 m, on ground, D. D. Awasthi and S. R. Singh, 8458 (LWG-AWAS).

***Cetraria odontella* (Ach.) Ach. (Fig. 2.6c; Fig. 2.39)**

Ach., Syn. Meth. Lich.: 230. 1814.

Basionym: *Lichen odontellus* Ach., Lichenogr. Suec. Prodr.: 213. 1798.

Synonym: *Cornicularia odontella* (Ach.) Röhl., Deutschl. Fl. 3 Abt. 2: 14. 1813.

**Thallus:** fruticose, densely tufted, expanded, distinctly flattened, with blunt apices; **cilia:** marginal, common; **upper surface:** chestnut brown basally, pale red at apical portion, pseudocyphellate; **pseudocyphellae:** plane, indistinct. **Apothecia:** absent.

**Chemistry:** Medulla K<sup>-</sup>, C<sup>-</sup>, P<sup>-</sup>. Protolichesteric and rangiformic acids.

**Ecology and distribution:** *Microhabitat occupied:* Terricolous; terricolous-rupicolous. In India, the species is exclusively terricolous and restrictedly distributed to Western Himalaya and known only from Uttarakhand. Outside India, the species is also reported from Russia; Scandinavian regions.

**SPECIMENS EXAMINED: INDIA: UTTARAKHAND, UTTARKASHI DISTRICT,** Gangotri, Gomukh area right bank, 6th moraine, alt. 3,810 m, on soil, D. D. Awasthi and S. R. Singh 8588 (LWG-AWAS); 2 km after Chirwasa towards Bhojwasa, alt. 3,600 m, on soil over rocks, S. Chatterjee and P. K. Divakar 02-000189 (LWG).

**CETRELIA** W. Culb. and C. Culb. (*Parmeliaceae*)

Contr. U. S. Natl. Herb. 34: 490.1968.

**Thallus:** foliose, large, to 24 cm across; **lobes:** to 25 mm wide; **upper surface:** greyish white, pseudocyphellate, with or without isidia and soredia; **lower surface:** rhizinate and usually punctate-pseudocyphellate; **photobiont:** a green alga; **medulla:** white. **Apothecia:** submarginal, lecanorine, usually perforate; **asci:** 8-spored; **spores:** colourless, simple. Atranorin present in upper cortex.

Out of 17 species known from the world, 9 species are known from India, of which 2 are terricolous.

**Key to the terricolous species of *Cetrelia*:**

- |     |   |                      |
|-----|---|----------------------|
| 1.  | Thallus sorediate, medulla C+ pink or red (olivetic acid).....        | <i>C. olivetorum</i> |
| 1a. | Thallus not sorediate, medulla C <sup>-</sup> , KC <sup>-</sup> ..... | <i>C. sinensis</i>   |

***Cetrelia olivetorum*** (Nyl.) W. L. Culb. and C. F. Culb. (Fig. 2.6d; Fig. 2.39)

Culberson and Culberson, Contr. U. S. Natl. Herb. 34: 515.1968.

Basionym: *Parmelia olivetorum* Nyl., Not. Sällsk. Fauna Fl. Fenn. Förh. n.s. 5: 180. 1866.

**Thallus:** foliose, loosely attached, whitish grey to brownish, to 14 cm across; **lobes:** to 18 mm wide, rounded; **upper surface:** tan to brownish, upto 0.5 mm wide pseudocyphellate, sorediate; **pseudocyphellae:** abundant, pores usually less than 0.5 mm across; **soredia:** farinose soredia at lobe margins; **lower surface:** black, rarely punctate, with few rhizines. **Apothecia:** not seen.

**Chemistry:** Medulla K<sup>-</sup>, C+ pink or red, P<sup>-</sup>. Atranorin and olivetic acid present.

**Ecology and distribution:** *Microhabitat occupied:* Terricolous; terricolous-rupicolous; muscicolous-rupicolous. In India, the species is distributed in Himachal Pradesh, Sikkim, Tamil Nadu and Uttarakhand while species growing on soil is known from different localities of Uttarakhand. Outside India, the species is also reported from Bhutan, China, Japan, Nepal, Taiwan; Europe and North America.

**SPECIMENS EXAMINED: INDIA: UTTARAKHAND, RUDRAPRAYAG DISTRICT**, Chopta, alt. 2,850 m, on soil with rock among mosses, Himanshu Rai and Pramod Nag 08-0012218 (LWG); **UTTARKASHI DISTRICT**, Govind wildlife sanctuary, on way from Sankri to Taluka 1 km before taluka, alt. 2,115 m, on soil over rock, D. K. Upreti, S. Nayaka, R. Bajpai 11-013285 (LWG).

*Cetrelia sinensis* W. L. Culb. and C. F. Culb. (Fig. 2.6e; Fig. 2.39)

W. L. Culberson and C. F. Culberson, Contr. U. S. Natl. Herb. 34: 523.1968.

**Thallus:** foliose, loosely attached, large, grey to brwnish; **lobes:** to 15 mm wide, rounded, with dark brown margins; **upper surface:** brownish, pseudocyphellate, lobulate; **lobules:** marginal, dorsiventral, dichotomous, sometimes coralloid branched, situated towards the centre of the thallus; **pseudocyphellae:** small to 0.6 mm wide, punctuate to elliptic; **lower surface:** black. **Apothecia:** not seen.

**Chemistry:** Medulla K<sup>-</sup>, C<sup>-</sup>, P<sup>-</sup>. Atranorin and imbricatic acid present.

**Ecology and distribution:** *Microhabitat occupied:* Terricolous; terricolous-rupicolous. In India, the species growing on soil and reported from different localities of Sikkim. Outside India, the species is also reported from China and Taiwan.

**SPECIMENS EXAMINED: INDIA: SIKKIM, NORTH SIKKIM**, Yangdi, above Thangu, alt. 4,250 m, on soil, D. K. Upreti, S. Chatterjee and P. K. Divakar 04-003945 (LWG); Thangu area, alt. 4,000 m, on soil over rock, D. K. Upreti, S. Chatterjee and P. K. Divakar 04-003905 (LWG).

**CLADIA** Nyl. (*Cladoniaceae*)

Bull. Soc. Linn. Normandie, ser. 2, 4: 167. 1870.

**Thallus:** dimorphic; **primary thallus:** granulose, often soon evanescent; **secondary thallus:** erect, pseudopodetia densely branched; **branches:** tapering with an external cartilaginous layer, lacking squamules and scyphi; centrally hollow; pseudopodetial wall repeatedly perforated; **pseudopodetia:** heteromerous, corticated; **photobiont:** a green alga. **Apothecia:** rare; brown, terminal, lecidine; **asci:** 8-spored; **spores:** colourless, simple.

Out of 14 species known from the world, 1 terricolous species is known from India.

*Cladia aggregata* (Sw.) Nyl. (Fig. 2.6f; Fig. 2.39)

Nylander, Bull. Soc. Linn. Normandie, ser. 2, 4: 69. 1870.

Basionym: *Lichen aggregatus* Sw., Prodr. Nov. Gen. Sp. Pl.: 147. 1788.

Synonym: *Cladonia aggregata* (Sw.) Ach., Kongl. Vetensk Akad. Nya Handl. 16: 68. 1795.

**Primary thallus:** not seen; **pseudopodetia:** caespitose, to 7 cm tall, yellow to pale brown in younger parts and shiny brown in older parts; **main branch:** to 2 mm in diameter; **branches:** cylindrical, perforated, apices furcate, spinulose; **axils:** usually open; **perforations:** round to oblong, 0.5–1.5 mm diameter. **Apothecia:** absent.

**Chemistry:** Pseudopodetia K<sup>-</sup>, C<sup>-</sup>, KC<sup>-</sup>, P<sup>-</sup>. Barbatic acid present.

**Ecology and distribution:** *Microhabitat occupied:* Terricolous; terricolous-muscicolous; terricolous-rupicolous; muscicolous-rupicolous. In India, the species is exclusively terricolous and widely distributed in Arunachal Pradesh, Assam, Manipur,

Meghalaya, Nagaland, Sikkim, Uttarakhand and West Bengal hills. Outside India, the species is also reported from Australia, Bhutan and Nepal; Africa, America.

**SPECIMENS EXAMINED: INDIA: ARUNACHAL PRADESH, WEST KAMENG DISTRICT**, Sela Pass, alt. 4,221 m, on soil, Upreti, Dubey, Khare, Mishra 08-009416 (LWG); **ASSAM, KAMRUP METROPOLITAN DISTRICT, GUWAHATI**, Kamakhya, on soil, D. C. Bhatt 3391 (LWG-AWAS), det. T Ahti 2001; **MEGHALAYA, CHERRAPUNJI**, 15 km Sohra towards Shillong from Cherapunji, on soil in vertical slope, D. K. Upreti 09-015932 (LWG); **SHILLONG**, Elephant falls, alt. 1,500 m, on soil, V. B. Singh s.n. (LWG); alt. 2,000 m, on soil among mosses, D. K. Upreti 20-213095 (LWG); **LAILYUGKOT, KHASI AND JAYANTIA HILLS**, alt. 1,829 m, on rock over soil, S. L. Kapoor and party 75934 (LWG); Elephant falls, alt. 1,500 m, on soil, P. Chandra s.n. (LWG); **SIKKIM, NORTH SIKKIM**, Shinghbo Rhododendron sanctuary, near Yumthang, alt. 3,500 m, on soil, D. K. Upreti, S. Chatterjee and P. K. Divakar 04-004117 (LWG); above Lachung, towards Yumthang, alt. 3,000 m, on soil, D. K. Upreti, S. Chatterjee and P. K. Divakar 04-004045 (LWG); above Lachung, Shingringtan area, alt. 2,900 m, on soil, D. K. Upreti, S. Chatterjee and P. K. Divakar 04-004262 (LWG); **UTTARAKHAND, ALMORA DISTRICT**, Shikhar, on soil with mosses in moist place, P. C. Pandey 81-54354(LWG); **CHAMOLI DISTRICT**, Badrinath, alt. 4,200 m, on soil, D. K. Upreti, L 13204 (LWG); **PITHORAGARH DISTRICT**, Narain Swami Ashram, alt. 3,000 m, on soil over rock, D. K. Upreti and Party 09-012166 A (LWG); **WEST BENGAL, DARJEELING DISTRICT**, Pashok road at about 6–8 miles from Darjeeling, alt. 1,981.2 m, on soil over rock with mosses, in crevices in shade, D. D. Awasthi and M. R. Agarwal 67.111(LWG-LWU); Sandakhphoo, alt. 3,633.216 m, on soil, D. K. Upreti 54584 (LWG); Tiger hill Senchal lake area, alt. 2134 m, on ground, D. D. Awasthi 64.64 (LWG-AWAS); near Sandakhphoo, alt. 3,353 m, on ground among mosses, D. D. Awasthi and M. R. Agarwal 67.367 (LWG-LWU); Sandakhphoo, alt. 3,633 m, on soil, P. D. Dogra 54584 (LWG).

### **CLADONIA** P. Browne (*Cladoniaceae*)

Browne, Civ. Nat. Hist. Jamaica: 81. 1756.

**Thallus:** dimorphic; **primary thallus:** horizontal, either crustose squamulose to subfoliose, persistent or evanescent; the squamules minute to small, medium or large adpressed or suberect, rounded to elongate, crenate to lobate; **upper surface:** grey-green, yellow-green, olive grey to brownish; **lower surface:** ecorticate, usually white, darkening towards base; squamules sometimes sorediate or pycnidiate; **photobiont:** a green alga (*Asterochloris*). **Podetia:** secondary thallus arising from primary thallus, of two types scyphose or escyphose, **podetial axils:** open or closed. **Apothecia:** developing on margin of scyphi or terminal on podetial tips, red, red-brown to brown rarely ochraceous, often aggregated; **asci:** with an amyloid structure of *Porpidia* type, 8-spored; **spores:** colourless, simple.

Out of 518 species known from the world, 59 terricolous species are known from India.

#### **Key to terricolous species of the *Cladonia*:**

- 
- |     |   |
|-----|---|
| 1.  | Primary thallus crustose, evanescent, podetia repeatedly intricately branched, apically deflexed on one side, lacking scyphi and cortex ..... 2   |
| 1a. | Primary thallus squamulose to subfoliose, persistent or disappearing, podetia always scyphose or podetia cylindrical, simple or branched, with or without scyphi, corticated or ecorticated, with or without squamules on podetia ..... 4 |
| 2.  | Pycnidial jelly red, podetia dichotomously branched, to 80 mm tall..... <i>C. ciliata</i>   |
-

2a.	Pycnidial jelly colourless, podetia di-, tri- to tetrachotomously branched.....	3	
3.	Podetia grey to bluish grey, K+ yellow (atranorin), podetia 50–100 mm tall .....		<i>C. rangiferina</i>
3a.	Podetia yellow to yellow-grey, K–, usnic acid present, podetia to 60 mm tall .....		<i>C. arbuscula</i> ssp. <i>squarrosa</i>
4.	Podetia always scyphose, scyphi well developed, often proliferating....	5	
4a.	Podetia cylindrical, simple or branched, completely escyphose, or partly scyphose, the scyphi then normal, small, deformed or indistinct .....	25	
5.	Hymenial discs red, K+ red .....	6	
5a.	Hymenial discs pale-brown to brown, K– .....	9	
6.	Podetia and scyphi farinose-sorediate, podetia to 35(–55) mm tall.....		<i>C. yunnana</i>
6a.	Podetia and scyphi esorediate .....	7	
7.	Zeorin present in podetia .....	8	
7a.	Zeorin absent, podetia to 10–20(–25) mm tall, scyphi to 12 mm wide, inner surface of scyphi with rounded plates .....		<i>C. borealis</i>
8.	Scyphi 2–6 mm wide, inner surface of scyphi with squamules or scales; podetia to 15 mm tall.....		<i>C. coccifera</i>
8a.	Scyphi to 1.5 mm wide, surface granulose, with downwards projecting microsquamules, podetia to 20 mm tall .....		<i>C. sinensis</i>
9.	Podetia P+ red (fumarprotocetraric acid).....	10	
9a.	Podetia P+ yellow or P– .....	22	
10.	Podetia and/ or scyphi sorediate .....	11	
10a.	Podetia and scyphi esorediate .....	16	
11.	Scyphi margins proliferating into secondary scyphi.....	12	
11a.	Scyphi margins proliferating into subulate or finger-like structures .....	14	
12.	Podetia with grayanic acid, scyphi goblet-shaped, surface sorediate .....		<i>C. grayi</i>
12a.	Podetia lacking grayanic acid .....	13	
13.	Podetia to 15 mm tall, surface corticated from base to. scyphus, scyphi sorediate on inner and outer surfaces.....		<i>C. humilis</i>
13a.	Podetia 5–20 mm tall, ecorticate-sorediate in upper part, soredia granulose .....		<i>C. chlorophaea</i>
14.	Podetia 5–10 mm tall, corticated from base to scyphus.....		<i>C. humilis</i>
14a.	Podetia 10–20 mm tall, usually sorediate throughout.....	15	
15.	Podetial surface farinose-sorediate, inner surface of scyphi also farinose sorediate, lacking microsquamules.....		<i>C. fimbriata</i>
15a.	Podetial surface granular and sorediate with microsquamules, inner surface of scyphi granular.....		<i>C. subsquamosa</i>
16.	Podetia proliferating from centre or margin of scyphi.....	17	
16a.	Podetia not proliferating from centre or margin of scyphi.....	21	
17.	Scyphi proliferating into secondary scyphi from margins, inner side of scyphi with peltate plates .....		<i>C. pocillum</i>
17a.	Scyphi proliferating from centre into secondary scyphi in 1–6 (7) tiers	18	
18.	Podetial surface verrucose corticate to ecorticate, with microsquamules .....		<i>C. ceratophyllina</i>
18a.	Podetial surface areolate, subcorticated with whitish intertices, lacking microsquamules .....	19	
19.	Scyphi flaring abruptly .....	20	
19a.	Scyphi flaring gradually.....		<i>C. verticillata</i>

20.	Podetia usually clearly glossy, more rarely slightly arachnoid or pruinose, areolate, dark brown to greenish-brown.....	<i>C. nitens</i>
20a.	Podetia greenish grey, branched, shallow.....	<i>C. calyciformis</i>
21.	Scyphi 2–5 mm wide, with schizidia on outer and inner surfaces, podetia 4–10 mm tall.....	<i>C. kurokawae</i>
21a.	Scyphi 5–7 mm wide, lacking schizidia, inner surface with peltate squamules, podetia to 10 mm tall.....	<i>C. pyxidata</i>
22.	Podetia P+ yellow (psoromic acid), 10–15 mm tall, scyphi narrow, inner surface granulose.....	<i>C. subconistea</i>
22a.	Podetia P–, sorediate.....	23
23.	Scyphi perforated at centre, marginal proliferations inrolled into perforation, podetia decorticate-farinose-sorediate in upper part.....	<i>C. cenotea</i>
23a.	Scyphi not perforated at centre, marginal proliferations develop into 3 (–5) tiered scyphi.....	24
24.	Scyphi to 10 mm wide, oblique, podetia 25 (–40) mm tall, surface mostly farinose sorediate, zeorin present.....	<i>C. carneola</i>
24a.	Scyphi 2–4 mm wide, podetia 20 mm tall, surface areolate-corticate below, farinose sorediate in upper part.....	<i>C. laii</i>
25.	Hymenial discs red, K+ red, pycnidia red.....	26
25a.	Hymenial discs pale-brown, brown to reddish brown, K–.....	28
26.	Squamules of primary thallus large, inrolled, lower side yellow, cotony, podetia rudimentary.....	<i>C. luteoalba</i>
26a.	Squamules of primary thallus otherwise.....	27
27.	Podetia 11–30 mm tall, surface corticate to ecorticate, granular sorediate with downwards projecting microsquamules.....	<i>C. didyma</i>
27a.	Podetia 5–10 mm tall, surface ecorticate, farinose-sorediate, never scyphose.....	<i>C. macilenta</i>
28.	Podetia K+ red (norstictic acid), squamulose at base, sorediate upwards, laterally furrowed, never scyphose.....	<i>C. acuminata</i>
28a.	Podetia K+ yellow or K–.....	29
29.	Podetia P+ red (fumarprotocetraric acid).....	30
29a.	Podetia P+ yellow or P–.....	55
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51.	Podetia simple, to 10 mm tall, surface smooth, with downwards projecting microsquamules, occasionally narrow scyphi present .....	<i>C. mongolica</i>

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53a.	Podetia grey to brownish, subulate or blunt, surface granulose, microsquamulose, narrow scyphi developing into fertile condition .....		<i>C. ramulosa</i>
54.	Podetia grey-brown, tips recurved, surface ecorticated, granulose and microsquamulose, rarely with narrow scyphi .....		<i>C. singhii</i>
54a.	Podetia grey, checkered or corticated at base, squamules at dichotomy, rarely with 3 mm wide scyphi marginally proliferating into scyphi or teeth.....		<i>C. stricta</i>
55.	Podetia sorediate .....	56	
55a.	Podetia esorediate .....	57	
56.	Podetia grey to olive-brown, P-, corticated at base, coarsely or finely sorediate in upper parts; rarely with, narrow scyphi.....		<i>C. rei</i>
56a.	Podetia grey, granulose, farinose-sorediate exposing stereome, P+ yellow (psoromic acid) .....		<i>C. fruticulosa</i>
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57a.	Podetia P- .....	59	
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58a.	Podetia di-to tetrachotomously branched, branches divaricate, surface glossy with minute reticulations .....		<i>C. nitida</i>
59.	Podetia dying at base .....	60	
59a.	Podetia not dying at base .....	62	
60.	Primary thallus absent (not known), podetia very slender, 50 mm or more tall, di-to trichotomously, intricately branched, surface smooth, never scyphose, usnic acid present .....		<i>C. delavayi</i>
60a.	Primary thallus squamulose, podetia stouter .....	61	
61.	Podetia (30)–50 mm or more tall, yellowish, dichotomously or sympodially richly branched, surface corticated, rarely with closed scyphi .....		<i>C. amaurocraea</i>
61a.	Podetia 20–30 mm tall, in dense cushions, grey to brown, surface corticated to decorticated with squamules and microsquamules, often with 2 mm wide, open scyphi .....		<i>C. squamosa</i>
62.	Podetia to 20 mm tall, simple to apically branched, surface corticated, cracked trabeculate, squamulose, never scyphose, always with hymenial discs (apotheciate).....		<i>C. indica</i>
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63a.	Podetia over 50 mm tall, brownish, branched, with occasional narrow scyphi, surface corticated.....		<i>C. crispata</i> var. <i>ctrariiformis</i>

### *Cladonia acuminata* (Ach.) Norrl

In Nylander and Norrlin, Herb. Lich. Fenn.: 57a. 1875.

Basionym: *Cenomyce pityrea* f. *acuminata* Ach., Syn. Meth. Lich.: 254. 1814.

**Primary thallus:** squamulose, usually persistent, sinuate to crenate-edged, narrowly lobed, becoming involute-concave, ascending; **squamules:** 2–5 mm long

and 0.3–2 mm wide, esorediate or sparsely granulose-sorediate on the margins and underside; **podetia**: whitish grey, up to 20 mm tall, 2 mm thick at base, curved, branched at apices with tapering tips, always escyphose; **podetial surface**: ribbed, squamulose at base, microsquamulose, granular and sorediate upwards; **podetial wall**: with lateral fissures, developed from perforated axils and slits; inner side of stereome grooved. **Apothecia**: dark brown to reddish-brown, up to 3 mm diam., perforate, lobate, or conglomerate, bulging over edge of the podetia; **hymenial discs**: brown; **spores**: oblong, 10–16 × 3 µm.

**Chemistry**: Podetia K<sup>+</sup> yellow to orange red, KC<sup>-</sup>, P<sup>+</sup> yellow to slowly orange-red. Atranorin, norstictic and connorstictic acids present. Rarely stictic, psoromic and other acids also reported.

**Ecology and distribution**: *Microhabitat occupied*: Terricolous. In India the species exhibits its restricted distribution to Western Himalaya and known to occur in Jammu and Kashmir only. Outside India, the species is also known from Asia, Europe, North and South America.

**SPECIMENS EXAMINED**: **INDIA**: JAMMU AND KASHMIR, ANANTNAG DISTRICT, between Baltal and Amarnath, alt. 3,750 m, on soil, A. Singh and D. K. Upreti 13960 (LWG), det. T. Ahti 2001; **BARAMULLA DISTRICT**, Gulmarg, alt. 2,700 m, on soil, A. Singh and D. K. Upreti 11657 (LWG), det. T. Ahti.

*Cladonia amaurocraea* (Flörke) Schaer

Schaerer, Lich. Helv. Spic.: 34.1823.

Basionym: *Capitularia amaurocraea* Flörke, in Weber and Mohr., Beitr. Naturk. 2: 334. 1810.

Synonym: *Cladonia amaurocraea* f. *oxyceras* (Ach.) H. Olivier, Étud. Clad.: 224. 1885.

**Primary thallus**: squamules minute, usually disappearing; **podetia**: yellow-grey, upper parts embrowned, to 50(–100) mm tall, 2–3 mm thick at base, dichotomously or sympodially branched; **axils**: open; rarely with 3 mm wide, closed scyphi marginally proliferating into spinulose structures; **sterile branches**: with spinescent tips; **podetial surface**: corticated, esorediate. **Hymenial discs**: reddish brown.

**Chemistry**: Podetia K<sup>-</sup>, C<sup>-</sup>, KC<sup>+</sup> yellow, P<sup>-</sup>. Usnic and barbatic acids present.

**Ecology and distribution**: *Microhabitat occupied*: Muscicolous-terricolous. In India, the species exhibits its restricted distribution to Eastern Himalaya and known to occur in Arunachal Pradesh and Sikkim. Outside India, the species is also known from Bhutan and Nepal; Europe, North America.

**SPECIMENS EXAMINED**: **INDIA**: ARUNACHAL PRADESH, WEST KAMENG DISTRICT, Tawang, alt. 4,000 m, on soil with mosses, Jaishree Rout s.n. (LWG); Sela pass, alt. 4,221 m, on soil with mosses, Upreti and Party 08-009406 (LWG).

*Cladonia arbuscula* (Wallr.) Flot

In Wendt, Thermen Warmbrunn: 94. 1839.

Basionym: *Patellaria foliacea* var. *arbuscula* Wallroth, Naturgesch. Säulchen-Flecht.: 169. 1829.

Synonyms: *Cladina arbuscula* (Wallr.) Hale and W. Culberson, Bryologist 73: 510. 1970. -*Cladonia sylvatica* (L.) Hoffm. s. auct., nomen utique rejectum, 1984. subsp. *squarrosa* (Wallr.) Ruoss

Ruoss, Bot. Helv. 97: 260. 1987.

Basionym: *Patellaria coccinea* var. *squarrosa* Wallroth, Naturgesch. Säulchen-Flecht: 191. 1829.

**Primary thallus:** not seen, reported to be crustose, evanescent; **podetia:** in tufts or mats, whitish grey to yellow, to 100 mm tall, 1.5 mm thick at base, anisotomically branched on all sides by di- to tetrachotomous branching, ultimate branchlets recurved on one side, internodes 4–7 mm long; **axils:** open. **Podetial surface:** with glomerules of photobiont cells. Pycnidial jelly colourless.

**Chemistry:** Podetia K<sup>-</sup>, C<sup>-</sup>, P<sup>+</sup> red. Usnic acid, fumarprotocetraric acid complex and often ursolic acid present.

**Ecology and distribution:** *Microhabitat occupied:* Terricolous. In India, the species exhibits its restricted distribution to Eastern Himalaya and known to occur in Sikkim only. Outside India, the species is also known from Asia, Europe, North and South America.

**SPECIMENS EXAMINED:** **INDIA:** **SIKKIM, NORTH SIKKIM,** near Chungthang, alt. 2,450 m, on soil, Sastri 673 (BSHC); Sebu La base camp, alt. 4,960 m, on soil, Sinha 1243 (BSHC); Thangu, along Testa bank, alt. 3,800 m, on soil, Sinha 1153 (BSHC).

### *Cladonia awasthiana* Ahti and Upreti

Ahti and Upreti. Biblioth. Lichenol. 88: 9. 2004.

**Primary thallus:** squamules small, often evanescent; **podetia:** grey-brown, usually 20–30 mm tall, 0.5–1 mm thick at base, scarcely branched at apices, subulate; occasionally with small scyphi, proliferating into subulate structures from margin; **podetial surface:** rough, basally squamulose, ecorticate or verruculose granulose-soresiate with microsquamules. **Hymenial disc:** brown; **pycnidia:** terminal.

**Chemistry:** Podetia: K<sup>-</sup>, P<sup>+</sup> red, UV<sup>+</sup> white. Fumarprotocetraric acid complex and homosekikaic acid present.

**Ecology and distribution:** *Microhabitat occupied:* Terricolous, muscicolous-terricolous, terricolous-rupicolous. The species is endemic to India and exhibits its wide distribution to Himachal Pradesh, Jammu and Kashmir, Sikkim and Uttarakhand. Outside India, the species is also known from Iran and Turkey. *Cladonia awasthiana* is close to *C. rei*, the latter is often P<sup>-</sup> (fumarprotocetraric acid absent), and more corticate.

**SPECIMENS EXAMINED:** **INDIA:** **HIMACHAL PRADESH, KULLU DISTRICT,** Great Himalayan National Park, Rolla, alt. 2,000 m, on soil, D. K. Upreti 99-52665 (LWG), det. T. Ahti 2001; Gusani to Rolla, alt. 1,800 m on soil over rock, D. K. Upreti 99-52614 (LWG), det. T. Ahti 2001; Karoangcha, alt. 1,950 m, on soil, D. K. Upreti 99-52656 (LWG), det. T. Ahti 2001; Beas river valley, on way to Barahi road, 2 km from Kullu, alt. 1,500 m, on rock over soil, D. K. Upreti and K. Dange 75034 (LWG), det. T. Ahti 2001; Sainj wild life Sanctuary, Shakti, alt. 2,200 m, on rock over soil with mosses, R. Srivastava 04-003310 (LWG); **SHIMLA DISTRICT,** Rampur, Sarahan, 2 km towards Gaura, alt. 2,000 m, on rock over soil, S. Nayaka and R. Srivastava 02-11581 (LWG); **JAMMU AND KASHMIR, ANANTNAG DISTRICT,** Pahalgam, alt. 2,100 m, on soil, A. Singh and D. K. Upreti 11624 (LWG), det. T. Ahti 2001; **BARAMULLA DISTRICT,** Gulmarg, on way from Gulmarg to Khilanmarg, alt. 2,655 m, on decaying wood, K. Dange 77.487 (LWG-LWU); **SIKKIM, NORTH SIKKIM,** Theu La base camp, south side, alt. 4,500 m, Sinha 1964 (BSHC); **UTTARAKHAND, CHAMOLI DISTRICT,** between Dugalbitta and Pothibasa, alt. 2,150 m, on rock over soil, A. Singh and M. Ranjan

107216 (LWG), det. T. Ahti 2001; on way of Nanda Devi Biosphere Reserve, Kanudhar, alt. 3,500 m, on soil, S. Rawat and D. Rawat 08-011261 (LWG); PITHORAGARH DISTRICT, Dharchula Sobhla, opposite mountain of village Vatan, alt. 2,000 m, on soil, Upreti and Hariharan 202026 (LWG), det. T. Ahti 2001; TEHRI GARHWAL DISTRICT, Dhanaulti, alt. 2,286 m, on soil, A. Singh and M. Ranjan 77598 (LWG), det. T. Ahti 2001; UTTARKASHI DISTRICT, Govind Wild Life Sanctuary, Taluka to Osla, alt. 2,097 m, on soil over mosses, D. K. Upreti, S. Nayaka, R. Bajpai 11-016095 A (LWG).

***Cladonia borbonica*** Nyl

Nylander, Bull. Soc. Linn. Normandie, ser. 2,2: 47. 1868.

**Primary thallus:** squamulose, squamules small; **podetia:** greyish brown, 5–30 mm tall, 1.5 mm thick at base, simple to branched, usually scyphose; **scyphi:** up to 2 mm wide, marginally dentate or proliferating into secondary scyphi or subulate structures; escyphose podetia subulate; **podetial surface:** decorticate to rarely corticated at basal part, sorediate and corticated in patches in upper parts; **basal squamules:** marginally granulose isidioid sorediate. **Hymenial discs:** brown.

**Chemistry:** Podetia K–, P+ red. Fumarprotocetraric acid present.

**Ecology and distribution:** *Microhabitat occupied:* Terricolous. In India, the species exhibits its restricted distribution to Eastern Himalayas and known to occur in Arunachal Pradesh (Awasthi 2007; Singh and Sinha 2010). During the study, no material of *Cladonia borbonica* has been examined by us. Outside India, the species is also known from Australasia, Oceania, Africa and South America. *Cladonia borbonica* resembles *C. subradiata* differing in the nature of scyphi (Awasthi 2007). The species description is based on Awasthi (2007).

***Cladonia borealis*** S. Stenroos

Stenroos, Ann. Bot. Fenn. 26: 160. 1989.

**Primary thallus:** squamulose, persistent; **squamules:** medium to large, orange-yellow, 4–5 mm long, 2–3 mm wide, crenate-lobate, upturned or involute, with dying bases ochraceous; **podetia:** yellow to brownish, 15–20 mm tall, always scyphose; scyphi 10–12 mm wide, inner surface with microsquamules; **margin:** dentate with red pycnidia or with stalked red hymenial discs; rarely proliferating into secondary scyphi. **Podetial surface:** rough, granulose, areolate corticated and esorediate. **Apothecia:** common, up to 6 mm wide, red; **spores:** fusiform, 9–10 × 3 μm.

**Chemistry:** Podetia K–, KC+ yellowish, P–. Usnic, barbatic and 4-*O*-demethyl barbatic and rhodocladonic acids and fatty substance present.

**Ecology and distribution:** *Microhabitat occupied:* Terricolous; muscicolous-rupicolous. In India, the species exhibits its restricted distribution to temperate regions of Sikkim and Uttarakhand. Outside India, the species is also known from Bhutan, Australasia, Antarctica, Europe, North and South America.

**SPECIMENS EXAMINED:** INDIA: SIKKIM, NORTH SIKKIM DISTRICT, Sebu La base camp, east side, alt. 4,960 m, on soil, Sinha 1236 (BSHC), det. T. Ahti, 2001; UTTARAKHAND, CHAMOLI DISTRICT, on way to Hemkund, alt. 4,050 m, on rock along with mosses over soil, A. Singh 85811 (LWG), det. T. Ahti 2001; Hemkund, alt. 4,000 m, on soil, A. Saklani s.n. (LWG), T. Ahti 2001.

***Cladonia calyciformis*** Nuno (Fig. 2.40)

Nuno, J. Jap. Bot. 47: 161. 1972.

**Primary thallus:** squamulose; **squamules:** 2–4 × 1–3 mm in size, lacinate, greyish green, persistent, esorediate; lower side white; **podetia:** 5–40 mm tall, 1–2.5 mm in diam. at base, greenish grey, branched, always scyphose, axils closed; **scyphi:** flaring abruptly, 0.5–5 mm wide, shallow, margins mostly with microsquamules, centrally proliferating into 3–4(–6) tiers of scyphi; **internodes:** 4–10 mm long; **podetial surface:** areolate subcorticate with fine white interstices, esorediate, verruculose, lacking granules and microsquamules, basally squamulose. **Hymenial discs:** indistinct, brown. **Pycnidia:** at margins of scyphi.

**Chemistry:** Podetia K–, KC–, P+ orange-red. Fumarprotocetraric acid only in Indian specimens. Homosekikaic acid reported in addition to fumarprotocetraric acid in type specimen.

**Ecology and distribution:** *Microhabitat occupied:* Terricolous; muscicolous-terricolous; terricolous-rupicolous; detriticolous-terricolous. In India, the species exhibits its restricted distribution to Meghalaya and Uttarakhand. Outside India, the species is also known from Bhutan, Australasia, Antarctica, Europe, North and South America.

**SPECIMENS EXAMINED: INDIA: UTTARAKHAND, ALMORA DISTRICT,** Binsar, alt. 1,800 m, on soil, D. K. Upreti and Jyoti Tandon 213335 (LWG); Jageshwar, alt. 1,829 m, on soil by roadside, D. D. Awasthi 3503 (LWG-AWAS); **BAGESHWAR DISTRICT,** Pokhari, alt. 1,600 m, on soil, P. C. Pandey 80-54330 (LWG); between Loharkhet to Dhakuri, alt. 2,700 m, on soil, D. K. Upreti and Jyoti Tandon 213365(LWG), det. T. Ahti 2001; en route to Pindari Glacier, Loharkhet-Dhakuri, alt. 1,700 m, on soil, Upreti, Chatterjee and Tandon L68940 (LWG), det. T. Ahti 2001; en route to Sunderdhunga Glacier before 5 km of Dhakuri, alt. 2,743 m on soil, Upreti and Tandon 213423 (LWG), det. T. Ahti 2001; near Lohaghat alt. 1,829 m, on soil, D. D. Awasthi 848 (LWG-AWAS); near Dhakuri ridge, alt. 2,591 m, on ground, D. D. Awasthi 7601 (LWG-AWAS); **CHAMPAWAT DISTRICT,** Lalwapani, alt. 1,700 m, D. K. Upreti 201879 (LWG); Saurlekh forest near Microwave station, alt. 2,700 m, on soil, Upreti and Hariharan 202246 (LWG), det. T. Ahti 2001; **DEHRADUN DISTRICT,** Mussoorie, alt. 2,134 m, on ground, O. A. Höeg, 3389 A(LWG-AWAS); **PITHORAGARH DISTRICT,** Gori Ganga catchment area, Dafiadhura, alt. 1,656 m, on soil, Vikas Pant s.n. (LWG); Gori Ganga catchment area, Deochula, alt. 2,000 m, on soil, Vikas Pant 20-67987 (LWG), det. T. Ahti 2001; **PAURI GARHWAL DISTRICT,** Nagdeo, alt. 1,982 m, on soil, A. Singh 86927 (LWG).

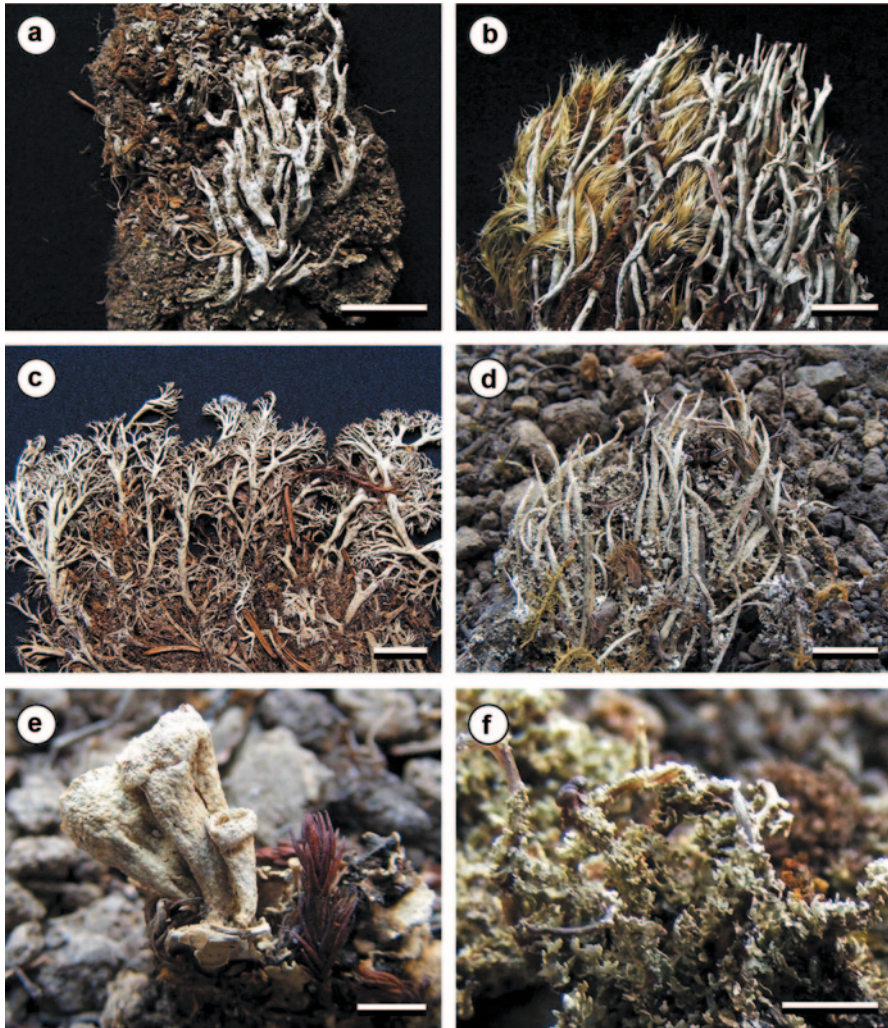
***Cladonia cariosa*** (Ach.) Spreng. (Fig. 2.7f; Fig. 2.40)

Sprengel. Syst. Veg. 4(1): 272. 1827.

Basionym: *Lichen cariosus* Ach., Lichenogr. Svec. Prodr.: 198. 1798.

**Primary thallus:** squamulose; **squamules:** small; 1–4 mm long, 1–2 mm wide, greenish grey, persistent; **podetia:** greyish brown, 5–8(–15) mm tall, 1–3 mm thick at base, simple to sparingly branched, always escyphose, apically flattened. **Podetial surface:** areolate-corticated, granular, esorediate; **podetial wall:** longitudinally fissured and striate. **Apothecia:** constantly present from early stages, chestnut brown to darker, larger than podetial support, solitary; **hymenial discs:** brown; **spores:** ellipsoid, 10.5–18 × 3.5–5.5 μm.

**Chemistry:** Podetia K+ yellow, P+ yellow or red. Atranorin, fumarprotocetraric acid complex present.



**Fig. 2.7** a *Cladonia acuminata* (Ach.) Norrll., b *C. amaurocraea* (Flörke) Schaer., c *C. arbuscula* (Wallr.) Flot., d *C. awasthiana* Ahti and Upreti, e *C. borealis* S. Stenroos, f *C. cariosa* (Ach.) Spreng. Scale in e=3 mm, in f=5 mm, in a, b, c, d=10 mm

**Ecology and distribution:** *Microhabitat occupied:* Terricolous; terricolous-rupicolous. In India, the species exhibits its distribution to temperate regions of Himachal Pradesh, Uttarakhand and Sikkim. The species is also known from Asia, Europe, North and South America.

**SPECIMENS EXAMINED:** **INDIA:** **HIMACHAL PRADESH, LAHAUL SPITI DISTRICT,** Koksar, alt. 3,100 m, on soil, Upreti 01-26567 B (LWG), det. T. Ahti 2001; **SIKKIM, NORTH SIKKIM,** Chubuk above Thangu, alt. 4,100 m, on soil, Upreti, Chatterjee, Divakar 04-003914 (LWG); **UTTARAKHAND, CHAMPAWAT DISTRICT,** Mayawati to Lohaghat, alt. 1,745 m, on rock

over soil, DK D. K. Upreti, S. Joshi, H. Rai, R. Khare, G. K. Mishra and A. Dwivedi 09-012606 (LWG); **UTTARKASHI DISTRICT**, Govind Wild Life Sanctuary, on way to Kedarkantha, alt. 2,324 m, on soil, D. K. Upreti, S. Nayaka, R. Bajpai 11-016074 (LWG).

***Cladonia carneola*** (Fr.) Fr. (Fig. 2.40)

Fries, Lichenogr. Eur. Reform.: 233. 1831.

Basionym: *Cenomyce carneola* Fries, Sched. Crit. Lich. Suec. 1–4: 23. 1825.

**Primary thallus:** squamulose; **squamules:** small, persistent or disappearing, deeply, irregularly lacinate; **podetia:** yellow-grey, to 40 mm tall, 1.5 mm thick at base, always scyphose; **scyphi:** 10–12 mm wide, to 8 mm deep, oblique, imperforate, proliferating from margins into 3(–5) tiers of scyphi with 1–4 scyphi from each scyphus; primary tier of scyphi up to 10 mm tall, successive tiers shorter, ultimate proliferations knob-shaped; margins of scyphi with brown to brown-black hymenial discs and pycnidia; **podetial surface:** mostly farinose-soeridiate. **Apothecia:** fairly common, 0.5–5 mm wide, pale brown; **spores:** fusiform,  $12\text{--}16.5 \times 3.5\text{--}5 \mu\text{m}$ ; **pycnidia:** very common, dark brown to black, conical to cylindrical, blunt to somewhat pointed, with hyaline gelatin; **conidia:**  $3\text{--}4 \times 0.5\text{--}1 \mu\text{m}$ .

**Chemistry:** Podetia K<sup>–</sup>, KC<sup>+</sup> yellow, P<sup>–</sup>. Usnic, isousnic acids and zeorin present.

**Ecology and distribution:** In India, the species exhibits its restricted distribution to Eastern Himalayas and known to Sikkim (Awasthi 2007; Singh and Sinha 2010). No material of *Cladonia carneola* has been examined by us, the description is based on Awasthi (2007). It is also reported from Bhutan and Nepal, Antarctica, Europe, North and South America.

***Cladonia cartilaginea*** Müll. Arg. (Fig. 2.8a; Fig. 2.40)

Müller Argoviensis, Flora 63: 260. 1880.

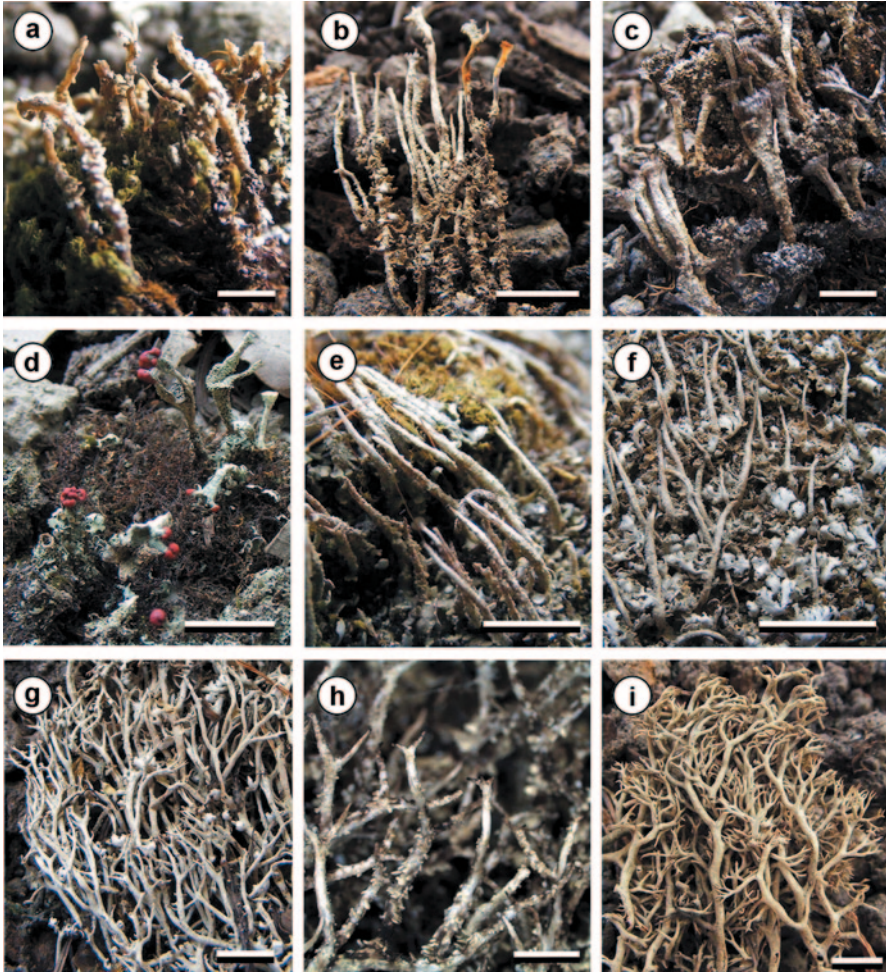
**Primary thallus:** squamulose; **squamules:** small, ascending, persistent or disappearing,  $1.5\text{--}9 \text{ mm} \times 0.5\text{--}2 \text{ mm}$ ,  $\pm$  lacinate; **podetia:** up to 2.5 cm tall, 0.3–2 mm wide, whitish to light grey, hard cartilagineous, simple or sparingly branched at apices, subulate, always escyphose, tips blunt to acute, branches flexuose or recurved; **podetial surface:** circular to angular, occasionally microsquamulose, somewhat striate, very hard inner medulla usually exposed, generally granular soeridiate. **Apothecia:** rather frequent, 0.3–1.5 mm wide, red brown; **hymenial discs:** dark brown at tips of podetia; **spores:** oblong,  $7\text{--}13 \times 2.5\text{--}3.5 \mu\text{m}$ ; **pycnidia:** on primary squamules or at tips of podetia, with hyaline gelatin; **conidia:**  $4\text{--}8 \times 0.5 \mu\text{m}$ .

**Chemistry:** Podetia K<sup>+</sup> yellowish, or K<sup>–</sup>, P<sup>+</sup> red, C<sup>–</sup>, KC<sup>–</sup>. Fumarprotocetraric acid present.

**Ecology and distribution:** *Microhabitat occupied:* Terricolous; detriticolous-terricolous; muscicolous-terricolous; terricolous-rupicolous. In India, the species exhibits its wide distribution to Arunachal Pradesh, Himachal Pradesh, Karnataka, Kerala, Manipur, Meghalaya, Sikkim, Tamil Nadu, Uttarakhand and West Bengal hills. The species is also known from Nepal, Africa, Central and South America.

**SPECIMENS EXAMINED: INDIA: ARUNACHAL PRADESH, DIBANG VALLEY DISTRICT,** Sella lake area, Roing, alt. 1,300 m, on soil over rock, D. K. Upreti and M. Ranjan 201546 (LWG), det. T. Ahti 2001; **HIMACHAL PRADESH, KINNAUR DISTRICT,** Racksham-Chitkul, alt.





**Fig. 2.8** **a** *Cladonia cartilaginea* Müll. Arg., **b** *C. ceratophyllina* (Nyl.) Vain., **c** *C. chlorophaea* (Flörke ex Sommerf.) Spreng., **d** *C. coccifera* (L.) Willd., **e** *C. coniocraea* (Flörke) Spreng., **f** *C. corniculata* Ahti and Kashiw., **g** *C. corymbescens* Nyl. ex Leight., **h** *C. crispata* (Ach.) Flot., **i** *C. delavayi* Abbayes. Scale in **h**=2 mm, in **a, b, c, e, g, i**=5 mm, in **d, f**=10 mm

3,500 m, on soil, Upreti and Srivastava 03-002755 (LWG); **KULLU DISTRICT**, Around Sainj forest guest house, alt. 1,500 m, on soil vertical face of roadside, D. K. Upreti 217537 (LWG), det. T. Ahti 2001; Parvati river valley, at Pulga Rest house, alt. 2,190 m, on soil over rock, D. K. Upreti and K. Dange 75187 A (LWG), det. T. Ahti 2001; Great Himalayan National Park, ecodevelopment zone, Sainj Valley Shangarh, alt. 2,200 m, on soil, R. Srivastava 04-003490 (LWG); **SHIMLA DISTRICT**, Rampur, Gaura up to 4 km towards rampur, alt. 1,800 m, on soil, S. Nayaka and R. Srivastava 02-81544 (LWG); **SIRMAUR DISTRICT**, Rajgarh, Omvan, alt. 1,400 m, on soil, Chaaterjee, Dubey and Nayaka 20-65646 (LWG), det. T. Ahti 2001; **BILASPUR DISTRICT**, Manhol, Tepra, Bahadurpur, alt. 1,850 m, on soil, D. K. Upreti, S. Joshi, H. Rai, R. Khare, G. K. Mishra and A. Dwivedi 03-001346 (LWG); **KARNATAKA**, **HASSAN DISTRICT**, Near Seklashpur Sambhalli alt. 900 m, on soil, D.

D. Awasthi, D. K. Upreti and U. Misra 79-325 (LWG-LWU), det. T. Ahti 2001; **KERALA**, **THIRUVANANTHAPURAM DISTRICT**, Ponnudi, alt. 1,100 m, on soil, Biju Haridas 06-007521 (LWG); **IDUUKI DISTRICT**, Thenmally, Tea estate area near Munnar, along roadside, alt. 1,800 m, on rock over soil, D. D. Awasthi, R. Tewari and R. Mathur 85.317 (LWG-LWU), det. T. Ahti 2001; **MANIPUR**, **IMPHAL**, on way from Imphal to Moreh Tongnoupal and Moreh, alt. 1,200 m, on rock over soil, V. S. Sharma s.n. (LWG), det. T. Ahti 2001; **MEGHALAYA**, **SHILLONG**, Elephant Falls, alt. 1,500 m, on soil, P. Chandra s.n. (LWG), det. T. Ahti 2001; **EAST KHASI DISTRICT**, Mawsmal area, 6–7 km from Cherrapunji, alt. 335 m, on ground, D. D. Awasthi 7940 (LWG-AWAS), det. T. Ahti 2001; area in front of Nirala Bungalow, alt. 1,885 m, on soil over rock, G. Panigrahi 3820 (LWG-AWAS), det. T. Ahti 2001; **SIKKIM**, **GANGTOK**, Tashi view point, alt. 1,750 m, on soil, Chatterjee and Divakar 20-77178 (LWG), det. T. Ahti 2001; **NORTH SIKKIM DISTRICT**, Mangan, alt. 1,204 m, on soil over rock, V. S. Sharma and M. Ranjan 76729 (LWG), det. T. Ahti 2001; Kalep before Thangu, alt. 3,900 m, on soil, Upreti, Chatterjee and Divakar 04-003865 (LWG); **TAMIL NADU**, **NILGIRI DISTRICT**, Ootacamund, alt. 2,400 m, on soil, G. Saran and Party s.n. (LWG) det. T. Ahti 2001; Ootacamund, on way to Doddabetta peak, alt. 2,567 m, on soil, G. Awasthi 82-13(LWG-LWU), det. T. Ahti 2001; **DINDIGUL DISTRICT**, Kodaikanal, alt. 1,700 m, on soil A. Singh L81409 (LWG), det. T. Ahti 2001; **PALNI HILLS**, Kodaikanal, Shenbaganur, on way to Tiger Shola, alt. 1,676 m, on ground, D. D. Awasthi and K. P. Singh 70.46(LWG-LWU), det. T. Ahti 2001; **UTTARAKHAND**, **ALMORA DISTRICT**, near Loharkhet (en route to Pindari Glacier), alt. 1,524 m, on soil, D. D. Awasthi and A. M. Awasthi 587 (LWG-AWAS), det. T. Ahti 2001; on way to phurkia to Mirtoli, alt. 3,475 m, on soil over stones, D. D. Awasthi 7763(LWG-AWAS), det. T. Ahti 2001; Tarikhet, alt. 1,600 m, on soil, D. K. Upreti L 18327 (LWG), det. T. Ahti 2001; **CHAMOLI DISTRICT**, Madmaheshwar, between Gondar and Laink, alt. 1,500 m, on soil covered rock, A. Singh and M. Ranjan 107079 (LWG); Badrinath south of temple near Brahmini village, alt. 3,162 m, on rock surface over soil, K. Dange 76.733 (LWG-LWU), det. T. Ahti 2001; Dumri forest area, alt. 2,100 m, on soil. D. K. Upreti, P. K. Divakar and S. Rawat 06-8700 (LWG); Durmi forest area, alt. 2,000 m, on soil, D. K. Upreti, P. K. Divakar and S. Rawat 06-10689 (LWG); **DEHRADUN DISTRICT**, Chakrata division, near Mundali, alt. 2,743 m, on soil, D. D. Awasthi 980 (LWG-AWAS), det. T. Ahti 2001; **NAINALT DISTRICT**, Jim Corbett Tiger Reserve, Sandikhal, alt. 1,575 m, on rocks over soil, D. K. Upreti and Jyoti Tandon 217433 (LWG), det. T. Ahti 2001; **PAURI GARHWAL DISTRICT**, Pauri, alt. 1,950 m, on soil, A. Singh 68049 (LWG), det. T. Ahti 2001; Nagdeo, alt. 1,981 m, on soil, A. Singh and party 86906 (LWG), det. T. Ahti 2001; Lansdown, Jaiharikal road, alt. 3,000 m, on soil, S. K. Katiyar s.n. (LWG); Khirsu, alt. 1,650 m, on soil, S. Nayaka and V. Shukla 04-004742 (LWG); Kandolia, alt. 1,650 m, on soil, V. Shukla and Y. Joshi 05-005316 (LWG); Pauri, Pauri-Devprayag road, alt. 1,650 m, on soil, V. Shukla and Y. Joshi 05-005318 (LWG); **PITHORAGARH DISTRICT**, Munsyari, alt. 2,200 m, on soil over rock, A. Singh 102707 (LWG), det. T. Ahti 2001; Kujouli village, alt. 1,550 m, on soil of moist place, D. K. Upreti L 18458 (LWG), det. T. Ahti 2001; Sandev Botanical Hotspot, alt. 1,875 m, on soil, Vikas Pant 02000987 (LWG); Banlek near Champawat, alt. 1,800 m, on soil, D. K. Upreti 201857 (LWG), det. T. Ahti 2001; Dwaj, alt. 2,500 m, on soil, S. Chatterjee 99-65325 (LWG), det. T. Ahti 2001; Lilam to bogudiyar en route to Milam Glacier, alt. 2,450 m, on soil, S. Joshi 07-010350 (LWG); Gori Ganga catchment area, Deochula, alt. 1,900 m, on soil, Vikas Pant 20-67972 (LWG), det. T. Ahti 2001; Askot Langam Kanta forest, alt. 1,900 m, on soil along roadside, D. K. Upreti 212971 (LWG), det. T. Ahti 2001; Lori forest, alt. 1,600 m, on soil in moist places, H. C. Pande 99-65597 (LWG), det. T. Ahti 2001; Askot-Sandev Botanical hot spot, Deochula, alt. 2,000 m, on soil and decaying wood, Vikas Pant 02-103988 (LWG); **RUDRAPRAYAG DISTRICT**, between Kalimath and Guptkashi, alt. 1,200 m, on rocks over soil, A. Singh and M. Ranjan 107098 (LWG), det. T. Ahti 2001; en route from Madmaheshwar to Guptkashi, alt. 1,300 m, on rocks over soil, A. Singh and M. Ranjan 106832 (LWG), det. T. Ahti 2001; Guptakashi, alt. 1,100 m, on soil, A. Singh and M. Ranjan 106843 (LWG), det. T. Ahti 2001; Mandakini river valley, on way from Sonprayag to Gaurikund, alt. 1,900 m, on rocks over soil, K. Dange 76.35(LWG-LWU),

det. T. Ahti 2001; Guptakashi, 2 km from temple in forest, alt. 1,350 m, on rock over soil, K. Dange 76.532 (LWG-LWU), det. T. Ahti 2001; Kimana, Ukhimath, alt. 1,400 m, on soil, S. Rawat 06-007205 (LWG); Tungnath, Tungnath Bugyal, alt. 3,400 m, on soil over rock, Himanshu Rai and Pramod Nag 08-0012241 (LWG). **UTTARKASHI DISTRICT**, Dharasu, Bagi Forest, alt. 1,067 m, on soil-covered rock, A. Singh and Party 75321 (LWG), det. T. Ahti 2001; Silkyara, between Yamunitri and Gangotri, alt. 1,620 m, on soil, A. Singh and Ram Pher 75333 (LWG), det. T. Ahti 2001; between Jankitchatti and Yamunotri, alt. 3,000 m, on soil-covered rock, A. Singh and Ram Pher 76062 (LWG), det. T. Ahti 2001; Govind Wild Life Sanctuary, on way to Taluka, alt. 2,115 m, on soil, D. K. Upreti, S. Nayaka, R. Bajpai 11-013274 (LWG); **WEST BENGAL, DARJEELING DISTRICT**, Tiger hill, Senchal Lake area, alt. 2,210 m, on soil, D. D. Awasthi 64-101(LWG-AWAS), det. T. Ahti 2001; Kurseong, alt. 1,500 m, on stone over soil, G. Saran and Party 68591 (LWG), det. T. Ahti 2001; Kalimpong, alt. 1,247 m, on soil, S. Saran and Party 79797 (LWG); Senchal lake, alt. 2,210 m, on soil, D. D. Awasthi 64.64 (LWG-LWU), det. T. Ahti 2001; Batasi-Palmajua, alt. 2,134 m, on soil, D. D. Awasthi 113 (LWG-AWAS), det. T. Ahti 2001; Tiger hill, alt. 2,210 m, on soil, D. D. Awasthi 64.64 (LWG-LWU), det. T. Ahti 2001.

***Cladonia cenotea*** (Ach.) Schaer. (Fig. 2.40)

Schaerer, Lich. Helv. Spic.: 35. 1823.

Basionym: *Baeomyces cenoteus* Ach., Methodus: 345. 1803.

**Primary thallus:** squamulose, persistent; **squamules:** 1–10 mm long, 1–2 mm wide, palmate-lobate, laciniate, with accessory isidioid lobules reiterating and resembling the original squamules; **podetia:** bluish grey to green, more than 50 mm tall, to 5 mm thick at base, simple, always scyphose; **scyphi:** to 8 mm wide, perforated in the middle; marginal proliferations inrolled into perforation; **podetial surface:** corticated, squamulose at base; decorticated and farinose sorediate in upper part. **Apothecia:** infrequent, 1–3 mm diam., dark brown; **hymenial discs:** pale brown to brown on margin of scyphi; **spores:** oblong to ellipsoid, (5–)7–17 × 3–5 µm. **Pycnidia:** at margins of funnel-like openings, cylindrical to conical, with red gelatin; **conidia:** 3–8 × 0.5–1 µm.

**Chemistry:** Podetia K–, C–, KC–, P–. Squamatic acid present.

**Ecology and distribution:** *Microhabitat occupied:* Terricolous. In India, the species exhibits its restricted distribution to Western Himalaya and known to occur in Jammu and Kashmir but needs to confirm the identity (Awasthi 2007; Singh and Sinha 2010). During study, no material of *Cladonia cenotea* has been examined by us; the description is based on Awasthi (2007). The species is also known from Pakistan, Africa, Asia, Europe, North and South America

***Cladonia ceratophyllina*** (Nyl.) Vain. (Fig. 2.8b; Fig. 2.40)

In Hue, Nouv. Arch. Mus. Hist. Nat. Paris, ser. 3, 10: 273. 1898.

Basionym: *Cladonia degenerans* var. *ceratophyllina* Nyl., Ann. Sci. Nat. Bot. sér. 4.11: 249. 1859.

**Primary thallus:** squamules small, persistent; **podetia:** grey to brown-black, 10–25(–40) mm tall, always scyphose; scyphi 1–3 mm wide, open or closed; proliferating from centre into 1–2 tiers of scyphi or subulate structures; **podetial surface:** verrucose with small squamules, corticated or ecorticated and esorediate.

**Chemistry:** Podetia K–, P+ orange-red, C–. Fumarprotocetraric acid present.

**Ecology and distribution:** *Microhabitat occupied:* Terricolous; terricolous-rupicolous. In India, the species exhibits its restricted distribution to Uttarakhand and

West Bengal hills. The species is also known from Madagascar, Réunion, Malawi and Zimbabwe.

**SPECIMENS EXAMINED:** **INDIA:** **UTTARAKHAND, ALMORA DISTRICT**, en route to Sunderdhunga Glacier, between Jatoli and Dhuniya don, alt. 3,352 m, on soil, D. K. Upreti and Jyoti Tandon 213835 B (LWG), det. T. Ahti 2001; **UTTARKASHI DISTRICT**, between Jankichatti and Yamunotri, alt. 3,000 m, on soil-covered rock, A. Singh and Ram Pher 76062 (LWG), det. T. Ahti 2001; **WEST BENGAL, DARJEELING DISTRICT**, Senchal in Tiger Hill, alt. 2,362 m, on ground, D. D. Awasthi 3116 (LWG-AWAS) det. T. Ahti 2001.

*Cladonia chlorophaea* (Flörke ex Sommerf.) Spreng. (Fig. 2.8c; Fig. 2.40)

Sprengel, Syst. Veg. 4 (1): 273. 1827.

Basionym: *Cenomyce chlorophaea* Flörke ex Sommerf., Suppl. Fl. Lapp.: 130. 1826.

**Primary thallus:** squamulose; **squamules:** 3–5 mm long, 2–3 mm wide, small, persistent, irregularly crenate-lobate; **podetia:** grey-brown, always scyphose; **scyphi:** to 5 mm wide and 4 mm wide, rarely proliferating from margin into secondary scyphi; **inner surface:** of scyphi granulose to squamulose; **outer surface:** sorediate; margin with brown to brown-black hymenial discs; **podetial surface:** areolate-corticated at base, ecorticate, granulose sorediate to microsquamulose in upper part.

**Chemistry:** Podetia K– or K+ yellowish, P+ orange-red, KC–. Fumarprotocetraric, protocetraric acids and rarely atranorin present.

**Ecology and distribution:** *Microhabitat occupied:* Terricolous; detriticolous-terricolous; muscicolous-terricolous; terricolous-rupicolous. In India, the species exhibits its wide distribution to Himachal Pradesh, Jammu and Kashmir, Meghalaya, Sikkim, Uttarakhand and West Bengal hills. Outside India, the species is also known from Nepal, Australasia, Antarctica, Europe, North and South America. *Cladonia chlorophaea* is close to *C. pyxidata*, the latter differing in the absence of soredia. *C. fimbriata* is subsimilar in being sorediate, but it has farinose soredia, while *C. chlorophaea* has granulose soredia.

**SPECIMENS EXAMINED:** **INDIA:** **HIMACHAL PRADESH, KULLU DISTRICT**, Parvati River valley, above Pulga, alt. 2,460 m, over boulders on soil, D. D. Awasthi and K. Dange 75195 (LWG-LWU), det. T. Ahti 2001; from Dhela to Lapah, alt. 3,000 m, on soil among mosses, D. K. Upreti 99-54092 (LWG), det. T. Ahti 2001; Great Himalayan National Park, around Soudhar, alt. 3,900 m, on mosses over soil, D. K. Upreti 99-53690 (LWG), det. T. Ahti 2001; **CHAMBA DISTRICT**, on way to Khajiar from Dalhousie, alt. 2,350 m, on soil, D. K. Upreti and S. Nayaka 01-75431 (LWG), det. T. Ahti 2001; **LAHAUL SPITI DISTRICT**, Koksar, alt. 3,100 m, on soil, D. K. Upreti 01-26523 B (LWG), det. T. Ahti 2001; **JAMMU AND KASHMIR, BARAMULLA DISTRICT**, Gulmarg, on way from Gulmarg to Khilanmarg, alt. 2,655 m, on rock over soil, K. Dange 77.517 (LWG-LWU), det. T. Ahti 2001; **MEGHALAYA, SHILONG**, near Mawlai on roadside, alt. 1,500 m, on ground by roadside, D. D. Awasthi 7913 (LWG-LWU), det. T. Ahti 2001; **UTTARAKHAND, BAGESHWAR DISTRICT**, Phurkiya to Mirtoli, alt. 3,505 m on soil over boulder, D. D. Awasthi 7794 (LWG-AWAS), det. T. Ahti 2001; near Phurkia (en route to Pindari glacier), alt. 3,200 m, on mossy soil, D. D. Awasthi and A. M. Awasthi 738 (LWG-AWAS), det. T. Ahti 2001; **CHAMOLI DISTRICT**, on way to valley of flower, alt. 3,900 m, on soil over rock with moss, A. Singh and Party 85882 (LWG); between Waan and Bhuna, alt. 2,896 m, on soil, A. Singh and party 90368 (LWG), det. T. Ahti 2001; Badrinath, East of Temple, on way to Devdarshini, alt. 3,150 m, on rock surface over soil, K. Dange 76.811 (LWG-LWU), det. T. Ahti 2001; Badrinath, south of the temple near Brahmini village, alt. 3,200 m, on rock over soil, K. Dange 76.728 (LWG-LWU),

det. T. Ahti 2001; Badrinath, east of the temple on way to Dhantoli village, alt. 3,250 m, on rock over soil, K. Dange 76.851 (LWG-LWU), det. T. Ahti 2001; Auli, below Ghursu top, alt. 3,300 m, on soil with mosses, D. K. Upreti 202349 (LWG), det. T. Ahti 2001; **DEHRADUN DISTRICT**, Chakrata division, Mundali, alt. 2,439 m, on soil, D. D. Awasthi 940 (LWG-AWAS), det. T. Ahti 2001; Chakrata, alt. 2,591 m, on soil in shady place, D. D. Awasthi 944 (LWG-AWAS), det. T. Ahti 2001; Chakrata Hills, Deoban, alt. 2,804 m, on rock over soil, D. D. Awasthi and M. Joshi 76.149 (LWG-LWU), det. T. Ahti 2001; Deoban forest, alt. 2,700 m, on base of *Quercus semecarpifolia* over soil, D. K. Upreti 01-78331 (LWG), det. T. Ahti 2001; **PITHORAGARH DISTRICT**, en route to Milam Glacier, alt. 4,425 m, on soil among mosses, B. S. Kholiya s.n. (LWG), det. T. Ahti 2001; Munsyari on way to Khaliya top after Bhujani, alt. 3,150 m, on soil, D. K. Upreti 212948 (LWG), det. T. Ahti 2001; Munsyari, Khaliya top, alt. 2,850 m, on soil among mosses, D. K. Upreti, S. Joshi, H. Rai, R. Khare, G. K. Mishra and A. Dwivedi 09-013449 (LWG); **RUDRAPRAYAG DISTRICT**, between Madmaheshwar and Gondar, alt. 3,000 m, on soil, A. Singh and M. Ranjan 107013, 107015, 107016, 107023, 107027, 107028 (LWG), det. T. Ahti 2001; en route Tungnath to Madmaheshwar, alt. 3,500 m, on soil, A. Singh and M. Ranjan 107130 (LWG), det. T. Ahti 2001; Tungnath, Chandrashila, alt. 3,750 m, on rock over soil, A. Singh and M. Ranjan 107136 (LWG), det. T. Ahti 2001; Kedarnath, hillside on east and north of the temple, alt. 2,650 m, on rock over soil, K. Dange 76.284 (LWG-LWU), det. T. Ahti 2001; Kedarnath, hillside on west and north of the temple, alt. 3,650 m, on rock over soil, K. Dange 76.231 (LWG-LWU), det. T. Ahti 2001; Kedarnath, hillside on east and north of the temple, alt. 3,650 m, on rock over soil, K. Dange 76.251 (LWG-LWU), det. T. Ahti 2001; Mandakini River Valley, on way from Rambara from Kedarnath, alt. 3,200 m, on rock over soil, K. Dange 76.341 (LWG-LWU), det. T. Ahti 2001; Kedarnath, hillside on east and north of the temple, alt. 3,650 m, on rock surface over soil, K. Dange 76.257 (LWG-LWU), det. T. Ahti 2001; on way from Chopta to Tungnath peak, alt. 3,350 m, on rock over soil, K. Dange 77.553 (LWG-LWU), det. T. Ahti 2001; Tungnath, alt. 3,500 m, on soil over rock, A. Singh and M. Ranjan 10713 (LWG), det. T. Ahti 2001; **UTTARKASHI DISTRICT**, on way to Gomukh 9 km from Gangotri, alt. 3,414 m, on soil, D. D. Awasthi and S. R. Singh 8317, 8318 (LWG-AWAS), det. T. Ahti 2001; on way to Gomukh 11 km from Gangotri, alt. 3,536 m, on soil, D. D. Awasthi and S. R. Singh 8357, 8358 (LWG-AWAS), det. T. Ahti 2001; Gomukh area, right bank, 2nd moraine, alt. 3,901 m, on rocky soil, D. D. Awasthi and S. R. Singh 8388 (LWG), det. T. Ahti 2001; Gomukh area, right bank, 5th moraine, alt. 3,840 m, on soil, D. D. Awasthi and S. R. Singh 8538 (LWG-AWAS); between Jankichatti and Yamunotri, alt. 3,000 m, on rocks over soil, A. Singh and Ram Pher 76047 (LWG), det. T. Ahti 2001; Yamunotri, alt. 3,180 m, on soil, A. Singh and Ram Pher 76073 (LWG), det. T. Ahti 2001; near Jankichatti, alt. 3,000 m, on soil-covered rock, A. Singh and Ram Pher 76090 (LWG), det. T. Ahti 2001; Phool Chatti and Narad Chatti, alt. 2,425 m, on soil, A. Singh 77532 B (LWG), det. T. Ahti 2001; Gangotri, alt. 3,100 m, on ground, Himanshu Rai and Pramod Nag 10-0014518 (LWG); Gangotri, alt. 3,137 m, on soil, Himanshu Rai and Pramod Nag 10-0014523 (LWG); Gangotri, alt. 3,104 m, on ground over *Pinus* litter, Himanshu Rai and Pramod Nag 10-0014528 (LWG); Gangotri, alt. 3,078 m, on soil, Himanshu Rai and Pramod Nag 10-0014531 (LWG); Gangotri, alt. 3,123 m, on ground, Himanshu Rai and Pramod Nag 10-0014542 (LWG); Gangotri, alt. 3,078 m, on soil, Himanshu Rai and Pramod Nag 10-0014543 (LWG); Govind Wild Life Sanctuary, on way to Kedarkantha, alt. 2,324 m, on soil, D. K. Upreti, S. Nayaka, R. Bajpai 11-016038 (LWG); **WEST BENGAL, DARJEELING DISTRICT**, below Sandakhpoo, alt. 3,353 m, on ground by roadside, D. D. Awasthi and M. R. Agarwal 67.361 (LWG-LWU), det. T. Ahti 2001.

### *Cladonia ciliata* Stirt

Stirton, Scott. Natur. 9: 308. 1888.

Synonyms: *Cladina ciliata* (Stirt.) Trass, Folia Crypt. Eston. 11: 6. 1878 (1879).

*Cladonia rangiferina* var. *tenuis* Flörke, De Cladon.: 164. 1828. *Cladonia tenuis*

(Flörke) Harmand, Lich. France 3: 228. 1907–1908. *Cladina tenuis* (Flörke) B. de Lesd., Bull. Soc. Bot. France 54: 680. 1907 (1908). *Cladina ciliata* f. *tenuis* (Flörke); Ahti, Beih. Nova Hedwigia 79: 42. 1984.

**Primary thallus:** squamules not seen, reported to be crustose, evanescent and usually growing in heath; **podetia:** in mats, to 80 mm tall, 1.5 mm thick at base; yellowish below and brownish at apices, usually dichotomously branched, ultimate branchlets recurved on one side with hymenial discs at tips; internodal region 3–5 mm long; **podetial surface:** smooth with glomerules of photobiont cells. Pycnidial jelly red.

**Chemistry:** Podetia K– or K+ yellowish, KC+ yellow, P+ red. Usnic acid (sometimes absent), fumarprotocetraric acid complex present.

**Ecology and distribution:** In India, the species exhibits its restricted distribution to Himalaya (Awasthi 2007; Singh and Sinha 2010). No material of *Cladonia ciliata* has been examined by us; the description is based on Awasthi (2007). Out of India, it is reported from Nepal, Macaronesia, Europe and North America.

***Cladonia coccifera* (L.) Willd. (Fig. 2.8d; Fig. 2.40)**

Willdenow, Fl. Berol. Prodr.: 361. 1787.

Basionym: *Lichen cocciferus* L., Sp. Pl.: 1151. 1753.

Synonym: *Cladonia applanata* Räsänen, Arch. Soc. Zool. Bot. ‘Vanamo’ 5(1): 28. 1950.

**Primary thallus:** squamulose; **squamules:** 3–10 mm long, 2–5 mm wide, sparsely divided into roundish lobes, glaucescent green above, white or often orange-yellow at base part, persistent; **margins:** esorediate; **podetia:** greenish yellow to grey, 5–15 mm tall, always scyphose; scyphi 2–8 mm wide, goblet-shaped, imperforate; **inner surface:** corticated with adpressed squamules; margin entire to rarely proliferating into scyphi; **podetial surface:** corticated at base with peltate squamules, becoming decorticated at scyphi, esorediate. **Apothecia:** infrequent, red, up to 4 mm wide; **hymenial discs:** red on margin of scyphi; **spores:** fusiform to oblong, 6–12 × 2.5–3.4 μm. **Pycnidia:** on cup margins, common, broadly pyriform, constricted at base, black to red, with red gelatin; **conidia:** 3 × 0.5 μm.

**Chemistry:** Podetia K–, P–, KC+ yellow. Usnic, isousnic and rhodocladonic acids, zeorin and sometimes porphyritic acid present.

**Ecology and distribution:** *Microhabitat occupied:* Terricolous; muscicolous-terricolous; terricolous-rupicolous. In India, the species exhibits its wide distribution to Arunachal Pradesh, Himachal Pradesh, Sikkim, Uttarakhand and West Bengal hills. Outside India, the species is also known from Nepal and Bhutan, Australasia, Europe, North and South America. *Cladonia coccifera* is close to *C. pleurota* (Flörke) Schaer., but is distinguished by larger squamules, esorediate podetia and inner surface of scyphi with scaly squamules. *C. borealis* is also somewhat similar, but is more corticated, inner surface of scyphi has round flat plates, tightly attached, and has barbatic acid, and no zeorin crystals.

**SPECIMENS EXAMINED: INDIA: ARUNACHAL PRADESH, WEST KAMENG DISTRICT, Tawang,** alt. 4,000 m, on soil, Jaishree Rout s.n. (LWG); Senge Dzong to Sela, alt. 4,176 m, on moist moss covered soil, Rolla Seshadri Rao 7737 (BSI); Bomdila, alt. 2,400 m, on soil, B.

Dutt and Party s.n. (LWG), det. T. Ahti 2001; **HIMACHAL PRADESH, KULLU DISTRICT**, Great Himalayan National Park, Dhela to Lapah, alt. 3,000 m, on soil among mosses, D. K. Upreti 99-54091 A (LWG), det. T. Ahti 2001; Rohtang pass area, alt. 3,600 m, on soil, D. K. Upreti 01-26518 (LWG), det. T. Ahti 2001; **SIRMAUR DISTRICT**, Renuka, Avate reserve forest, alt. 2,010 m, on soil, Chatterjee, Dubey and Nayaka 20-66753 (LWG), det. T. Ahti 2001; **SIKKIM, NORTH SIKKIM**, Tshangmo, alt. 3,862 m, on ground, D. D. Awasthi 397 (LWG-AWAS); Chubuk, above Thangu, alt. 4,100 m, on soil, Upreti, Chatterjee and Divakar 04-003944 A (LWG); **WEST SIKKIM**, Jongri, alt. 3,962, on soil, M. N. Bose 6326 (LWG-LWU); near Changu, alt. 3,353 m, on soil, D. D. Awasthi 117 B (LWG-AWAS), det. T. Ahti 2001; **UTTARAKHAND, BAGESHWAR**, Phurkia, alt. 3,150 m, on Soil over rock, A. Singh 91964 (LWG), det. T. Ahti 2001; **PITHORAGARH DISTRICT**, Munsiyari, alt. 2,100 m, on soil, D. K. Upreti 212924 (LWG), det. T. Ahti 2001; en route to Milam Glacier, alt. 4,000 m, on soil, B. S. Kholia s.n. (LWG), det. T. Ahti 2001; Munsiyari on way to Khaliya Top after Bhujani, alt. 3,050 m, on soil, D. K. Upreti 212950 (LWG), det. T. Ahti 2001; Narain Swami Ashram, alt. 2,743 m, on soil, D. K. D. K. Upreti, S. Joshi, H. Rai, R. Khare, G. K. Mishra and A. Dwivedi 09-012181 (LWG); **RUDRAPRAYAG DISTRICT**, Tungnath to Chandrashila, alt. 3,750 m, on rock surface over soil, A. Singh and M. Ranjan 10715 (LWG), det. T. Ahti 2001; Kedarnath hillside on west of the temple, alt. 3,620 m, on rock surface over soil, K. Dange 76.187 (LWG-LWU); Kedarnath, hillside on east and north of temple, alt. 3,650 m, on rock over soil, K. Dange 76.242 A (LWG-LWU); Tungnath, Tungnath Bugyal, alt. 3,400 m, on soil over rock, Himanshu Rai and Pramod Nag 08-0012203, 08-0012204, 08-0012205, 08-0012206, 08-0012208, 08-0012209, 08-0012220, 08-0012211, 08-0012233 (LWG); Tungnath, below the temple (6±2 m) on the right of the road to Chandrashila, alt. 3,400 m, on soil over rock, Himanshu Rai and Pramod Nag 08-0012213, 09-0012253 (LWG), det. T. Ahti Sept. 2009; **UTTARKASHI DISTRICT**, Above Yamunotri, alt. 3,658 m, on ground among mosses, D. D. Awasthi 880 (LWG-AWAS); **WEST BENGAL, DARJEELING DISTRICT**, Sandakhpoo area, alt. 3,353 m, on ground, M. N. Bose 6355 (LWG-AWAS); near Sandakhpoo, alt. 3,658 m, on ground, D. D. Awasthi 2498 (LWG-AWAS); on way from Sandakhpoo to Pahlut, alt. 3,658 m, on ground, D. D. Awasthi and M. R. Agarwal 67.470 (LWG-AWAS); Tiger hill, alt. 2,362 m, on soil over rock, M. N. Bose 6210 (LWG-AWAS).

***Cladonia coniocraea*** (Flörke) Spreng. (Fig. 2.8e; Fig. 2.40)

Sprengel, Syst. Veg. 4(1): 272. 1827.

Basionym: *Cenomyce coniocraea* Flörke, Deutschl. Lich. 7: 14. 1821, *nom. cons.*

**Primary thallus:** squamulose; **squamules:** small to medium-sized, persistent, 3–9 mm long, 2–5 mm wide, deeply lacinate to palmately lobed, sparingly to abundantly sorediate along margins of underside; **podetia:** green, 5–15 mm tall, usually simple, sparingly branched, tapering, subulate, escyphose or sometimes scyphose; **scyphi:** infrequent, 1–2 mm wide, totally sorediate; **podetial surface:** corticated near base with or without squamules, major upper part decorticated, farinose-sorediate. **Hymenial discs:** brown at tips of podetia. **Pycnidia:** infrequent, on tips of podetia, ovoid, with hyaline gelatin; **conidia:** 4–8 × 0.5–1.5 µm.

**Chemistry:** Podetia K<sup>-</sup> or K<sup>+</sup> faintly brownish, P<sup>+</sup> red, KC<sup>-</sup>. Fumarprotocetraric acid present.

**Ecology and distribution:** *Microhabitat occupied:* Terricolous; muscicolous-terricolous; terricolous-rupicolous; detriticolous-terricolous. In India, the species exhibits its wide distribution to Arunachal Pradesh, Himachal Pradesh, Jammu and Kashmir, Nagaland and Uttarakhand. Outside India, the species is also known from Australia and Bhutan, Africa, Europe, North America. *Cladonia coniocraea* is often confused with commoner *C. ochrochlora*, which is more robust and corticated higher up, even inside scyphi.

**SPECIMENS EXAMINED: INDIA: HIMACHAL PRADESH, SHIMLA DISTRICT**, Chaupal, Ghadal, alt. 2,500 m, on soil, S. Nayaka and R. Srivastava 02-77786 (LWG); **JAMMU AND KASHMIR, BARAMULLA DISTRICT**, Khilanmarg, alt. 2,286 m, on soil, K. N. Kaul and Party s.n. (LWG), det. T. Ahti 2001; Babarishi, alt. 2,250 m, on soil with mosses, K. N. Kaul and party s.n. (LWG), det. T. Ahti 2001; **UTTARAKHAND, ALMORA DISTRICT**, en route to Sunderdhunga Glacier, between Jatoli and Dhuniyadon, alt. 3,248 m, on soil, D. K. Upreti and Jyoti Tandon 213817 A (LWG); Chaubattia, alt. 8,400 m, on decayed bark, A. Singh 90202 (LWG), det. T. Ahti 2001; **BAGESHWAR DISTRICT**, en route to Pindari Glacier from Dwali to Phurkiya, alt. 2,972 m, on soil, S. Joshi and Y. Joshi 07-008880 (LWG); **UTTARKASHI DISTRICT**, Gangotri towards Kedartal, alt. 3,100 m, on soil, S. Chatterjee and P. K. Divakar 02-000435 (LWG); Gangotri, alt. 3,123 m, on soil over rocks, Himanshu Rai and Pramod Nag 10-0014510 (LWG); Govind Wild Life Sanctuary, Gyan Khad, alt. 2,074 m, on rock over soil, D. K. Upreti, S. Nayaka, R. Bajpai 11-015810 (LWG); Gyan Khad, alt. 2,324 m, on soil, D. K. Upreti, S. Nayaka, R. Bajpai, 11-016074 B (LWG); Taluka to Osla, alt. 2,170 m, on soil and decaying wood, D. K. Upreti, S. Nayaka, R. Bajpai 11-015854 (LWG); Taluka to Osla, alt. 2,052 m, on rock over soil, D. K. Upreti, S. Nayaka, R. Bajpai 11-015880 (LWG).

*Cladonia corniculata* Ahti and Kashiw. (Fig. 2.8f; Fig. 2.40)

In Inoue, Stud. Cryptog. S. Chile: 136. 1984.

**Primary thallus:** squamulose; **squamules:** small, soresiate, brownish on upper surface; **podetia:** white to yellow-grey, branched in the apical region, always escyphose, subulate to blunt with brown hymenial discs or pycnidia at tips; **podetial surface:** ecorticated, farinose-soresiate; **soredia:** caducous exposing medulla (ste-reome); microsquamules at base.

**Chemistry:** Podetia K<sup>-</sup>, P<sup>+</sup> red. Fumarprotocetraric acid and protocetraric acids present.

**Ecology and distribution:** *Microhabitat occupied:* Terricolous; terricolous-rupicolous; detriticolous-terricolous; muscicolous-terricolous. In India, the species exhibits its wide distribution to Arunachal Pradesh, Himachal Pradesh, Jammu and Kashmir, Kerala, Meghalaya, Sikkim, Uttarakhand and West Bengal hills. Outside India, the species is also known from China, South Africa and Thailand, Australasia, Central and South America. *Cladonia corniculata* is close to *C. cartilaginea* differing in having finer soredia, and taller and more branched podetia.

**SPECIMENS EXAMINED: INDIA: HIMACHAL PRADESH, KULLU DISTRICT**, Great Himalayan National Park, around Shilt, alt. 3,000 m, on rock over soil, D. K. Upreti 99-53626 B (LWG); **SHIMLA DISTRICT**, Sanjauli, alt. 2,100 m, on soil, A. Singh and Ram Pher L18228 (LWG), det. T. Ahti 2001; **SOLAN DISTRICT**, Kandaghat, koel, alt. 1,615 m, on soil, S. Nayaka 20-85719 (LWG), det. T. Ahti 2001; **JAMMU AND KASHMIR, ANANTNAG DISTRICT**, Pahalgam, west side, alt. 2,400 m on dead wood, M. Sheikh 05-006119 (LWG); **BARAMULLA DISTRICT**, Gulmarg, South side of Gulmarg, alt. 2,500 m, on dead wood, M. Sheikh 05-006045 (LWG); **KERALA, MUNNAR DISTRICT**, Rajmala, alt. 1,840 m, on mud walls, Biju Haridas 06-014769 (LWG); **SIKKIM, NORTH SIKKIM**, Near Yumthang, alt. 3,800 m, on soil, Upreti, Chatterjee, and Divakar 04-004203 (LWG); **EAST SIKKIM**, near lower Zuluk, alt. 2,600 m, Sinha 886 (BSHC); **WEST SIKKIM**, Kongri village forest, alt. 2,000 m, Sinha 336 A (BSHC); **TAMIL NADU, DINDIGUL DISTRICT, PALNI HILLS**, Kodaikanal, Shenbaganur, alt. 1,829 m, on soil, D. D. Awasthi and K. P. Singh 70-61 C (LWG), det. T. Ahti 2001; Kodaikanal, Pillar rock area, alt. 2,240 m, on decaying wood K. P. Singh 70.742 (LWG-LWU), det. T. Ahti 2001; **NILGIRI HILLS**, Doddabetta forest toward north, alt. 2,286 m, on soil with mosses, V. S. Sharma s.n. (LWG), det. T. Ahti 2001; Ootacamund, on way to Doddabetta peak, alt. 2,567 m, on soil, G. Awasthi 82-14 (LWG-LWU), det. T. Ahti 2001; **MADURAI**, Shola near 9th mile Kodaikanal-Berijiam road, alt. 2,286 m, on ground, G. Foreau and D. D. Awasthi



4203 B (LWG-AWAS), det. T. Ahti 2001; **UTTARAKHAND, BAGESHWAR DISTRICT**, between Loharkhet and Dhakuri, alt. 2,550 m, on soil at base of tree, A. Singh 84657 (LWG), det. T. Ahti 2001; Khati to Dwali, alt. 2,438 m, on ground in shade, D. D. Awasthi 7633 (LWG-AWAS), det. T. Ahti 2001; en route to Sunderdhunga Glacier, alt. 2,700 m, on soil, Upreti and Tandon 213390 (LWG), det. T. Ahti 2001, en route Loharkhet to Dhakuri, alt. 2,680 m, on soil, S. Joshi and Y. Joshi 07-008873 (LWG); **CHAMOLI DISTRICT**, Mandakini River Valley, on way from Sonprayag to Gaurikund, alt. 1,850 m, on ground, K. Dange 76.60 (LWG-LWU), det. T. Ahti 2001. Mandakini River Valley, on way from Sonprayag to Gaurikund, alt. 1,890 m, on rock over soil, K. Dange 76.67 (LWG-LWU), det. T. Ahti 2001; Mandakini River Valley, on way from Gaurikund to Rambara, alt. 2,750 m, on rock surface on mud, K. Dange 76.99 (LWG-LWU), det. T. Ahti 2001; Hemkund area, alt. 2,743 m, on soil, A. Saklani s.n. (LWG), det. T. Ahti 2001; **DEHRADUN DISTRICT**, Mussoorie, alt. 2,058 m, on dead wood stump, D. D. Awasthi 3820 (LWG-AWAS), det. T. Ahti 2001; Chakrata hills, on way to Deoban, alt. 2,591 m, on stones over soil with mosses, D. D. Awasthi and M. Joshi 76.76 (LWG-LWU), det. T. Ahti 2001; **PAURI GARHWAL DISTRICT**, Lansdown, Jaiharikal Road, alt. 3,600 m, on soil, S. K. Katiyar s.n. (LWG); **PITHORAGARH DISTRICT**, Lohaghat, alt. 2,650 m, on soil, D. K. Upreti 212942 (LWG), det. T. Ahti 2001; Gori-Ganga catchment area, alt. 1,650 m, on soil, Vikas Pant 02-000721 (LWG); Askot, Snadev Botanical Hotspot, alt. 2,000 m, on soil, Vikas Pant 02-103973 (LWG); **RUDRAPRAYAG DISTRICT**, Madmaheshwar between Kalimath and Laink, alt. 1,300 m, on soil, A. Singh and M. Ranjan 106875 (LWG), det. T. Ahti 2001; between Madmaheshwar and Gondar, alt. 3,000 m, on soil, A. Singh and M. Ranjan 106999 (LWG), det. T. Ahti 2001; between Madmaheshwar and Gondar, alt. 3,000 m, on soil, A. Singh and M. Ranjan 106998 (LWG), det. T. Ahti 2001; between Kalimath and Gupta Kashi, alt. 1,200 m, on rock over soil, A. Singh and M. Ranjan 107096 (LWG), det. T. Ahti 2001; between Madmaheshwar and Gondar, alt. 3,000 m, on soil, A. Singh and party 1070204 (LWG), det. T. Ahti 2001; between Madmaheshwar and Gondar, alt. 3,000 m, on rock over soil, A. Singh and M. Ranjan 107011 (LWG), det. T. Ahti 2001; Kedarnath, hillside on east and north of the temple, alt. 3,650 m, on rock surface over soil, K. Dange 76.277 (LWG-LWU), det. T. Ahti 2001; Kedarnath on way from Sonprayag to Tryuginarain, alt. 2,100 m, on rock over soil, K. Dange 76.339 (LWG-LWU), det. T. Ahti 2001; Kedarnath, on way from Sonprayag to Tryuginarain, alt. 2,190 m, on rock over soil, K. Dange 76.385 (LWG-LWU), det. T. Ahti 2001; Kedarnath, on way from Sonprayag to Tryuginarain, alt. 2,100 m, on rock over soil, K. Dange 76.389(LWG-LWU), det. T. Ahti 2001; Kedarnath, on way from Sonprayag to Tryuginarain, alt. 2,350 m, on rock over soil, K. Dange 76.401(LWG-LWU), det. T. Ahti 2001; Kedarnath, on way from Sonprayag to Tryuginarain, alt. 2,100 m, on rock over soil, K. Dange 76.407(LWG-LWU), det. T. Ahti 2001; Kedarnath, on way from Sonprayag to Tryuginarain, alt. 2,100 m, on rock over soil, K. Dange 76.431 (LWG-LWU), det. T. Ahti 2001; Kedarnath, on way from Sonprayag to Tryuginarain, alt. 2,100 m, on rock over soil, K. Dange 76.439 (LWG-LWU), det. T. Ahti 2001; **TEHRI GARHWAL DISTRICT**, between Silkara and Gangrani, alt. 1,981 m, on soil, D. D. Awasthi 894 (LWG-AWAS), det. T. Ahti 2001; **NAINITAL DISTRICT**, Jim Corbett National Park, Dugadda, alt. 950 m, on soil in vertical slope, D. K. Upreti and Jyoti Tandon 217402 (LWG), det. Ahti 2001; on the way of Tiffin Top, alt. 2,439 m, on the rock surface over soil along with mosses, D. D. Awasthi and K. Dange 74.59 (LWG-LWU), det. T. Ahti 2001; **UTTARKASHI DISTRICT**, Gomukh area, right bank 2nd moraine, alt. 3,901 m, on rocky soil, D. D. Awasthi and S. R. Singh 8393 (LWG-AWAS), det. T. Ahti 2001; between Janki Chatti and Yamunotri, alt. 3,000 m, on soil, A. Singh and party 76058, 76059 (LWG), det. T. Ahti 2001; Gangotri-Gomukh trek, Chirwasa, alt. 3,500 m, on soil, S. Chatterjee and P. K. Divakar 02-000250 (LWG); Govind Wild Life Sanctuary, from Sankri to Taluka, Gomighat, alt. 1,982 m, on soil over rock, D. K. Upreti, S. Nayaka, R. Bajpai 11-013255, 11-013290 (LWG); Govind Wild Life Sanctuary, Taluka to Osla, alt. 2,150 m, on soil, D. K. Upreti, S. Nayaka, R. Bajpai 11-015816 (LWG); **WEST BENGAL, DARJEELING DISTRICT**, Observatory Hill, alt. 2,134 m, on ground, D. D. Awasthi 3871 (LWG-AWAS), det. T. Ahti 2001.

***Cladonia corymbescens*** Nyl. ex Leight. (Fig. 2.8g; Fig. 2.40)

Leighton, Ann. Mag. Nat. Hist. ser. 3, 18: 407. 1866.

Synonym: *Cladonia rangiformis* var. *incurva* Müll. Arg., Flora.74: 372. 1891.

**Primary thallus:** squamulose; **squamules:** minute to small, soon disappearing; **podetia:** white to dark brown, 10–25(–35) mm tall, dying at base, repeatedly subcorymbosely branched, escyphose, subulate at apices; **axils:** perforated; **podetial surface:** smooth, corticated, with or without squamules at base, longitudinally fissured, esorediate.

**Chemistry:** Podetia K+ yellow, P+ red, C–. Atranorin, fumarprotocetraric and protocetraric acids present.

**Ecology and distribution:** *Microhabitat occupied:* Terricolous; muscicolous-terricolous; terricolous-rupicolous. In India, the species exhibits its wide distribution to Arunachal Pradesh, Himachal Pradesh, Kerala, Sikkim, Tamil Nadu, Uttarakhand and West Bengal hills. Outside India, the species is also known from Bhutan, China, Nepal, New Caledonia and New Zealand. *Cladonia corymbescens* is close to *C. furcata*. The latter has a very hard central stereome. It is also close to *C. submultiformis*, the latter differs in the presence of highly squamulose podetia, abundant hymenial discs and homosekikaic acid.

**SPECIMENS EXAMINED: INDIA: HIMACHAL PRADESH, KULLU DISTRICT,** Great Himalayan National Park, on way from Dhela to Lapah, alt. 3,000 m, on soil, D. K. Upreti 99-54094 (LWG), det. T. Ahti 2001; around Patal, alt. 2,800 m, on soil over rock, D. K. Upreti 99-53667 B (LWG); **MANDI DISTRICT,** en route from Bart to Winch camp, alt. 2,200 m, on soil, D. K. Upreti 213547 (LWG), det. T. Ahti 2001; **KERALA, KOLLAM DISTRICT,** Agasthyamala Biosphere Reserve, Athirumala, near Dormitory, alt. 1,100 m, on soil, Biju Haridas 06-014702 (LWG); **SIKKIM, EAST SIKKIM,** Kupup, alt. 4,100–4,200 m, Sinha 1504 (BSHC); **WEST SIKKIM,** Yuksum, alt. 1,880 m, on soil, M. N. Bose 6276 (LWG-AWAS), det. T. Ahti 2001; Yuksum-Tsoka trek, alt. 2,425 m, on soil, G. P. Sinha 184 (BSHC), det. T. Ahti 2001; **TAMIL NADU, MADURAI,** Shenbaganur, Kodaikanal, along heving's path, alt. 1,829 m, on soil, G. Foreau and D. D. Awasthi 4300 (LWG-AWAS), det. T. Ahti 2001; **UTTARAKHAND, BAGESHWAR DISTRICT,** Dwali, alt. 2,700 m, on soil over rock, A. Singh 91918 (LWG), det. T. Ahti 2001; en route to Sunderdhunga Glacier, between Dhakuri and Jatoli, alt. 2,286 m, on soil, D. K. Upreti and Jyoti Tandon 213486 (LWG), det. T. Ahti 2001; between Loharkhet and Dhakuri, alt. 2,550 m, at base of tree trunk on soil, A. Singh 84659 (LWG), det. T. Ahti 2001; near Phurkia on way to Pindari glacier, alt. 3,200 m, on mossy soil, D. D. Awasthi and A. M. Awasthi 742 (LWG-AWAS), det. T. Ahti 2001; en route to Pindari Glacier from Dhakuri to Khati, alt. 2,683 m, on soil, S. Joshi and Y. Joshi 07-008876 (LWG); **CHAMOLI DISTRICT,** between Waan and Bagrigad, alt. 2,100 m, on soil, A. Singh s.n. (LWG), det. T. Ahti 2001; Badrinath near Vasudhara Glacier, alt. 3,900 m, on soil, D. K. Upreti 202376, 202378, 202380 (LWG), det. T. Ahti 2001; Gopeshwar, alt. 1,400 m, on soil, H. R. Negi L 3707 (LWG), det. T. Ahti 2001. Dumri forest, alt. 2,000 m, on soil, D. K. Upreti, P. K. Divakar, S. Rawat 06-10690 (LWG); **DEHRADUN DISTRICT,** Chakrata, Deoban, alt. 2,743 m, on ground among mosses, D. Awasthi 479 (LWG-AWAS), det. T. Ahti 2001; Chakrata, Mundali, alt. 2,591 m, on soil among mosses, D. D. Awasthi 937, 985 (LWG-AWAS), det. T. Ahti 2001; **NAINITAL DISTRICT,** Nainital, on way of Naina Peak, alt. 2,438 m, on rock surface over soil, D. D. Awasthi and K Dange 74.17 (LWG-LWU), det. T. Ahti 2001; **PITHORAGARH DISTRICT,** Dharchula, alt. 2,400 m, on soil, D. K. Upreti L/18414 (LWG), det. T. Ahti 2001; Munsiyari, on way to Khaliya top after Bhujani, alt. 3,050 m, on soil, D. K. Upreti 212953 (LWG), det. T. Ahti 2001; en route to Milam glacier, alt. 4,340 m, on soil among mosses, B. S. Kholia s.n. (LWG), det. T. Ahti 2001; **RUDRAPRAYAG DISTRICT,** Guptakashi, Madmaheshwar to Gondar, alt. 3,000 m, on soil, A. Singh and M. Ranjan 107004 (LWG),

det. T. Ahti 2001; Madmaheshwar between Chopta and Tungnath, alt. 3,000 m, on soil, A. Singh and M. Ranjan 107014 (LWG), det. T. Ahti 2001; Dugalbitta to Madmaheshwar, alt. 2,300 m, on soil, A. Singh and Party 107109 (LWG), det. T. Ahti 2001; Madmaheshwar between Chopta and Tungnath, alt. 2,750 m, on rock over soil, A. Singh 107121 (LWG); Madmaheshwar, between Dugalbitta and Pothibasa, alt. 2,250 m, on soil, A. Singh and M. Ranjan 1070205 (LWG), det. T. Ahti 2001; Kedarnath, on way from Sonprayag to Triyuginarain, alt. 2,238 m, on rock surface over soil, K. Dange 76.411 (LWG-LWU), det. T. Ahti 2001; Kedarnath on way from Sonprayag to Triyuginarain, alt. 2,238 m, on rock surface over soil, K. Dange 76.432 (LWG-LWU), det. T. Ahti 2001; Kedarnath on way from Sonprayag to Triyuginarain, alt. 2,238 m, on rock surface over soil, K. Dange 76.478 (LWG-LWU), det. T. Ahti 2001; on way from Chopta to Tungnath peak, alt. 3,050 m, on rock over soil among mosses in moist places, K. Dange 76.601, 76.601 Dup (LWG-LWU), det. T. Ahti 2001; Chopta, alt. 2,800 m, on soil, D. K. Upreti and B. Kumar 06-005978 (LWG); Kedarnath valley, around Kedarnath Temple, alt. 3,500 m, on soil, D. K. Upreti, P. K. Divakar and B. Kumar 06-006217 (LWG); Tungnath area, alt. 3,250 m, on soil, D. K. Upreti and S. Nayaka 07-010194 (LWG); **TEHRI GARHWAL DISTRICT**, Dhanaulti, alt. 2,286 m, on rock over red soil with mosses, A. Singh and party 77589 (LWG), det. T. Ahti 2001; **UTTARKASHI DISTRICT**, Gangotri towards Kedartal, alt. 3,100 m, on rock over soil, S. Chatterjee and P. K. Divakar 02-000412 (LWG); Gangotri towards Kedartal, alt. 3,100 m, on soil, S. Chatterjee and P. K. Divakar 02-000421 (LWG), det. T. Ahti 2001; **WEST BENGAL, DARJEELING DISTRICT**, below Sandakhpoo, alt. 3,353 m, in sandy soil, D. D. Awasthi and M. R. Agarwal 67.358 (LWG-LWU), det. T. Ahti 2001; Sandakhpoo, alt. 3,570 m, on soil, P. D. Dogra s.n. (LWG), det. T. Ahti 2001; Tiger Hill, alt. 2,438 m, on soil, M. N. Bose 6232 (LWG-AWAS), det. T. Ahti 2001.

***Cladonia crispata*** (Ach.) Flot. (Fig. 2.8h; Fig. 2.40)

In Wendt, Die Thermen zu Warmbrunn 93 (Merkw. Flecht. Hirschb.): 4. 1839.

Basionym: *Baeomyces turbinatus* var. *crispatus* Ach., Methodus: 341. 1803.

var. *cestrariiformis* (Delise) Vain.

In Olivier, Rev. Bot. Bull. Mens. 4: 238. 1886.

Basionym: *Cenomyce gracilis* var. *cestrariiformis* Delise in Duby, Bot. Gall. 2: 625. 1830, as '*cestrariaeformis*'.

**Primary thallus:** squamulose; **squamules:** small, persistent or disappearing; **podetia:** pale to dark brown, over 50 mm tall, to 1.5 mm thick at base, branched and axils open at apices, generally escyphose, subulate or blunt, rarely with very narrow scyphi; **podetial surface:** areolate, corticated with few squamules at base, esorediate. **Apothecia:** formed along the margin of scyphi, moderately abundant, 0.15–0.8 mm in diam.; **hymenial discs:** rare, brown at tips of podetia. **Conidiomata:** abundant on margins of scyphi. **Pycnidia:** with reddish gel.

**Chemistry:** Podetia K<sup>-</sup>, or K<sup>+</sup> yellow, P<sup>+</sup> yellow or P<sup>-</sup>, UV<sup>+</sup> white or UV<sup>-</sup>. Squamatic acid with barbatic and rarely thamnolic acid present.

**Ecology and distribution:** *Microhabitat occupied:* Terricolous. In India, the species exhibits its restricted distribution to Sikkim and Uttarakhand. Outside India, the species is also known from Australasia, Europe, North and South America.

**SPECIMENS EXAMINED:** **INDIA: SIKKIM, WEST SIKKIM,** Dzongri, on soil, L. K. Rai (BSHC), det. T. Ahti; **UTTARAKHAND, RUDRAPRAYAG DISTRICT,** Chopta to Tungnath, alt. 3,250 m, on soil, D. K. Upreti and S. Nayaka 07-011203 (LWG).

***Cladonia delavayi*** Abbayes (Fig. 2.8i; Fig. 2.40)

Abbayes, Candollea 16: 203. 1958.

**Primary thallus:** not known; **podetia:** in dense mats, whitish grey to grey, with indefinite growth, dying basally, di- or trichotomously densely branched, forming unidirectional helicoids; **branches:** deflexed, curved and intricate, always escyphose; axils closed; **podetial surface:** thick-corticated, smooth to verruculose-areolate, esorediate, lacking squamules. **Hymenial discs:** brown black. **Pycnidia:** at tips of ultimate branchlets, pycnidial gel colourless.

**Chemistry:** Podetia K<sup>-</sup>, P<sup>-</sup>, C<sup>-</sup>, KC<sup>+</sup> yellowish. Usnic, cryptochlorophaeic and 4-*O*-cryptochlorophaeic acids present.

**Ecology and distribution:** *Microhabitat occupied:* Terricolous; muscicolous-terricolous; terricolous-rupicolous. In India, the species exhibits its wide distribution to Arunachal Pradesh, Sikkim, Uttarakhand and West Bengal hills. Outside India, the species is also known from Bhutan, China and Nepal. *Cladonia delavayi* resembles *C. ciliata* in external morphology, but anatomically is close to *C. amaurocraea*.

**SPECIMENS EXAMINED: INDIA: ARUNACHAL PRADESH, WEST KAMENG DISTRICT,** Senge Dzong to Sela, alt. 4,176 m, on moist moss covered surface over soil, Rolla Seshagiri Rao 7726 (LWG-LWU); **SIKKIM, WEST SIKKIM,** Phithang-Dzongri 3 km, alt. 3,963 m, on soil in open places, G. P. Sinha 262 (BSHC), det. T. Ahti 2001; Yaksum, alt. 1,880 m, on soil, M. N. Bose 6275 (LWG-LWU); **NORTH SIKKIM,** Lachung, alt. 2,700 m, on soil over rock, Sharma and Ranjan 76794 (LWG), det. T. Ahti 2001; Singhbo Rhododendron Sanctuaray, near Yumthang, alt. 3,500 m, on soil, Upreti, Chatterjee and Divakar 04-004094 (LWG); Changu, alt. 3,658 m, on ground among mosses, D. D. Awasthi 109 (LWG-AWAS); **UTTARAKHAND, BAGESHWAR DISTRICT,** above Phurkiya towards Pindari glacier, alt. 3,505 m, on soil among mosses, D. D. Awasthi and A. M. Awasthi 787 (LWG-AWAS); **CHAMOLI DISTRICT,** Pathar Nachauni, alt. 4,050 m, on soil with mosses, A. Singh 91512 (LWG); **CHAMPAWAT DISTRICT,** Marodkhan on way to Ghat, alt. 1,618 m, on rock over soil, G. K. Mishra 10-015298 (LWG); **WEST BENGAL, DARJEELING,** Tiger hill, alt. 2,362 m, on soil, M. N. Bose 6218 (LWG-AWAS).

***Cladonia didyma*** (Fée) Vain. (Fig. 2.9a; Fig. 2.41)

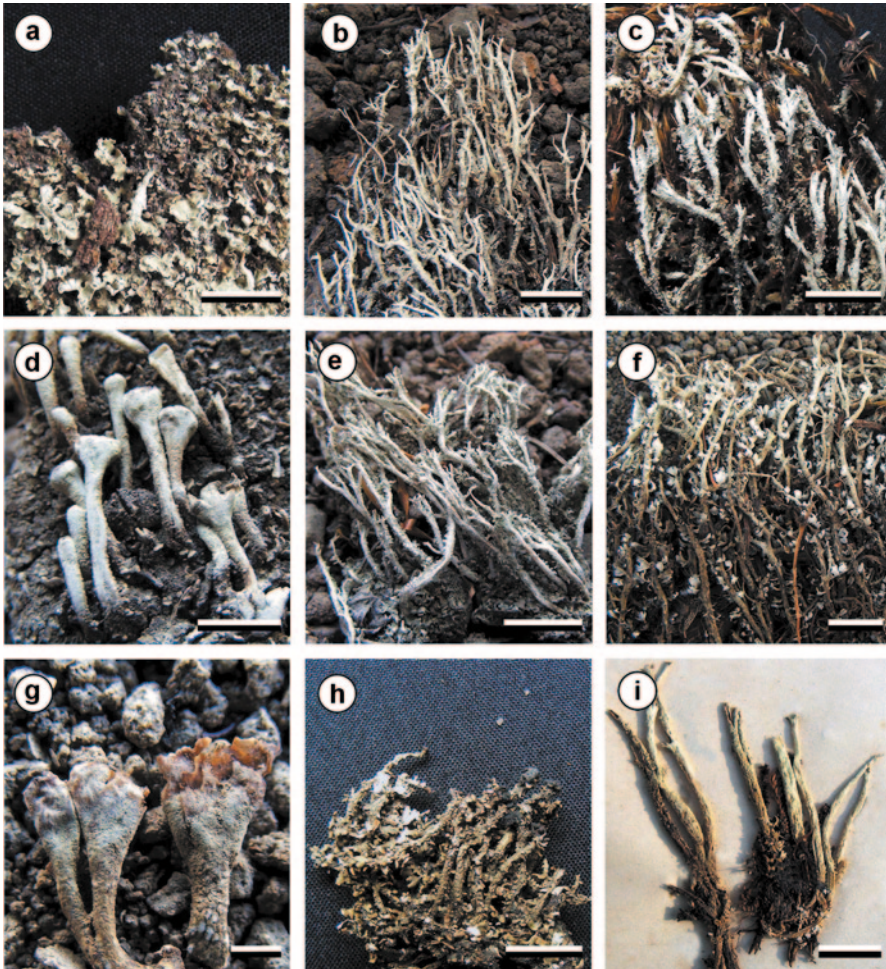
Vainio, Acta Soc. Fauna Fl. Fenn. 4: 137. 1887.

Basionym: *Scyphophorus didymus* Fée, Essai Crypt. Ecorc.: 118. 1825.

Synonym: *Cladonia vulcanica* Zoll. and Moritzi, Natuur-Genesks. Arch. Ned. Indie 1: 396. 1844. -*C. didyma* var. *vulcanica* (Zoll. and Moritzi) Vain., Acta Soc. Fauna Fl. Fenn. 4: 145. 1887.

**Primary thallus:** squamulose, persistent; **squamules:** dense, 1–2 × 1–1.5 (4) mm, crenate to irregularly crenulate to lobulate-laciniate, esorediate, with shiny upper side; **podetia:** pale grey to brownish, 5–15 mm tall, 1–2 mm thick at base, simple to sparingly branched, usually subulate, escyphose; very rarely with narrow deformed scyphi; **podetial surface:** corticated to ecorticated, granulose-sorediate, with dense squamules and microsquamules projecting downwards. **Hymenial discs:** red, at tips of podetia.

**Chemistry:** Podetia K<sup>+</sup> yellow or K<sup>-</sup>, KC<sup>+</sup> yellowish, P<sup>+</sup> yellow orange or P<sup>-</sup>. Two chemical strains (in addition to rhodocladonic acid) present: (1) barbatic,



**Fig. 2.9** **a** *Cladonia didyma* (Fée) Vain., **b** *C. farinacea* (Vain.) A. Evans, **c** *C. fenestralis* Nuno, **d** *C. fimbriata* (L.) Fr., **e** *C. fruticulosa* Kremp., **f** *C. furcata* (Huds.), **g** *C. humilis* (With.) J. R. Laundon, **h** *C. indica* Ahti and Upreti, **i** *C. laii* S. Stenroos Schrad. Scale in **g**=3 mm; **d**=5 mm; in **a, b, c, e, f, h, i**=10 mm

didymic acids and (2) thamnolic, didymic acids, sometimes additional barbatic acid. The Indian specimens usually belong to second chemical strain (Awasthi 2007).

**Ecology and distribution:** *Microhabitat occupied:* Detriticolous-terricolous. In India, the species exhibits its wide distribution to temperate regions of Arunachal Pradesh, Kerala, Sikkim, Tamil Nadu, Uttarakhand and West Bengal hills. Outside India, the species is also known from Bhutan, Australasia, Oceania, Africa, North and South America.

**SPECIMENS EXAMINED:** **INDIA: ARUNACHAL PRADESH, WEST KAMENG DISTRICT,** from Bomdila to Sela, alt. 2,962 m, on decaying wood, Upreti, Dubey, Khare and Misra 08-009360

(LWG); **SIKKIM, NORTH SIKKIM**, 2 km before Shingba Rhododendron Sanctuary, alt. 3,300 m, on decaying wood, Upreti, Chatterjee and Divakar 04-004078 (LWG).

***Cladonia farinacea*** (Vain.) A. Evans (Fig. 2.9b; Fig. 2.41)

Evans, *Rhodora* 52: 95. 1950.

Basionym: *Cladonia furcata* var. *farinacea* Vain., in Hariot, *J. Bot. (Morot)* 1: 283. 1887.

**Primary thallus:** squamulose; **squamules:** medium-sized, olive-green on upper side and yellowish grey on lower side; **podetia:** grey-white, 40–50(–80) mm tall, to 1.5 mm thick at base, usually dichotomously branched, always escyphose, tapering, subulate; **axils:** open with slits; **podetial surface:** corticated at base, sparingly squamulose; **upper parts:** farinose-sorediate. **Hymenial discs:** brown at tips of podetia. **Pycnidia:** at podetial tip.

**Chemistry:** Podetia K<sup>+</sup> yellow, KC<sup>-</sup>, P<sup>+</sup> red. Atranorin, fumarprotocetraric acid, rarely ursolic acid present.

**Ecology and distribution:** *Microhabitat occupied:* Terricolous. In India, the species exhibits its restricted distribution to temperate regions of Jammu and Kashmir, Tamil Nadu and Uttarakhand. Outside India, the species is also known to be reported from Australia, Bhutan, Japan and North and South America. *Cladonia farinacea* resembles *C. furcata* but differs in the presence of patches of farinose soredia.

**SPECIMENS EXAMINED:** **INDIA:** **JAMMU AND KASHMIR, BARAMULLA DISTRICT**, Baba Rishi, alt. 2,286 m, on soil, K. N. Kaul and Party s.n. (LWG), T. Ahti 2001; **TAMIL NADU, NILGIRI AVALANCHE**, Emerald road, along roadside, near forest rest house, alt. 2,134 m, on red sandy soil in moist places, K. P. Singh 71.331 (LWG-LWU); **UTTARAKHAND, PITHORAGARH DISTRICT**, Askot-Sandev Botanical Hotspot, alt. 2,000 m, on soil, Vikas Pant 02-103959 (LWG).

***Cladonia fenestralis*** Nuno (Fig. 2.9c; Fig. 2.41)

Nuno, *J. Jap. Bot.* 50: 291. 1975.

Synonyms: *Cladonia gracilis* var. *squamosissima* Müll. Arg., *Flora* 74: 372. 1891. *C. squamosissima* (Müll. Arg.) Ahti, *Ann. Bot. Fenn.* 17:233. 1980.

**Primary thallus:** not seen; **podetia:** growing on humus-rich soil, dark to brownish, simple or sparingly branched, subulate, escyphose or scyphose; **scyphi:** up to 2 mm wide, often deformed; **podetial surface:** corticated or ecorticated, esorediate, squamulose; **squamules:** reflexed exposing white lower surface; podetial wall very soft, with longitudinal fissures or slits. **Hymenial discs:** brown and pycnidia at tips of podetia.

**Chemistry:** Podetia K<sup>-</sup>, P<sup>+</sup> red. Fumarprotocetraric and succinprotocetraric acids present.

**Ecology and distribution:** *Microhabitat occupied:* Terricolous; terricolous-rupicolous. In India, the species exhibits its wide distribution to Arunachal Pradesh, Himachal Pradesh, Kerala, Sikkim, Uttarakhand and West Bengal hills. Outside India, the species is also known from China, Japan, Korea, Malaysia, Myanmar, Papua New Guinea and the Philippines.

**SPECIMENS EXAMINED:** **INDIA:** **HIMACHAL PRADESH, KULLU DISTRICT**, Great Himalayan National Park, around Soupdhar, alt. 3,900 m, on soil under Rhododendron bushes, D. K.

Upreti 99-53691(LWG), det. T. Ahti 2001; on way to Dhela-Lapah, alt. 3,000 m, on soil, D. K. Upreti 99-54095 (LWG), det. T. Ahti 2001; **KINNAUR DISTRICT**, Chitkul forest area, alt. 3,950 m, on soil, Upreti, Srivastava and Prakash 03-002727 (LWG); **KERALA, KOTTAYAM DISTRICT**, Kolahalamedu Vagamon, on soil, 3.8 m, Biju Haridas 06-014695 (LWG); **KOLLAM DISTRICT**, Agasthyamala Biosphere Reserve, Athirumala, Pathalamatty, alt. 500 m, on soil, Biju Haridas 06-014691 (LWG); **PALAKKAD DISTRICT**, Silent Valley National Park, alt. 84 m, on soil and rhizome of ferns, Biju Haridas 06-014756 (LWG); **SIKKIM, NORTH SIKKIM**, 2 km before Shingbo Rhododendron Sanctuary, alt. 3,300 m, on soil, Upreti, Chatterjee and Divakar 04-004080 (LWG); above Lachen, alt. 3,000 m, on soil over rocks, Upreti, Chatterjee and Divakar 04-004080 (LWG); **WEST SIKKIM**, Phitang-Dzongri, alt. 3,963 m, on ground, G. P. Sinha 263 (BSHC), det. T. Ahti 2001; near Changu, alt. 3,600, on soil among mosses, D. D. Awasthi 118 (LWG-AWAS), det. T. Ahti 2001; Jongri, alt. 3,658 m, on soil, M. N. Bose 6285 (LWG-AWAS), det. T. Ahti 2001; **UTTARAKHAND, BAGESHWAR DISTRICT**, above Phurkiya to Mirtoli, alt. 3,505 m, on ground, D. D. Awasthi 7790 (LWG-AWAS), det. T. Ahti 2001; **CHAMOLI DISTRICT**, on way to Hemkund, alt. 3,900 m, on soil, A. Singh 85807 B (LWG), det. T. Ahti 2001; **DEHRADUN DISTRICT**, Mussoorie, alt. 1,950 m, on soil, W. Dudgeon s.n. (LWG), det. T. Ahti 2001; **PITHORAGARH DISTRICT**, en route to milam glacier, alt. 3,353 m, on mossy soil, D. D. Awasthi and A. M. Awasthi 7706 (LWG-AWAS), det. T. Ahti 2001; en route to milam glacier, alt. 4,000 m, on soil, B. S. Kholia s.n. (LWG), det. T. Ahti 2001; **RUDRAPRAYAG DISTRICT**, Madmaheshwar, alt. 3,400 m, on rock over soil, A. Singh and M. Ranjan 106983 (LWG), det. T. Ahti 2001; **UTTARKASHI DISTRICT**, Govind Wild Life Sanctuary, from Sankri to Taluka, alt. 2,100 m, on rock over soil, D. K. Upreti, S. Nayaka, R. Bajpai 11-015663 (LWG); **WEST BENGAL, DARJEELING DISTRICT**, Tiger Hill, alt. 2,438 m, on soil, M. N. Bose 6231 A(LWG-AWAS); Sandakhpoo, alt. 3,636 m, on soil, P. D. Dogra 54591 (LWG), det. T. Ahti 2001.

***Cladonia fimbriata* (L.) Fr. (Fig. 2.9d; Fig. 2.41)**

Fries, Lichenogr. Eur. Reform.: 222. 1831.

Basionym: *Lichen fimbriatus* L., Sp. Pl.: 1152. 1753.

**Primary thallus:** squamulose; **squamules:** small, irregularly lobed, persistent; **podetia:** always scyphose; **scyphi:** 2–5 mm wide, 1–3 mm goblet-shaped, closed, farinose-sorediate on inner surface; **margin:** with finger-like proliferations or crenate with brown hymenial discs and pycnidia; **podetial surface:** sometimes corticated and with squamules at base, farinose-sorediate.

**Chemistry:** Podetia K–, P+ orange-red, C–, KC–, fumarprotocetraric acid present.

**Ecology and distribution:** *Microhabitat occupied:* Terricolous; muscicolous-terricolous; detriticolous-terricolous; terricolous-rupicolous. In India, the species exhibits its wide distribution to Western Himalaya and known from Himachal Pradesh, Jammu and Kashmir and Uttarakhand. Outside India, the species is also known from Bhutan, China, Nepal, Bhutan, Nepal and Pakistan, Australasia, Africa, Antarctica, Europe, North and South America. *Cladonia fimbriata* is close to *C. chlorophaea*, the difference is the presence of farinose soredia in the former and granulose soredia in the latter.

**SPECIMENS EXAMINED:** **INDIA: HIMACHAL PRADESH, KINNAUR DISTRICT**, Chitkul forest area, alt. 3,950 m, on soil, Upreti, Srivastava and Prakash 03-002725 B(LWG); **LAHAUL SPITI DISTRICT**, Koksar, alt. 3,100 m, on soil, D. K. Upreti 01-26567 A (LWG), det. T. Ahti 2001; Lahaul Valley, Rohtang Pass, alt. 3,750 m, on moist soil, Upreti and Divakar, 02-000023 B(LWG); Spiti Valley, Kunzum Pass, alt. 4,500 m, on soil in moist places, Upreti and Divakar 02-000081 A (LWG); **JAMMU AND KASHMIR, ANANTNAG DISTRICT**, Achabal mountain,

alt. 2,134 m, near the base of Pine tree, on soil over bark, P. N. Mujoo 70.26 (LWG-LWU), det. T. Ahti 2001; Pahalgam, on way to chandanwari, alt. 2,700 m, on soil surface with mosses, K. Dange 77.360 (LWG-LWU), det. T. Ahti 2001; Pahalgam near Mamal Village, alt. 2,605 m, on soil over rock, A. Singh 13974 (LWG), det. T. Ahti 2001; **BARAMULLA DISTRICT**, on way to Gulmarg, alt. 2,286 m, on rock over soil, P. N. Mujoo 70.113 (LWG-LWU), det. T. Ahti 2001; Gulmarg, on way from Gulmarg to Khilanmarg, alt. 2,655 m, on rock over soil, K. Dange 70.503 (LWG-LWU), det. T. Ahti 2001; at Gulmarg on north west side, alt. 2,605 m, on decaying wood and soil, K. Dange 77.482 (Dupl), det. T. Ahti 2001; on way to Khilanmarg, alt. 2,600 m, on rock over soil among mosses, M. Sheikh 05-006065 (LWG); Tangmarg, Baba Rishi, alt. 2,286 m, on rock over soil, K. N. Kaul s.n. (LWG), det. T. Ahti 2001; **SRINAGAR DISTRICT**, Srinagar, alt. 1,585 m, on soil, K. N. Kaul s.n. (LWG), det. T. Ahti 2001; **UTTARAKHAND, CHAMOLI DISTRICT**, Badrinath near Vasudhara Glacier, alt. 2,900 m, on soil, D. K. Upreti 202364 (LWG), det. T. Ahti 2001; on way to Nanda Devi Biosphere Reserve, Lodhucha Thaili, alt. 3,400 m, on soil and dead wood, S. Rawat 08-01007 (LWG); **UTTARAKASHI DISTRICT**, above Yamunotri, alt. 3,962 m, on soil among mosses, D. D. Awasthi 968 (LWG-AWAS), det. T. Ahti 2001; on way to Gomukh, 9 km from Gangotri, alt. 3,414 m, on soil, D. D. Awasthi and S. R. Singh 8319 (LWG-AWAS), det. T. Ahti 2001; 4 km after Gangotri towards Chirwasa, alt. 3,200 m, on soil, S. Chatterjee and P. K. Divakar 02-000175 A (LWG); Gangotri towards Kedartal, alt. 3,100 m, on soil, S. Chatterjee and P. K. Divakar 02-00215, 02-00025, 02-000416, 02-000417, 02-000417 A (LWG); Gangotri, alt. 3,133 m, on soil, Himanshu Rai and Pramod Nag 10-0014513 (LWG); Gangotri, alt. 3,104 m, on ground, Himanshu Rai and Pramod Nag 10-0014521 (LWG); Gangotri, alt. 3,078 m, on soil, Himanshu Rai and Pramod Nag 10-0014531 (LWG); towards Kedar Tal, alt. 3,200 m, on decaying wood, S. Chatterjee and P. K. Divakar 02-000420 (LWG).

***Cladonia fruticulosa* Kremp. (Fig. 2.9e; Fig. 2.41)**

Krempelhuber, Verh. K. K. Zool.-Bot. Ges. Wien 30: 331. 1881.

Synonym: *Cladonia formosana* Asahina, J. Jap. Bot. 17: 485. 1941.

**Primary thallus:** squamulose; **squamules:** small to medium-sized, persistent, cottony and granulose-soresiate on lower surface; **podetia:** pale grey, usually 10–20(–30) mm tall, 0.5–1 mm thick at base; simple to rarely branched; apices blunt or rarely scyphose; **scyphi:** to 4 mm wide, shallow, closed, often deformed; **podetial surface:** irregularly corticated with squamules or totally soresiate; **soredia:** granulose or farinose, exposing medulla. **Hymenial discs:** pale brown at tips of podetia or margin of scyphi.

**Chemistry:** Podetia K–, P+ deep yellow or red. Three chemical strains known: (1) Psoromic acid strain (dominant in India), (2) Psoromic and usnic acid strain and (3) Fumarprotocetraric, protocetraric and lichesterinic acids strain also present in Indian specimens.

**Ecology and distribution:** *Microhabitat occupied:* Terricolous; terricolous-rupicolous; detriticolous-terrlicolous. In India, the species exhibits its wide distribution to Arunachal Pradesh, Himachal Pradesh, Jammu and Kashmir, Karnataka, Kerala, Manipur, Meghalaya, Mizoram, Nagaland, Sikkim, Tamil Nadu, Uttarakhand and West Bengal hills. Outside India, the species is also known from Bhutan, Nepal, Sri Lanka, Australasia, Oceania and Africa.

**SPECIMENS EXAMINED: INDIA: ARUNACHAL PRADESH, DIBANG VALLEY DISTRICT**, Sally lake area Roing, alt. 3,000 m, on soil, D. K. Upreti and B. C. Upreti 201546 B (LWG), det. T. Ahti 2001; **Upper Siang district**, Jenging, near circuit house, alt. 795 m, on soil, D. K. Upreti and Party 08-009340 (LWG); **HIMACHAL PRADESH, KULLU DISTRICT**, Great Himalayan National Park, Sainj wild life sanctuary, Maraur, alt. 2,600 m, on dead wood, R.



Srivastava 04-003288 (LWG); **KARNATAKA, CHIKMAGALUR DISTRICT**, Chickmagalore way to Kummangundi, alt. 1,400 m, on soil with mosses, Awasthi, Upreti and Misra 79-432 A (LWG-LWU), det. T. Ahti 2001; **KERALA, PONMUDI DISTRICT**, Trivendrum, alt. 914 m, on soil, A. Singh and M. Ranjan 102381 (LWG), det. T. Ahti 2001; **MANIPUR, IMPHAL**, on way from Imphal to Morch (between Morch and Tengnonpal), alt. 1,219 m, on soil, V. S. Sharma and Party s.n. (LWG), det. T. Ahti 2001; **MEGHALAYA, EAST KHASI HILLS**, Cherrapunji, alt. 1,484 m, on ground, C. Bhatt 3385 (LWG-AWAS), det. T. Ahti 2001; **SHILLONG**, near Mawlai by roadside, alt. 1,500 m, on ground, D. D. Awasthi 7912 (LWG-AWAS), det. T. Ahti 2001; **MIZORAM, MAMIT DISTRICT**, Reiek Tourist resort, alt. 800 m, on soil vertical slope, D. K. Upreti 09-010694 (LWG); **SIKKIM, SOUTH SIKKIM**, 5 km before Damthang, alt. 2,600 m, on soil, Upreti and Chatterjee 01-26695 (DUP) (LWG), det. T. Ahti 2001; 5 km before Damthang, alt. 2,600 m, on soil along road in vertical face, 3/31/2001, Upreti and Chatterjee 01-26695 (LWG), det. T. Ahti 2001; **EAST SIKKIM**, Rumtek, alt. 1,800 m, on soil over rock, Chatterjee and Divakar 20-77081 (LWG), det. T. Ahti 2001; **NORTH SIKKIM**, Sakyong, alt. 1,800 m, on soil, Arvind Saklani s.n. (LWG), det. T. Ahti 2001; Mangan, alt. 1,204 m, on soil, V. S. Sharma and M. Ranjan 76722 (LWG), det. T. Ahti 2001; **TAMIL NADU, NILGIRI HILLS**, Dodabetta, Trails from Samer to Tiger Hills, alt. 2,607 m, in coniferous forest on soil, Lumsch, Upreti and Divakar 19715/1 (LWG); **MADURAI DISTRICT**, shola near 9th mile Kodaikanal-Berijam Road, alt. 2,286 m, on ground with mosses, G. Foreau and D. D. Awasthi 4201 (LWG-AWAS), det. T. Ahti 2001; **DINDIGUL DISTRICT, PALNI HILLS**, alt. 1,905 m, on stone over soil, K. P. Singh 73.8 (LWG-LWU), det. T. Ahti 2001; Kodaikanal, alt. 1,700 m, on soil, G. Foreau s.n. (LWG), det. T. Ahti 2001; **UTTARAKHAND, BAGESHWAR DISTRICT**, Dwali to Phurkiya, alt. 2,872 m, on soil over rock with decaying moss, D. D. Awasthi 7642 (LWG-AWAS), det. T. Ahti 2001; on way from Jhirtolli-Taluka, alt. 1,550 m, on soil, along the roadside in moist places, D. K. Upreti 201502 (LWG), det. T. Ahti 2001; **CHAMOLI DISTRICT**, way to Nanda Devi Biosphere Reserve, Belta, alt. 3,300 m, on rock over soil, 06 Jun 2008, S. Rawat 08-011036 (LWG); **DEHRADUN DISTRICT**, Chakrata division, near Mundali, alt. 2,591 m, D. D. Awasthi on decaying wood 934 (LWG-LWU), det. T. Ahti 2001; **PAURI-GARHWAL DISTRICT**, Pauri, Kiyonkaleshwar forest, alt. 1,379 m, on soil, V. Shukla and Y. Joshi 05-005335 (LWG); Khirsu reserve forest, alt. 1,835 m, on damp soil, Himanshu Rai 11-0014548 (LWG); **PITHORAGARH DISTRICT**, Nanipatal forest, alt. 1,800 m, on soil, D. K. Upreti 79-18 B (LWG-LWU), det. T. Ahti 2001; Askot, alt. 1,900 m, on soil, D. K. Upreti 212972 (LWG), det. T. Ahti 2001; Gori Ganga catchment area, Daphiyadhar, alt. 1,789 m, on soil, Vikas Pant s.n. (LWG), det. T. Ahti 2001; **RUDRAPRAYAG DISTRICT**, Kedarnath, on way from Sonprayag to Triyuginain, alt. 2,238 m, on rock over soil, K. Dange 76.416 (LWG-AWAS), det. T. Ahti 2001; **UTTARKASHI DISTRICT**, Silkayara, alt. 1,620 m, on soil, A. Singh 75325 A, B, 75327, 75330, 75337 (LWG), det. T. Ahti 2001; Gangotri, alt. 3,100 m, soil on rock, Himanshu Rai and Pramod Nag 10-0014509, 10-0014314, 10-0014529 (LWG); **WEST BENGAL, DARJEELING**, Near Mani bhaujan, alt. 1,829 m, on soil, D. D. Awasthi 114 (LWG-AWAS), det. T. Ahti 2001; Near Mani bhaujan, alt. 1,829 m, on soil, D. D. Awasthi 115 (LWG-AWAS), det. T. Ahti 2001; above Kurseong, alt. 1,676 m, on soil, D. D. Awasthi 3934 (LWG-AWAS), det. T. Ahti 2001; Senchal-Takdah, alt. 2,596 m, on ground, M. N. Bose 6260 (LWG-AWAS), det. T. Ahti 2001; Kalimpong division, on way to Munsong from Kalimpong, alt. 1,524 m, on ground, D. D. Awasthi and M. R. Agarwal 67.326 A (LWG-AWAS), det. T. Ahti 2001; Mall, alt. 2,134 m, on soil, K. Mohan s.n. (LWG), det. T. Ahti 2001.

***Cladonia furcata* (Huds.) Schrad. (Fig. 2.9f; Fig. 2.41)**

Schrader, Spic. Fl. Germ.: 107. 1794.

Basionym: *Lichen furcatus* Huds., Fl. Angl.: 458. 1762.

**Primary thallus:** squamulose, usually disappearing; **squamules:** up to 4 mm long and 3 mm wide, irregularly lobate to crenate-lobate, medium-sized, soon disappearing; **podetia:** grey to brownish, 10–50 mm or more tall, dying at base, dichotomously or irregularly branched, subulate or tapering, never scyphose; **axils:**

open, splitting; **podetial surface**: smooth to areolate, corticated, esorediate, irregularly squamulose; squamules reflexed upwards. **Apothecia**: frequent, brown, up to 1.5 mm diam., subglobose, usually clustered at tips of branches; **hymenial discs**: red-brown; **spores**: fusiform to oblong,  $5-15 \times 3-5 \mu\text{m}$ . **Pycnidia**: common, at tips of podetia, urn-like, constricted at base, with hyaline gelatin; **conidia**:  $3-8 \times 0.5-1 \mu\text{m}$ .

**Chemistry**: Podetia K<sup>-</sup> or K<sup>+</sup> yellowish brown, P<sup>+</sup> red, KC<sup>-</sup>. Fumarprotocetraric acid and atranorin present.

**Ecology and distribution**: *Microhabitat occupied*: Terricolous; muscicolous-terricolous; terricolous-rupicolous. In India, the species exhibits its wide distribution to Arunachal Pradesh, Himachal Pradesh, Kerala, Manipur, Nagaland, Sikkim, Tamil Nadu, Uttarakhand and West Bengal hills. Outside India, the species is also known from Bhutan, Nepal and Pakistan, Australasia, Africa, Europe, North and South America. *Cladonia furcata* is close to *C. scabriuscula*, distinguished by fully corticated podetia.

**SPECIMENS EXAMINED: INDIA: ARUNACHAL PRADESH, WEST KAMENG DISTRICT**, Sessa Orchid Sanctuary, alt. 3,600 m, on soil, P. Das 01-002891 (LWG); **HIMACHAL PRADESH, KULLU DISTRICT**, en route to Dhela, alt. 3,078 m, on soil among mosses, D. K. Upreti and Y. Joshi 08-006974 (LWG); 7 km before Pulga Shila, alt. 2,300 m, on soil among mosses, D. K. Upreti and Y. Joshi 08-006989(LWG); Great Himalayan National Park, Dhela to Lapah, alt. 3,300 m, on soil, D. K. Upreti 99-54070 B (LWG), det. T. Ahti 2001; around Soup-dhar, alt. 3,900 m, on soil under Rhododendron bushes, D. K. Upreti 99-53691 (LWG); **KERALA, IDUKKI DISTRICT**, Munnar way to Anayirangal Dam, alt. 1,600 m, on soil, Biju Haridas 06-014656 (LWG); **SIKKIM, SOUTH SIKKIM**, on Damthang-Tendong, 6 km trek, alt. 2,325 m, on soil, G. P. Sinha 144 (BSHC); **WEST SIKKIM**, Tshoka-Pithang trek, alt. 3,475 m, on ground, G. P. Sinha 217 (BSHC); **NORTH SIKKIM**, Lachen, alt. 3,000 m, on soil, D. K. Upreti, S. Chatterjee and P. K. Divakar 04-003742 (LWG); Near Yumthang, alt. 3,800 m, on soil, D. K. Upreti, S. Chatterjee and P. K. Divakar 04-004187 (LWG); **TAMIL NADU, NILGIRI HILLS**, Dodabetta, trails from Samer to Tiger Hills, alt. 2,607 m, in coniferous forest on soil, Lumbsch, Upreti and Divakar 19715 (LWG); **UTTARAKHAND, BAGESHWAR DISTRICT**, en route to Pindari Glacier between Loharkhet-Dhakuri, alt. 2,350 m, on soil among mosses, Upreti, Chatterjee and Tandon L68947 (LWG); Dhakuri ridge (on way to Pindari), alt. 2,896 m, on soil with mosses, D. D. Awasthi and A. M. Awasthi 636 (LWG-AWAS), det. T. Ahti 2001; from Dwali to Phurkiya, alt. 2,972 m, on soil, S. Joshi and Y. Joshi 07-008881 (LWG); **CHAMOLI DISTRICT**, on way to Hemkund, alt. 3,900 m, on soil, A. Singh 85807 A (LWG), det. T. Ahti 2001; near Badrinath, alt. 3,350 m, on soil, D. K. Upreti and S. Nayaka 07-010126 (LWG); way to Niti, alt. 3,118 m, on soil, D. K. Upreti and S. Nayaka 07-010299 (LWG); en route to Nanda Devi Biosphere Reserve, alt. 3,700 m, on soil, S. Rawat and D. Rawat 08-010932 (LWG); **DEHRADUN DISTRICT**, Dehradun, alt. 560 m, on soil, Dudgeon s.n.(LWG), det. T. Ahti 2001; **PITHORAGARH DISTRICT**, Dharchula Sobhla, opposite mountain of village Vatan, alt. 2,200 m, on soil, Upreti and Hariharan 202087 (LWG), det. T. Ahti 2001; en route to Milam Glacier, alt. 4,000 m, on soil among mosses, D. S. Kholia s.n. (LWG), det. T. Ahti 2001; Munsyari, Khaliya top, alt. 2,850 m, on soil, D. K. Upreti, S. Joshi, H. Rai, R. Khare, G. K. Mishra and A. Dwivedi 09-013468 (LWG); Barabey in forest around Latora Temple, alt. 1,800 m, on soil, Upreti and Tandon 104854(LWG), det. T. Ahti 2001; Dharchula en route to Narain Ashram, Sossa, alt. 2,440 m, on soil, D. K. Upreti L/ 18402 (LWG), det. T. Ahti 2001; **RUDRAPRAYAG DISTRICT**, Tungnath, Chandrashila, alt. 3,750 m, on soil, A. Singh and M. Ranjan 107175 (LWG); Chopta, alt. 2,900 m, on soil over rock, S. Rawat 06-007231 (LWG); around Tungnath, alt. 3,250 m, on soil, D. K. Upreti and S. Nayaka 07-010182 (LWG); Tungnath Bugyal,

alt. 3,400 m, on soil over rock with mosses, Himanshu Rai and Pramod Nag 08-0012234 (LWG); **UTTARAKASHI DISTRICT**, above Yamunotri, alt. 3,962 m, on soil, D. D. Awasthi 916 (LWG-AWAS), det. T. Ahti 2001; Govind Wild Life Sanctuary, Taluka to Osla, alt. 2,097 m, on mosses over soil, D. K. Upreti, S. Nayaka, R. Bajpai 11-016096 B (LWG); Govind Wild Life Sanctuary, from Sankri to Taluka, alt. 2,100 m, on rock over soil, D. K. Upreti, S. Nayaka, R. Bajpai 11-015662 (LWG); **WEST BENGAL, DARJEELING DISTRICT**, Senchal-Takdah road, alt. 2,050 m, on soil with mosses, M. N. Bose 6246 (LWG-AWAS), det. T. Ahti 2001; Tiger hill, north face of the Hill, alt. 2,591 m, on ground in shady place among mosses, D. D. Awasthi and M. R. Agarwal 67.29 (LWG-LWU), det. T. Ahti 2001; Sandakhpoo, alt. 3,200 m, on ground among mosses, D. D. Awasthi 111 (LWG-AWAS), det. T. Ahti 2001; on way from Sandakhpoo to Phalut, alt. 3,658 m, in shady place on ground, D. D. Awasthi and M. R. Agarwal 67.420 (LWG-LWU), det. T. Ahti 2001; Sandakhpoo, alt. 3,353 m, on soil among mosses, D. D. Awasthi 110 (LWG-LWU), det. T. Ahti 2001; Kurseong, alt. 1,500 m, on soil, G. Saran and party 79777 (LWG), det. T. Ahti 2001.

***Cladonia grayi*** G. Merr. ex Sandst. (Fig. 37)

Sandstede, Cladon. Exsicc. No. 1847. 1929.

**Primary thallus:** squamulose; **squamules:** medium to large-sized; **podetia:** whitish grey to grey, 10–15 mm tall, to 3 mm thick at base, always scyphose; **scyphi:** up to 7 mm wide, goblet-shaped, inner side ecorticated, soredate; **margins:** crenate or proliferating into scyphi, and with brown-black hymenial discs and pycnidia; **podetial surface:** corticated, verrucose-areolate at base, ecorticated soredate in upper parts.

**Chemistry:** Podetia K–, KC–, P– or P+ red, UV+ whitish blue.

**Ecology and distribution:** *Microhabitat occupied:* Terricolous. In India, the species exhibits its restricted distribution to Eastern Himalayas (Awasthi 2007; Singh and Sinha 2010). During study no material of *Cladonia grayi* has been examined by us, the description is based on Awasthi (2007). Outside India, the species is also reported from Bhutan, Pakistan and South Africa, Europe, North and South America.

***Cladonia humilis*** (With.) J.R. Laundon (Fig. 2.9g; Fig. 2.41)

Laundon, Lichenologist 16: 220. 1984.

Basionym: *Lichen humilis* Wither., Bot. Arr. Veg. Gr. Brit.: 721. 1776.

Synonyms: *Cladonia fimbriata* f. *conista* Nyl., Ann. Sci. Nat., Bot., sér. 4, 15: 370. 1861. *Cladonia conista* (Nyl.) Robbins in Allen, Rhodora 32: 92. 1930.

**Primary thallus:** squamulose, persistent; **squamules:** 3–10 mm long, 1–3 mm wide, large; **margins:** entire or irregularly lobate; **podetia:** 5–12(–35) mm tall, pale grey to glaucescent green, simple, always scyphose; **scyphi:** 3–4 mm wide, closed, gradually flaring, short-stalked; **inner surface:** soredate; **outer surface:** soredate and squamulose; **margins:** rarely proliferating into scyphi or digitate structures; **podetial surface:** corticated or ecorticated at base, coarsely to farinose-soredate upwards. **Apothecia:** very rare, long-stalked, brown; **hymenial discs:** brown. **Pycnidia:** rare, at cup margins, subglobose.

**Chemistry:** Podetia K–, P+ orange-red. Fumarprotocetraric acid and usually either atranorin or bourgeanic acid present.

**Ecology and distribution:** *Microhabitat occupied:* Terricolous-rupicolous. In India, the species exhibits its restricted distribution to Western Himalaya and only

known from Jammu and Kashmir and Uttarakhand. Outside India, the species is also known from Australia and Nepal, Africa, North and South America. *Cladonia humilis* is close to *C. chlorophaea*, but is distinguished by shorter podetia, broader scyphi, grey, smooth cortex at base and farinose soredia on podetial surface, plus different chemistry (in India, perhaps only the bourgeanic acid strain present).

**SPECIMENS EXAMINED:** **INDIA: JAMMU AND KASHMIR, BARAMULLA DISTRICT,** Babarishi, alt. 2,250 m, on soil, K. K. Kaul s.n. (LWG), det. T. Ahti 2001; **UTTARAKHAND, RUDRAPRAYAG DISTRICT,** on way from Chopta to Tungnath peak, alt. 2,850 m, on soil over rock, K. Dange 76.551 (LWG-LWU), det. T. Ahti 2001.

***Cladonia indica*** Ahti and Upreti (Fig. 2.9h; Fig. 2.41)

Ahti and Upreti, *Biblioth. Lichenol.* 88: 11. 2004.

**Primary thallus:** squamulose; **squamules:** medium-sized, dark brown, thick, persistent; **podetia:** pale grey, usually 8–20 mm tall, to 1 mm thick at base, usually simple, rarely branched at apices, always escyphose sometimes scyphoid axils present; **podetial surface:** rough, corticated, verruculose, striate-tuberculate with plenty of squamules up to the tip. **Hymenial discs:** usually present, brown, on most tips of podetia; **spores:** fusiform, 10–12 × 2 µm. **Conidia:** 8–10 × 1 µm.

**Chemistry:** Podetia K<sup>-</sup>, P<sup>-</sup>, UV<sup>+</sup> yellowish white. Homosekikaic acid (with satellites) present.

**Ecology and distribution:** *Microhabitat occupied:* Terricolous; detriticolous-terricolous. The species is endemic to India and exhibits its distribution to Eastern Himalaya and known only from Arunachal Pradesh. *Cladonia indica* is very close to *C. submultiformis*, but is more robust and has no atranorin and fumarprotocetraric acid.

**SPECIMENS EXAMINED:** **INDIA: ARUNACHAL PRADESH, DIBANG VALLEY DISTRICT,** Roing along the banks of river Deopani, alt. 350 m, on soil, D. K. Upreti and B. C. Joshi 201606 (LWG), det. T. Ahti 2001; Roing along Deopani forest, alt. 700 m, on soil, D. K. Upreti and B. C. Joshi L 81701 (LWG), det. T. Ahti 2001; alt. 700 m, on decaying wood, D. K. Upreti and B. C. Joshi L 81716 (LWG), det. T. Ahti 2001.

***Cladonia kanewskii*** Oksner (Fig. 2.41)

Oksner, *Ukrayins'k. Bot. Zhurn.* 3:9. 1926.

**Primary thallus:** not seen; **podetia:** greenish to yellowish grey, to 30 mm tall, robust, 1–2 mm thick at base, dichotomously branched; **branches:** flattened, subulate with spine like tips; rarely with 3 mm wide scyphi; **axils:** perforated; **podetial surface:** smooth, esorediate. **Hymenial discs:** brown at tips of podetia.

**Chemistry:** Podetia P<sup>-</sup>. Usnic acid and terpenoids present.

**Ecology and distribution:** *Microhabitat occupied:* Terricolous. In India, the species exhibits its restricted distribution to Eastern Himalaya and known only from Sikkim. Outside India, the species is also known from Mongolia and North America.

**SPECIMENS EXAMINED:** **INDIA: SIKKIM, EAST SIKKIM,** Kupup, north border side, alt. 4,100–4,200 m, on soil, Sinha 1505 (BSHC); **NORTH SIKKIM,** Sebu La base camp, east side, alt. 4,960 m, on soil, Sinha 1239 (BSHC).

***Cladonia kurokawae*** Ahti and S. Stenroos (Fig. 2.41)

In Ahti et al., *Mycosystema* 8–9: 54. 1996.

**Primary thallus:** squamulose; **squamules:** large, lobed, ascending, persistent; **podetia:** pale grey, 4–11 mm tall, simple, always scyphose; **scyphi:** 2–5(–8) mm wide, inner side granulose, outer side areolate, corticated with granules and schizidia; **margins:** with brown hymenial discs; true soredia absent.

**Chemistry:** Podetia K<sup>+</sup> yellow, P<sup>+</sup> orange-red. Atranorin, fumarprotocetraric acid present.

**Ecology and distribution:** *Microhabitat occupied:* Terricolous. In India, the species exhibits its restricted distribution to Eastern Himalayas and is known from Arunachal Pradesh and Sikkim (Awasthi 2007; Singh and Sinha 2010). No material of *Cladonia kurokawae* has been examined by us; the description is based on Awasthi (2007). Outside India, the species is also reported from China, Japan and South Korea.

***Cladonia laii*** S. Stenroos (Fig. 2.9i; Fig. 2.41)

Stenroos, *Acta Bryolichenol. Asiat.* 1: 53. 1989 (1990)

**Primary thallus:** squamulose; **squamules:** small to medium-sized, lobulate, brownish; **podetia:** yellowish green, up to 20 mm tall, 1.5–2 mm thick at base, flattened, always scyphose; **scyphi:** up to 4 mm wide, shallow or deformed, margin dentate or proliferating into 2–3 tiers of scyphi; **podetial surface:** areolate, corticated, squamulose at basal region, farinose-sorediate upwards. **Hymenial discs:** brown on margin of scyphi.

**Chemistry:** Podetia K<sup>–</sup>, KC<sup>–</sup> or KC<sup>+</sup> yellow, P<sup>–</sup>. Usnic, barbatic and 4-*O*-methylbarbatic acids present.

**Ecology and distribution:** *Microhabitat occupied:* Terricolous; muscicolous-terricolous; terricolous-rupicolous. In India, the species exhibits its restricted distribution to Sikkim and Uttarakhand. Outside India, the species is also known from Bhutan, China, Nepal and Taiwan.

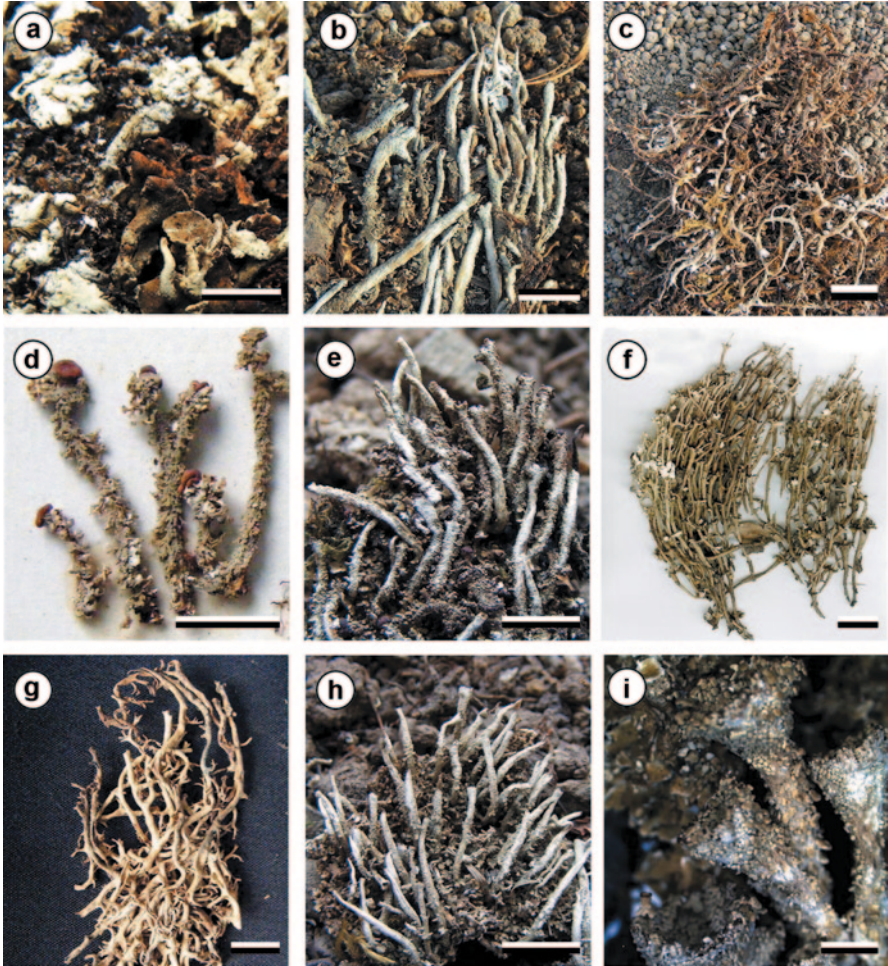
**SPECIMENS EXAMINED:** **INDIA:** SIKKIM, EAST SIKKIM, Tsangmo, alt. 3,780 m, on soil among mosses, D. D. Awasthi 123 A (LWG-AWAS), det. T. Ahti 2001; **NORTH SIKKIM,** Llonakh valley, Chhaber lake, below Luna La, alt. 4,000 m, Sinha 1601 (BSHC); **UTTARAKHAND, CHAMOLI DISTRICT,** on way to Hemkund, alt. 3,900 m, on soil over rock among mosses, A. Singh 85863 (LWG), T. Ahti 2001; Hemkund area, alt. 2,700 m, on soil, A. Saklani s.n. (LWG), det. T. Ahti 2001.

***Cladonia luteoalba*** Wheldon and A. Wilson (Fig. 2.10a; Fig. 2.41)

Wheldon and A. Wilson, *Fl. W. Lancashire:* 450. 1907.

Synonym: *Cladonia foliacea* var. *meiophora* Asahina in Hara (ed.) *Fl. Eastern Himal. Lichens:* 597. 1966.

**Primary thallus:** squamulose; **squamules:** medium to large-sized, persistent, inrolled, greenish yellow on upper side and cottony, arachnoid and yellow on lower side, growing in bogs and heath; **podetia:** rather rare, to 10 mm tall, simple, subulate or with indistinct scyphi; **podetial surface:** ecorticated esorediate. **Pycnidia:** red on podetial apices.



**Fig. 2.10** a *Cladonia luteoalba* Wheldon and A. Wilson, b *C. macilentata* Hoffm., c *C. macroptera* Räs., d *C. mauritiana* Ahti and J. C. David, e *C. mongolica* Ahti, f *C. nitens* Ahti (isotype, University of Helsinki-H), g *C. nitida* Ahti, h *C. ochrochlora* Flörke, i *C. pocillum* (Ach.) Grognot. Scale in i=2 mm; in b, e=5 mm; in a, c, d, f, g, h=10 mm

**Chemistry:** Podetia K<sup>-</sup>, KC<sup>-</sup>, P<sup>+</sup> or P<sup>-</sup>, UV<sup>+</sup> white or UV<sup>-</sup>. Three chemical strains reported: (1) Usnic, fumarprotocetraric acids strain, (2) Usnic and squamatic acids strain, and (3) Usnic acid and zeorin strain.

**Ecology and distribution:** *Microhabitat occupied:* Terricolous; muscicolous-terricolous. In India, the species is distributed to Arunachal Pradesh, Sikkim, Uttarakhand and West Bengal hills. Outside India, the species is also known from China, Japan, Nepal and Sri Lanka, Europe, North and South America.

**SPECIMENS EXAMINED:** **INDIA:** **SIKKIM, NORTH SIKKIM,** above Lachen, alt. 3,000 m, on soil, Upreti, Chatterjee and Divakar 04-003819 (LWG); **UTTARAKHAND, PITHORAGARH DISTRICT,** alt. 2,800 m, on soil along with mosses, D. K. Upreti 212909 (LWG), det. T. Ahti 2001.

***Cladonia macilenta*** Hoffm. (Fig. 2.10b; Fig. 2.41)

Hoffmann, *Deutschl. Fl.* 2: 126. 1796.

Synonyms: *Baeomyces bacillaris* Ach., *Methodus*: 329. 1803. *Cladonia bacillaris* (Ach.) Genth, *Fl. Nassau*: 406. 1835.

**Primary thallus:** squamulose; **squamules:** 1–6 mm long, 2–5 mm wide, minute, often sorediate, persistent; **podetia:** 2–30 mm tall, 1–4 mm wide, grey to brownish, usually simple, always escyphose; apices blunt or subulate, sterile or with scarlet red hymenial discs at tips; **podetial surface:** farinose-sorediate, somewhat furfuraceous, with disappearing cortex on upper portions, but basally thickly corticate (also below apothecia); **soredia:** coarse at base, sometimes intergrading with isidioid structures. **Apothecia:** scarce, 0.5–3 mm wide, red; **spores:** oblong, 8–13 × 3–4 μm. **Pycnidia:** common, on primary squamules or tips of podetia, ovoid to cylindrical, with red gelatin; **conidia:** 3–8 × 0.5–1 μm.

**Chemistry:** Podetia K<sup>+</sup> yellow or K<sup>-</sup>, P<sup>+</sup> yellow-red or P<sup>-</sup>, KC<sup>+</sup> orange-red or KC<sup>-</sup>.

Two major chemical strains: (1) K<sup>+</sup>, P<sup>+</sup>, thamnolic and barbatic acids strain and (2) K<sup>-</sup>, P<sup>-</sup>, barbatic acid strain. Rarely usnic acid, squamatic acid and bellidiflorin also present.

**Ecology and distribution:** *Microhabitat occupied:* Terricolous; detriticolous-terricolous. In India, the species exhibits its wide distribution to Arunachal Pradesh, Himachal Pradesh, Jammu and Kashmir, Kerala, Sikkim, Tamil Nadu, Uttarakhand and West Bengal hills. Outside India, the species is also known from Bhutan, Nepal and Sri Lanka, Australasia, Africa, Europe, North and South America.

**SPECIMENS EXAMINED:** **INDIA:** **HIMACHAL PRADESH, KULLU DISTRICT,** Parvati river valley, near Pulga rest house, alt. 2,190 m, on decaying wood stump of conifers, D. D. Awasthi and K. Dange 75-293 C (LWG-LWU), det. T. Ahti 2001; **JAMMU AND KASHMIR, UDHAMPUR DISTRICT,** alt. 2,286 m, on decaying stump, D. D. Awasthi and K. P. Singh 70.196 (LWG-LWU), det. T. Ahti 2001; **KERALA, IDUKKI DISTRICT,** Munnar near Lockhart state, alt. 1,500 m, on soil, Biju Haridas 06-014650 (LWG); **SIKKIM, WEST SIKKIM,** Pemayangtse Monastery surroundings, alt. 2,075 m, on soil, G. P. Sinha 176 (BSHC), det. T. Ahti 2001; **TAMIL NADU, DINDIGUL,** Palni hills, Kodaikanal Bear Shola, alt. 1,829 m, on decaying wood, K. P. Singh 70.822 (LWG-LWU), det. T. Ahti 2001; Kodaikanal, alt. 2,133 m, on soil over decaying wood, Fr. Foreau s.n. (LWG), det. T. Ahti 2001; Shola Kodaikanal to Beujam, alt. 2,210 m, on soil, G. Foreau 4131 (LWG-AWAS), det. T. Ahti 2001; Shenbaganur, Eucalyptus forest, alt. 1,676 m, on decaying wood, G. Foreau 3740 A (LWG-AWAS), det. T. Ahti 2001; **UTTARAKHAND, BAGESHWAR DISTRICT,** en route to Sunderdhunga Glacier between Jatoli and Dhuniyadon, alt. 3,048 m, on soil, Upreti and Tandon 213817 B (LWG); **CHAMOLI DISTRICT,** between Dugalbitta and Pothibasa, alt. 2,150 m, on decaying wood and ground, A. Singh 107212 (LWG), det. T. Ahti 2001; **PITHORAGARH DISTRICT,** Munsiyari, Nain Singh Top, alt. 2,700 m, on decaying wood log, Upreti and Tandon L104613 (LWG), det. T. Ahti 2001.

***Cladonia macroceras*** (Delise) Hav. (Fig. 2.41)

Havaas, *Bergens Mus. Aarbok, Naturvidensk. Rekke* 1927 (3): 12. 1928.

Basionym: *Cenomyce gracilis* var. *macroceras* Delise in Duby, *Bot. Gall.* 2:624. 1830.

**Primary thallus:** squamulose; **squamules:** small, reddish brown on upper surface, white on lower surface; **podetia:** up to 30 mm tall, 1–2 mm thick and black at base, brown upwards, simple to branched, generally escyphose, subulate, rarely scyphose; **scyphi:** shallow with marginal teeth; **podetial surface:** corticated, with spathulate squamules at right angles to podetia up to the tip; podetial wall cartilagineous. **Hymenial discs:** rare, brown on margin of scyphi.

**Chemistry:** Podetia K<sup>+</sup> red-brown, or K<sup>-</sup>, P<sup>+</sup> red. Fumarprotocetraric acid, rarely atranorin also present.

**Ecology and distribution:** *Microhabitat occupied:* Terricolous. In India, the species exhibits its restricted distribution to Western Himalaya and only known from Uttarakhand. Outside India, the species is also known from China and Japan, Europe and North America.

**SPECIMENS EXAMINED: INDIA: UTTARAKHAND, CHAMOLI DISTRICT,** Badrinath between Vasudhara and Bhagirathi Glacier, alt. 4,200 m, on soil, D. K. Upreti 202389 (LWG), T. Ahti 2001.

*Cladonia macroptera* Räs. (Fig. 2.10c; Fig. 2.41)

Räsänen, J. Jap. Bot. 16: 149. 1940.

**Primary thallus:** squamulose; **squamules:** small to medium-sized, deeply incised, persistent; **podetia:** whitish brown, sparsely branched with open axils, always escyphose, subulate; **podetial surface:** areolate, corticated, esorediate, with dense upturned squamules and microsquamules up to the tips. **Pycnidia:** brown-black at tips.

**Chemistry:** Podetia K<sup>+</sup> brownish or K<sup>-</sup>, Pd<sup>+</sup> red, KC<sup>-</sup>. Fumarprotocetraric acid present.

**Ecology and distribution:** *Microhabitat occupied:* Terricolous; muscicolous-terricolous; terricolous-rupicolous. In India, the species exhibits its wide distribution to Arunachal Pradesh, Himachal Pradesh, Jammu and Kashmir, Kerala, Sikkim, Uttarakhand and West Bengal hills. Outside India, the species is also known from China, Bhutan, Nepal and Japan. *Cladonia macroptera* is close to *C. scabriuscula*, but is distinguished by robust podetia and large, deeply lacinate podetial squamules, while podetial surface is granular to scabrose in the latter.

**SPECIMENS EXAMINED: INDIA: ARUNACHAL PRADESH, WEST KAMENG DISTRICT,** Sengen Dzong to Sela-Zang, alt. 4,176 m, on very moist moss covered soil under *Rhododendron campanulatum* shrub, Rolla Seshadri Rao 7768 BSI, det. T. Ahti 2001; **KERALA, PATHANAMTHITTA DISTRICT,** Kochu Panba, alt. 2,000 m, on soil, Biju Haridas 06-014645 (LWG); **SIKKIM, EAST SIKKIM,** Meimenchu lake surroundings, alt. 3,200–3,500 m, Sinha 1457 (BSHC); **NORTH SIKKIM,** La Jakthang, alt. 3,400 m, Sinha 1720 (BSHC); **UTTARAKHAND, BAGESHWAR DISTRICT,** near Pindari glacier, alt. 3,597 m, in between boulders on soil, D. D. Awasthi 7706 (LWG-AWAS), det. T. Ahti 2001; **UTTARAKHAND, DEHRADUN DISTRICT,** on way to Yamunotri, alt. 2,743 m, on ground among mosses, D. D. Awasthi 899 (LWG-AWAS), det. T. Ahti 2001; **WEST BENGAL, DARJEELING DISTRICT,** Sandakhpoo, alt. 3,658 m, on ground among mosses in shady place, D. D. Awasthi 2491 (LWG-AWAS), det. T. Ahti 2001; on way from Sandakhpoo to Phalut, alt. 3,658 m, on ground, D. D. Awasthi and M. R. Agarwal 67.491 (LWG-LWU), det. T. Ahti 2001; Tiger Hill, alt. 2,134 m, on soil, M. N. Bose 6202 (LWG-AWAS), det. T. Ahti 2001; alt. 2,438 m, on ground, D. D. Awasthi 3107 (LWG-AWAS), det. T. Ahti 2001; alt. 1,437 m, on ground, M. N. Bose s.n. (LWG-LWU), det. T. Ahti 2001.



***Cladonia mauritiana*** Ahti and J. C. David (Fig. 2.10d; Fig. 2.41)

In J. C. David and Hawksworth, *Biblioth. Lichenol.* 57: 94. 1995.

**Primary thallus:** squamulose; **squamules:** subcrustose to small; **podetia:** whitish grey, 10–20 mm tall, 0.5–1 mm thick at base, simple to sparingly branched in upper part, escyphose or with very narrow scyphi; **podetial surface:** areolate, corticated, esorediate and with dense squamules and microsquamules projecting downwards; **stereome:** often exposed. **Hymenial discs:** brown at tips of podetia.

**Chemistry:** Podetia K<sup>+</sup> yellow to red, P<sup>+</sup> red. Fumarprotocetraric, protocetraric and confumarprotocetraric acids present.

**Ecology and distribution:** *Microhabitat occupied:* Terricolous; muscicolous-terricolous; terricolous-rupicolous; detriticolous-terricolous. In India, the species exhibits its distribution to Arunachal Pradesh, Karnataka, Kerala, Tamil Nadu and West Bengal hills. Outside India, the species is also known from Madagascar, Malaysia, Mauritius, Réunion, Comoro Island, Seychelles and Thailand. *Cladonia mauritiana* is close to *C. ramulosa* and allied species, but distinguished by small podetia, densely microsquamulose in upper part.

**SPECIMENS EXAMINED:** **INDIA:** KARNATAKA, SHIMOGA DISTRICT, Agumbe, alt. 826 m, on soil, A. Singh and V. Nath L81178 (LWG), det. T. Ahti 2001; KERALA, TRIVENDRAM, Ponnudi, alt. 900 m, on soil, A. Singh and M. Ranjan 102394 (LWG), det. T. Ahti 2001; IDUKKI DISTRICT, Snathampara, alt. 1,100 m, on soil, D. K. Upreti L87180 (LWG), det. T. Ahti 2001; TAMIL NADU, DINDIGUL, Kodaikanal, alt. 1,700 m, on soil, A. Singh L 81409 B (LWG), det. T. Ahti 2001; Shenbaganur, Tiger Shola, alt. 1,676 m, on ground, D. D. Awasthi and K. P. Singh 70.168 (LWG-LWU), det. T. Ahti 2001; Pambar Shola, alt. 2,134 m, on ground, G. Foreau, 3756 (LWG-AWAS), det. T. Ahti 2001; North Brook, alt. 2,133 m on soil, S. Chandra s.n. (LWG), det. T. Ahti 2001; Palni Hills, Oothu area, alt. 1,143 m, on decaying wood, D. D. Awasthi and K. P. Singh 70.375 (LWG-LWU), det. T. Ahti 2001; WEST BENGAL, DARJEELING DISTRICT, Kalimpong, alt. 1,247 m, K. P. Srivastava s.n. (LWG), det. T. Ahti 2001.

***Cladonia mongolica*** Ahti (Fig. 2.10e; Fig. 2.41)

In Huneck et al., *Nova Hedwigia* 44: 196. 1987.

**Primary thallus:** squamules small, persistent, brown on upper surface, growing on decaying wood or mossy boulders; **podetia:** brown, stiff, to 10 mm tall, 0.5(–1) mm thick at base, simple, mostly escyphose with blunt apices; rarely with narrow scyphi; **podetial surface:** smooth with squamules and macrosquamules projecting downward or granulose, esorediate. **Hymenial discs:** brown at tips of podetia.

**Chemistry:** Podetia K<sup>–</sup>, or K<sup>+</sup> yellowish brown, KC<sup>–</sup>, P<sup>+</sup> red. Fumarprotocetraric acid and protocetraric acid complex present.

**Ecology and distribution:** *Microhabitat occupied:* Terricolous; terricolous-rupicolous; muscicolous-terricolous; detriticolous-terricolous. In India, the species exhibits its distribution to Himachal Pradesh, Jammu and Kashmir, Sikkim and Uttarakhand. Outside India, the species is also known from Bhutan, China, Mongolia, Nepal and Russia. *Cladonia mongolica* is close to *C. ochrochlora*, distinguished by the presence of microsquamules, and general esorediate condition.

**SPECIMENS EXAMINED:** **INDIA:** HIMACHAL PRADESH, KULLU DISTRICT, Great Himalayan National Park, on way to Dhela-Lopah, alt. 3,000 m, on decaying wood, D. K. Upreti 99-54051 D (LWG), det. T. Ahti 2001; SOLAN DISTRICT, Kandaghat, alt. 1,615 m, on soil, S. Nayaka 20-85737 (LWG), det. T. Ahti 2001; JAMMU AND KASHMIR, ANANTNAG DISTRICT,

Pahalgam, alt. 2,000 m, on rock over soil, M. Sheikh 05-006150 (LWG); **SIKKIM, EAST SIKKIM**, Meimenchu check post, alt. 3,700 m, Sinha 1416 (BSHC); **UTTARAKHAND, ALMORA DISTRICT**, Shitalakhet, Sahi Devi temple forest, alt. 1,900 m, on soil, Upreti and Prakash 01-76622 (LWG); **CHAMOLI DISTRICT**, Badrinath, east of temple on way to Devdarshani, alt. 3,150 m, on soil over rock, K. Dange 76.802 (LWG-LWU), det. T. Ahti 2001; between Waan and Bhuna, alt. 3,750 m, on soil, A. Singh 91567 (LWG), det. T. Ahti 2001.

***Cladonia nitens*** Ahti (Fig. 2.10f; Fig. 2.41)

Ahti, Biblioth. Lichenol. 96:12. 2007.

**Primary thallus:** squamulose, persistent to late disappearing; **squamules:** usually small, 2–8 × 1–5 mm wide, below whitish to bluish-brown; **podetia:** dark to pale brown, necrotic basal parts strongly melanotic; 1.5–7 cm tall, with stalks about 1 mm thick, often in dense clumps, slender, unbranched or little branched, tips always scyphose, mature scyphi 1–4(7) mm wide, 2–3 mm high, centrally proliferating, forming 1–2(7) tiers, the oldest internodes 0.8–1.2 cm long, often also with marginal proliferations; **scyphi:** rather abruptly flaring, scyphal plates soon with some perforations and slits when viewed from above, margins clearly incurved, only the oldest ones can be flattish or even recurved, soon dentate and irregularly cleft; **podetial surface:** areolate, areolae smooth to somewhat rugulose, shiny or at most slightly arachnoid, with narrow, arachnoid interspaces. **Hymenial discs:** infrequent, reddish brown, often aggregated on older scyphi; **spores:** not observed. **Conidiomata:** common, ca. 200 µm diam., at scyphus margins, shortly stalked, black, ampullaceous or pyriform, strongly constricted at base, conidia not seen.

**Chemistry:** Podetia K<sup>-</sup>, P<sup>+</sup> red; fumarprotocetraric acid and traces of protocetraric and confumarprotocetraric acids; additionally unknown terpenoids often present.

**Ecology and distribution:** *Microhabitat occupied:* Terricolous. In India, the species exhibits its restricted distribution to Eastern Himalaya and known only from Sikkim, which was reported by Ahti (2007). Outside India, the species is also known from Bhutan, Mongolia, Nepal, Russia and the USA.

**SPECIMENS EXAMINEDS:** **INDIA:** **SIKKIM, WEST SIKKIM**, Yoksam, alt.1,700 m, on soil, M. Togashi 115 (193) (TNS); Jongri, alt. 4,000 m, on soil, M. Togashi 116 (194) (TNS).

***Cladonia nitida*** Ahti (Fig. 2.10g; Fig. 2.41)

Ahti, Mycosystema 4: 61. 1991 (1992)

**Primary thallus:** not known; **podetia:** pale grey to brown, to 50 mm tall, 0.5–1 mm thick at base, di- to tetrachotomously branched, branches divaricate, escyphose; **axils:** widely open; **podetial surface:** glossy, smooth to reticulately cracked, maculate, lacking squamules and soredia. **Pycnidia:** on tips of podetia, hymenial discs not seen.

**Chemistry:** Podetia K<sup>+</sup> yellow, P<sup>+</sup> yellow. Thamnic acid present.

**Ecology and distribution:** *Microhabitat occupied:* Terricolous; muscicolous-terricolous. In India, the species exhibits its restricted distribution to Eastern Himalaya and known only from Arunachal Pradesh. Outside India, the species is also known from Vietnam.

**SPECIMENS EXAMINED: INDIA: ARUNACHAL PRADESH, WEST KAMENG DISTRICT,** Senge Dzong to Sela-Zang, alt. 4,176 m, on very moist moss covered soil under *Rhododendron campanulatum* shrub, mixed with another lichens, R. S. Rao 7767 (LWG-AWAS).

***Cladonia ochrochlora* Flörke (Fig. 2.10h; Fig. 2.41)**

Flörke, *Clad. Comm.*: 75. 1828.

**Primary thallus:** squamulose; **squamules:** medium to large-sized, lobed, grey-olive on upper surface and sorediate marginally; **podetia:** 10–20 mm tall, 1–1.5 mm thick at base, generally escyphose, subulate, simple, rarely with 3 mm wide, shallow scyphi; **podetial surface:** basally corticated, upper part decorticated, farinose-sorediate. **Hymenial discs:** brown on tips of podetia or margin of scyphi.

**Chemistry:** Podetia K+ brownish or K–, KC–, P+ red. Fumarprotocetraric and protocetraric acids present.

**Ecology and distribution:** *Microhabitat occupied:* Terricolous; muscicolous-terricolous; terricolous-rupicolous; detriticolous-terricolous. In India, the species exhibits its wide distribution to Himachal Pradesh, Jammu and Kashmir, Kerala, Sikkim, Tamil Nadu, Uttarakhand and West Bengal hills. Outside India, the species is also known from Nepal and Sri Lanka, Europe, North and South America.

**SPECIMENS EXAMINED: INDIA: HIMACHAL PRADESH, KULLU DISTRICT,** Great Himalayan National Park, around Patal, alt. 2,800 m, on soil over rock, D. K. Upreti 99-53667 (LWG), det. T. Ahti 2001; Parbati river valley, just before Pulga rest house, alt. 2,250 m, over boulders on soil D. D. Awasthi and K. Dange 75134 (LWG-LWU), det. T. Ahti 2001; Gati Beat area, alt. 2,500 m, on decaying wood log, D. K. Upreti 217379 (LWG), det. T. Ahti 2001; **SHIMLA DISTRICT,** Rohru, Jubbal, along Sandali naala, alt. 1,650 m, on dead wood, S. Nayaka and R. Srivastava 02-87170 (LWG); **JAMMU AND KASHMIR, ANANTNAG DISTRICT,** Pahalgam, west side near power house, alt. 2,000 m, on soil among mosses, M. Sheikh 05-006107 9LWG); **BARAMULLA DISTRICT,** Baba Rishi, alt. 2,286 m on soil, K. N. Kaul s.n. (LWG), det. T. Ahti 2001; **KARNATAKA, CHIKMAGALUR DISTRICT,** Dattatryapeeta, alt. 1,650 m, on iron rocks over soil, D. D. Awasthi, D. K. Upreti and U. Misra 79-535 (LWG-LWU), det. T. Ahti 2001; **MEGHALAYA, EAST KHASI DISTRICT,** Mawphlang sacred forest, alt. 1,500 m, on decaying bark, S. Chopra s.n (LWG), det. T. Ahti 2001; **SIKKIM, NORTH SIKKIM,** near Yumthang, alt. 3,800 m, on decaying wood, Upreti, Chatterjee and Divakar 04-004211 (LWG); **TAMIL NADU, KAMBAM DISTRICT,** Meghamalai wildlife Sanctuary, Upper Manalar, alt. 1,456 m, on soil in evergreen forest, S. Nayaka 99-75940 (LWG); **DINDIGUL,** Kodaikanal, Pillar rock, alt. 2,250 m, on soil, Ajay Singh s.n. (LWG), det. T. Ahti 2001; Palni hills, on way to Guvangi, alt. 1,676 m, on rocks over soil, K. P. Singh 73.28 (LWG-LWU), det. T. Ahti 2001; Nilgiri Avalanche, on hill face above power house, alt. 2,286 m, on ground, K. P. Singh 71-257 B (LWG-LWU), det. T. Ahti 2001; Emerald road along roadside near forest rest house, alt. 2,134 m, on red sandy rock soil in moist place, K. P. Singh 71.342 (LWG-LWU), det. T. Ahti 2001; Ootacamund, below Doddabeta peak in *Eucalyptus* plantation, alt. 2,286 m, on ground, D. D. Awasthi and K. P. Singh 71.104 (LWG-LWU), det. T. Ahti 2001; Kodaikanal, alt. 2,134 m, on decaying moss over soil, O. A. Höeg 2530 (LWG-AWAS), det. T. Ahti 2001; **MADURAI,** Shola near 9th mile, Kodaikanal-Barijam road, alt. 2,286 m, on ground, G. Foreau and D. D. Awasthi 4203 B (LWG-AWAS), det. T. Ahti 2001; **SALEM DISTRICT,** Yercaud Shevaroy hills, alt. 1,450 m, on decaying wood, D. K. Upreti and Hariharan 202185 (LWG), det. T. Ahti 2001; **UTTARAKHAND, CHAMOLI DISTRICT,** between Govind Ghat and Ghangharia, alt. 1,830 m, on soil, s.da., A. Singh s.n. (LWG), det. T. Ahti 2001; Aali bugyal to Waan, alt. 3,200 m, on soil with mosses, 26 Oct 1967, A. Singh and Party 91113 (LWG), det. T. Ahti 2001; on way to Nanda Devi Biosphere Reserve, Lodncha Thaili, alt. 3,400 m, on rock over soil, 06 Jun 2008, S. Rawat 08-011016 (LWG); on way to NDBR, Kothidhar, alt. 3,550 m, on dead wood, S. Rawat and D. Rawat 08-010963 (LWG); **DEHRADUN DISTRICT,** Chakrata hills, north face of the hill, alt. 1,829 m, on rocks in moist

places over soil, 21 June 1976, D. D. Awasthi and M. Joshi 76.16 (LWG-LWU), det. T. Ahti 2001; **PITHORAGARH DISTRICT**, en route to Milam glacier, alt. 4,000 m, on soil, B. S. Kholia s.n. (LWG), det. T. Ahti 2001; on way from Merthi to Didihat, alt. 1,725 m, on moist soil, D. K. Upreti L 18351 A (LWG), det. T. Ahti 2001; **RUDRAPRAYAG DISTRICT**; Mandakini river valley, on way from Gaurikund to Rambara, alt. 2,390 m, on decaying wood, K. Dange 76.100 (LWG-LWU), det. T. Ahti 2001; Kedarnath, hillside on east and north of the temple, alt. 3,650 m, on rock over soil among mosses, K. Dange 76.313 (LWG-LWU), det. T. Ahti 2001; on way from Chopta to Tungnath peak, alt. 3,050 m, on rock over soil among mosses, K. Dange 76.603 (LWG-LWU), det. T. Ahti 2001; Talla, alt. 1,900 m, on rocks over soil, S. Rawat 06-007271 (LWG); **TEHRI GARHWAL**, Dhanaulti, alt. 2,286 m, on soil, A. Singh and M. Ranjan 77578 (LWG), det. T. Ahti 2001; **UTTARKASHI DISTRICT**, Gangotri, alt. 3,137 m, on soil, Himanshu Rai and Pramod Nag 10-0014526 (LWG); Gangotri, alt. 3,078 m, on soil (ground), Himanshu Rai and Pramod Nag 10-0014537 (LWG); Gangotri, alt. 3,133 m, on soil, Himanshu Rai and Pramod Nag 10-0014538 (LWG); **WEST BENGAL, DARJEELING DISTRICT**, Batasi, Palmajua, alt. 2,134 m, on soil of degenerated wood, D. D. Awasthi 119 (LWG-LWU), det. T. Ahti 2001.

***Cladonia pocillum*** (Ach.) Grognot (Fig. 2.10i; Fig. 2.42)

Grognot, Pl. Crypt. Saone-et-Loire: 82. 1863.

Basionym: *Baeomyces pocillum* Ach., Methodus: 336. 1803.

Synonym: *Cladonia pyxidata* var. *pocillum* (Ach.) Schaer., Lich. Helv. Spic. 1(7): 373. 1836.

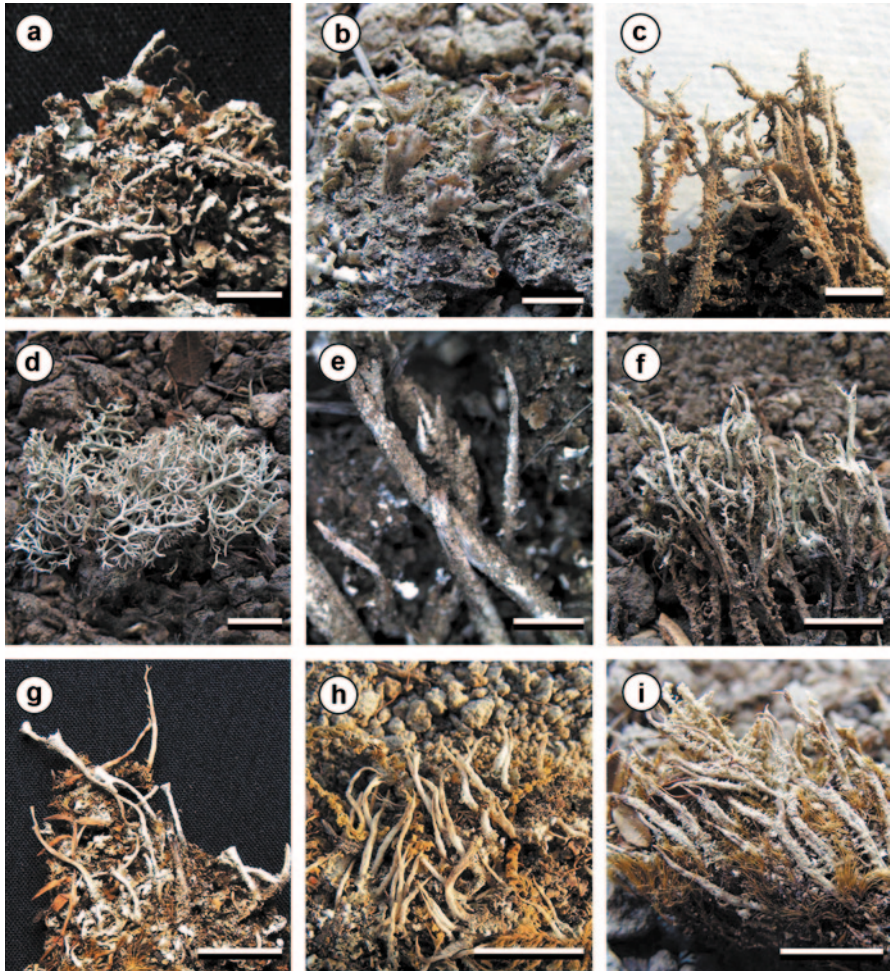
**Primary thallus:** squamulose to subfoliose, mat-forming, 1–4 cm wide, persistent; **squamules:** dense, small, thick, entire to lobed, whitish-brown on upper surface and chalky white on lower surface; **lobes:** 2–5 mm wide, margins subentire to crenate-lobate, fused, esorediate; upper side: greenish to olivaceous to copper to castaneous, often glossy and cracked; **medulla:** conspicuously white, with chalk-like structure; **lower surface:** cottony-fibrillose; **podetia:** common but sometimes scarce even on well-developed thalli, brownish, 5–8(–10) mm tall, always scyphose; **scyphi:** to 3 mm wide, inner and outer surfaces granulose-areolate; **podetial surface:** corticated at base, and with downward projecting microsquamules in upper part. **Apothecia:** fairly common on the podetia, up to 3 mm wide, brown; **hymenial discs:** brown on margin of scyphi; **spores:** not observed. **Pycnidia:** common on cup margins, pyriform, with hyaline gelatin; **conidia:** 6–7 × 1 μm

**Chemistry:** Podetia K–, P+ red. Fumarprotocetraric and protocetraric acid complex present.

**Ecology and distribution:** *Microhabitat occupied:* Terricolous; muscicolous-terricolous; terricolous-rupicolous; detriticolous-terricolous. In India the species exhibits its wide distribution to Himachal Pradesh, Jammu and Kashmir, Uttarakhand and West Bengal hills. Outside India, the species is also known from Bhutan, Nepal, New Zealand and Pakistan; Africa, Antarctica, Europe, North and South America. *Cladonia pocillum* is close to *C. pyxidata*, but is distinguished by pale brown podetia with granular to microsquamulose surface, and primary squamules thick, chalky white on lower side. *C. pyxidata* has peltate squamules on the inner and outer surfaces of scyphi.

**SPECIMENS EXAMINED:** **INDIA: HIMACHAL PRADESH, CHAMBA DISTRICT**, Brahmaur, Hdsar-Mani Mahesh, Doonch, alt. 2,150 m, on soil, Upreti and Nayaka 01-75503 B (LWG), det. T. Ahti 2001; **KULLU DISTRICT**, on way to Manali towards sulphur spring from Kullu, alt. 1,982 m, on stones and sandy soil, D. D. Awasthi and Party s.n. (LWG-LWU), det. T. Ahti

2001; Kothi forest area, alt. 2,500 m, on decaying wood, D. K. Upreti 213573 (LWG), det. T. Ahti 2001; **KANGRA DISTRICT**, Chhilka, alt. 3,300 m, on ground, Ö. A Höeg 1782 (LWG-AWAS), det. T. Ahti 2001; **LAHAUL SPITI DISTRICT**, Lahaul Valley, Rohtang Pass, alt. 3,750 m, on moist soil, Upreti and Divakar 02-000018 A (LWG); **JAMMU AND KASHMIR**, **ANANTNAG DISTRICT**, between Baltal and Amarnath, alt. 3,300 m, on soil, A. Singh 13947(LWG), det. T. Ahti 2001; between Baltal and Amarnath, alt. 3,900 m, on soil, A. Singh and D. K. Upreti 13953 (LWG); **BARAMULLA DISTRICT**, Gulmarg, on way from Gulmarg to Khilanmarg, alt. 2,655 m, on rock over soil, K. Dange 77.506 (LWG-LWU), det. T. Ahti 2001; Baba Rishi, alt. 2,286 m, on soil, K. N. Kaul and Party s.n. (LWG), det. T. Ahti 2001; **LEH DISTRICT**, Khardungla pass area, alt. 4,700 m, on soil, D. K. Upreti and S. Chatterjee 03-001801 (LWG); Ladakh, North Pullu, alt. 4,500 m, on soil, A. Singh and M. Ranjan L18302 (LWG), det. T. Ahti 2001; Hemis National Park, Tiblis 2, alt. 4,600 m, on soil, H. R. Negi L17B (CES), det. T. Ahti 2001; **SRINAGAR DISTRICT**, Zaberwan, alt. 2,134 m, on soil with mosses, B. K. Kaul 4010 (LWG-AWAS), det. T. Ahti 2001; **UTTARAKHAND**, **BAGESHWAR DISTRICT**, alt. 3,300 m, on soil, A. Singh 91132 (LWG), det. T. Ahti 2001; near Phurkiya en route to Pindari Glacier, alt. 2,900 m, on soil, D. D. Awasthi and A. M. Awasthi 731 (LWG-AWAS), det. T. Ahti 2001; near Phurkiya en route to Pindari Glacier, Mirtoli to ridge of moraine, alt. 3,658 m, on soil over stones, D. D. Awasthi 7701 (LWG-AWAS), det. T. Ahti 2001; near Pindari glacier, Mirtoli to ridge of moraine, alt. 3,658 m, over stone on soil, D. D. Awasthi 7701 (LWG-AWAS), det. T. Ahti 2001; Bhuna, alt. 3,150 m, on rock over soil, A. Singh 91573 (LWG), det. T. Ahti 2001; Martoli, lane near Pindari Glacier, alt. 3,750 m, on soil over rocks, A. Singh 91989 (LWG), det. T. Ahti 2001; en route to Pindari Glacier from Dwali to Phurkiya, alt. 2,972 m, on soil, S. Joshi and Y. Joshi 07-008874 (LWG), det. T. Ahti 2001; **CHAMOLI DISTRICT**, on way to Hemkund, alt. 4,115 m, on rock with mosses on soil, A. Singh 85813 (LWG), det. T. Ahti 2001; Waan to Bhuna, alt. 3,048 m, on soil, A. Singh and Party 91131 (LWG), det. T. Ahti 2001; Badrinath, South of temple near Brahmini village, alt. 3,163 m, on boulders over soil, K. Dange 76.771 (LWG-LWU), det. T. Ahti 2001; Badrinath east of temple, on way to Devdarshani, alt. 3,150 m, on rock surface over soil, K. Dange 76.808 (LWG-LWU), det. T. Ahti 2001; Nanda Devi Biosphere Reserve, Lata khark, alt. 3,600 m, on soil, S. Rawat 08-011086 (LWG); **DEHRADUN DISTRICT**, Chakrata, Deoban, alt. 2,743 m, on soil, D. D. Awasthi 480 (LWG Ex Herb AWAS), det. T. Ahti 2001; **PITHORAGARH DISTRICT**, Sandev Botanical Hotspot, Deochula, Pamtori, alt. 1,500 m, on soil, Vikas Pant 02000917 (LWG); Sandev Botanical Hotspot, alt. 1,875 m, on soil, Vikas Pant 02000989 (LWG); between Rilkot and Milam, alt. 3,300 m, on soil over rock, A. Singh 102808 (LWG), det. T. Ahti 2001; **RUDRAPRAYAG DISTRICT**, Tungnath, Tungnath-Chandrashila, alt. 3,750 m, on soil over rock, A. Singh and M. Ranjan 107139 (LWG), det. T. Ahti 2001; Tungnath, en route from Tungnath temple to Chandrashila, alt. 3,750 m, on soil over rock with mosses, A. Singh and M. Ranjan 107140, 107145, 107177 A (LWG), det. T. Ahti 2001; on way to Gomukh 4 Km from Gangotri, alt. 3,322 m, on soil, D. D. Awasthi and S. R. Singh 8263 (LWG-AWAS), det. T. Ahti 2001; Kedarnath, hillside on west of the temple, alt. 3,603 m, on rock over soil, K. Dange 76.181 A, B, 76.190 (LWG-LWU), det. T. Ahti 2001; Kedarnath, hillside on east and north of the temple, alt. 3,650 m, on rock over soil, K. Dange 76.319, 76.245 (LWG-LWU), det. T. Ahti 2001; Kedarnath, hillside on east and north of the temple, alt. 3,650 m, on boulders over soil, K. Dange 76.274 (LWG-LWU), det. T. Ahti 2001; Kedarnath, hillside on west and north of the temple, alt. 3,650 m, on rock over soil, K. Dange 76.318 (LWG-LWU), det. T. Ahti 2001; Mandakini River Valley, on way to Rambara from Kedarnath, alt. 3,165 m, on rock over soil, K. Dange 76.324 (LWG-LWU), det. T. Ahti 2001; **UTTARAKASHI DISTRICT**, between Janki Chatti and Yamunotri, alt. 3,048 m, on soil covered rock, A. Singh and Ram Pher 76060 (LWG), det. T. Ahti 2001; Gangotri, alt. 3,000 m, on soil, A. Singh 97282 (LWG), det. T. Ahti 2001; **WEST BENGAL**, **DARJEELING**, on way from Sandakhpoo to Phalut, alt. 3,658 m, on ground in shady place, D. D. Awasthi and M. R. Agarwal 67.425 (LWG), det. T. Ahti 2001.



**Fig. 2.11** a *Cladonia praetermissa* A. W. Archer, b *C. pyxidata* (L.) Hoffm., c *C. ramulosa* (With.) J. R. Laundon, d *C. rangiferina* (L.) F. H. Wigg., e *C. rei* Schaer., f *C. scabriuscula* (Delise) Nyl., g *C. sinensis* S. Stenroos and J. B. Chen, h *C. singhii* Ahti and P. K. Dixit, i *C. squamosa* Hoffm. Scale in e=2 mm; in a, b, c, d=5 mm; in f, g, h, i=10 mm

***Cladonia praetermissa*** A. W. Archer (Fig. 2.11a; Fig. 2.42)

Archer. *Muelleria* 5: 273. 1984.

**Primary thallus:** squamulose; **squamules:** of medium to large sized, crenate and persistent; **podetia:** 5(–10) mm tall, 0.5 mm thick at base, simple, subulate, always escyphose; **podetial surface:** corticated, squamulose at base; ecorticated and sorediate at apices. **Hymenial discs:** rarely brown on tips.

**Chemistry:** Podetia K+ weakly yellow or K–, KC–, P+ red. Atranorin, fumarprotocetraric, protocetraric acids and rarely psoromic acid present.

**Ecology and distribution:** *Microhabitat occupied:* Terricolous. In India the species exhibits its restricted distribution to Central India and known only from Madhya Pradesh. Outside India, the species is also known from Australasia and Africa.

**SPECIMENS EXAMINED: INDIA: MADHYA PRADESH, ANUPPUR DISTRICT,** Shambhudhara, Amarkantak, alt. 1,550 m, on red hard soil, Arvind Prajapati 10-014003 (LWG); sal forest near BALCO mines, alt. 1,505 m, on red hard soil, D. K. Upreti 201720 (LWG).

*Cladonia pyxidata* (L.) Hoffm. (Fig. 2.11b; Fig. 2.42)

Hoffmann, *Deutschl. Fl.* 2: 121. 1796.

Basionym: *Lichen pyxidatus* L., *Sp. Pl.*: 1151. 1753.

**Primary thallus:** squamulose, persistent; **squamules:** 2–5 mm long, 1–3 mm wide, entire or irregularly crenate-lobate, small to medium sized, brown, involute, rather thick and persistent; **lobes:** mostly ascending, lower side brownish white; **medulla:** fairly thin; **podetia:** 3–20 mm tall, greenish grey to brownish, always scyphose; **scyphi:** 3–5 mm wide, closed, with peltate plates or squamules on inner surface; margins with brown hymenial discs and rarely proliferating; **podetial surface:** corticate or ecorticate, dull, cortex verruculose, breaking into granules or giving rise to isidioid, schizidioid or phyllidioid structures, corticated at base, decorticated upwards, esorediate, often with schizidia. **Apothecia:** common, up to 8 mm wide, on c. 3 mm long stalks on cup margins, reddish brown to darker **spores:** oblong-ellipsoid, 12–16.5 × 3.5–4.5 μm. **Pycnidia:** very common, on cup margins, ovoid, constricted or not at base, with hyaline gelatin; **conidia:** 3.5–9 × 0.5–1.5 μm.

**Chemistry:** Thallus UV+ whitish. Podetia K–, P+ orange-red, C–, KC–. Fumarprotocetraric and protocetraric acids present.

**Ecology and distribution:** *Microhabitat occupied:* Terricolous; muscicolous-terricolous; terricolous-rupicolous; detriticolous-terricolous. In India the species exhibits its wide distribution to Arunachal Pradesh, Himachal Pradesh, Jammu and Kashmir, Sikkim and Uttarakhand. Outside India, the species is also known from Nepal and Pakistan; Australasia; Africa, Antarctica, Europe, North and South America. *Cladonia pyxidata* is close to *C. verticillata*, but is distinguished by the absence of proliferations from the central part of scyphi.

**SPECIMENS EXAMINED: INDIA: ARUNACHAL PRADESH, WEST KAMENG DISTRICT,** Tawang, alt. 4,000 m, on soil, 5/20/2009, Jaishree Rout s.n. (LWG); alt. 4,145 m, on soil, Ashish Kar 04-009735 (LWG); **HIMACHAL PRADESH, KULLU DISTRICT,** Manali, alt. 1,950 m, on ground, O. A. Höeg 1501 (LWG-AWAS), det. T. Ahti 2001; Great Himalayan National Park, on the way from Dhela to Lapah, alt. 3,000 m, on soil, D. K. Upreti 99-5405 G (LWG); Eco-development zone, Sainj Valley, Shangarh, alt. 2,200 m, on soil, R. Srivastava 04-003487 (LWG); Shilt, alt. 2,800 m, on soil with mosses, S. Nayaka and R. Srivastava 02-001053 (LWG); alt. 2,800 m, on decaying wood, S. Nayaka and R. Srivastava 02-001120 (LWG); Kothi area, alt. 2,700 m, on soil over rocks in moist places, D. K. Upreti 01-26506 (LWG), det. T. Ahti 2001; Gumtaro to Patal, alt. 2,750 m, on soil, D. K. Upreti 99-53646 (LWG), det. T. Ahti 2001; Parbati river Valley, just below Kheer Ganga, alt. 3,150 m, on boulders over soil, D. D. Awasthi and K. Dange 75330 (LWG-LWU), det. T. Ahti 2001; **KINNAUR DISTRICT,** Chitkul Forest Area, alt. 3,950 m, on soil over rock, Upreti, Srivastava and Prakash 03-002713 (LWG); **LAHAUL SPITI DISTRICT,** Koksar, alt. 3,100 m, on soil, Upreti 01-26523 A (LWG), det. T. Ahti 2001; Lahaul valley, alt. 3,200 m, on soil, Upreti and Divakar 02-000050 (LWG); Chhatru, alt. 3,200 m, on soil, Upreti and Divakar 02-000048 (LWG); Rohtang Pass, alt. 3,750 m, on moist soil, Upreti and Divakar 02-000020 (LWG);

**SHIMLA DISTRICT**, Narkanda, 3–4 km towards Hatu peak, alt. 2,800 m, on rock over soil, S. Nayaka and R. Srivastava 02-67168(LWG); **JAMMU AND KASHMIR, ANANTNAG DISTRICT**, Pahalgam, near mamal village, alt. 2,100 m, on soil, D. K. Upreti 11617 (LWG), det. T. Ahti 2001; on way to Chandanwari, alt. 2,700 m, on rock over soil with mosses, K. Dange 77–360 A (LWG-LWU), det. T. Ahti 2001; **BARAMULLA DISTRICT**, Gulmarg, on way from Gulmarg to Khilanmarg, alt. 2,655 m, on rock surface along with mosses over soil, K. Dange 77.507 (LWG-LWU), det. T. Ahti 2001; **SRINAGAR DISTRICT**, Srinagar city, Shankaracharya Hill (Sulaiman Hill/Takht-e-Sulaiman), alt. 1,200 m, on ground, D. D. Awasthi 2636 (LWG-AWAS), det. T. Ahti 2001; **UDHAMPUR DISTRICT**, Patnitop, alt. 2,500 m, on soil over rock, M. Sheikh 05-006681 (LWG); **SIKKIM, NORTH SIKKIM**, 2 km before Shinghbo Rhododendron Sanctuary, near Yumthang, alt. 3,300 m, on soil, Upreti, Chatterjee and Divakar 04-004085 (LWG); Giagaon after Thangu, alt. 4,600 m, on soil, Upreti, Chatterjee and Divakar 04-004022 (LWG); above Lachen, alt. 3,000 m, on soil, Upreti, Chatterjee and Divakar 04-003766 (LWG); Yangdi, above Thangu, alt. 4,250 m, on soil, Upreti, Chatterjee and Divakar 04-003959 (LWG); Yangdi, above Thangu, alt. 4,250 m, on decaying wood, Upreti, Chatterjee and Divakar 04-003962 (LWG); **UTTARAKHAND, BAGESHWAR DISTRICT**, Dwali to Phurkia, alt. 2,872 m, on decaying moss over stones, D. D. Awasthi 7642 (LWG-AWAS), det. T. Ahti 2001; en route to Pindari Glacier, Dwali-Kafni, alt. 2,800 m, on soil, Upreti and Party L69079 (LWG), det. T. Ahti 2001; on way to Phurkiya to Mirtoli, alt. 3,475 m, on soil over stones, D. D. Awasthi 7763 (LWG-AWAS), det. T. Ahti 2001; en route to Pindari Glacier from Phurkiya to zero Point, alt. 3,435 m, on soil, S. Joshi and Y. Joshi 07-008871 (LWG); en route to Pindari Glacier from Dwali to Phurkiya, alt. 2,972 m, on soil, S. Joshi and Y. Joshi 07-015748 (LWG); **CHAMOLI DISTRICT**, on way to Hemkund, alt. 3,505 m, on soil over rock, A. Singh 85844 (LWG), det. T. Ahti 2001; Badrinath, South of Temple near Brahmini village, alt. 3,163 m, on rock surface over soil, K. Dange 76.727, 76.771 (LWG-LWU), det. T. Ahti 2001; Badrinath, on east of temple on way to Dhanaulti village, alt. 3,250 m, on rock surface over soil, K. Dange 76.851 (LWG-LWU), det. T. Ahti 2001; Auli, Ghursu Top, alt. 3,300 m, on soil, D. K. Upreti 202348 (LWG), det. T. Ahti 2001; Badrinath between Vasudhara and Bhagirathi Galcier, alt. 4,200 m, on soil, D. K. Upreti 202388 (LWG), det. T. Ahti 2001; Badrinath between Vasudhara and Bhagirathi Glacier, alt. 4,200 m, on soil, D. K. Upreti L 13210 (LWG), det. T. Ahti 2001; Badrinath, Mana village towards Vasudhara Glacier, alt. 3,133 m, on soil, S. M. Singh 03-001830 (LWG); Valley of flowers, alt. 3,250 m, on rocks over soil, S. Rawat 06-007125 (LWG); Malari, alt. 3,400 m, on soil, S. Rawat 07-008621 (LWG); Malari area, alt. 3,300 m, on soil, S. Rawat 06-006860 (LWG); Badrinath, way from Mana to Vasudhara, alt. 3,350 m, on soil, D. K. Upreti and S. Nayaka 07-010125 (LWG); on way to Niti, alt. 3,300 m, on soil, D. K. Upreti and S. Nayaka 07-010266 (LWG); on way to Nanda Devi Biosphere Reserve, Srenikhal, alt. 3,700 m, on soil, S. Rawat 08-010931 (LWG); on way to Nanda Devi Biosphere Reserve, Kothidhar, alt. 3,550 m, on soil, S. Rawat and D. Rawat 08-010965 (LWG); on way to Nanda Devi Biosphere Reserve, Betla, alt. 3,300 m, on rock over soil, S. Rawat 08-011048 (LWG); Valley of flowers, alt. 3,010 m, on soil over rock, s.da., H. P. Sharma s.n. (LWG), det. T. Ahti 2001; on way to NDBR, Lata khark, alt. 3,600 m, on dead wood of *Taxus baccata*, S. Rawat and D. Rawat 08-010940 (LWG); **DEHRADUN DISTRICT**, Chakrata Hills, Deoban, alt. 2,804 m, on rock over soil with mosses, D. D. Awasthi and M. Joshi 76.107 (LWG-LWU), det. T. Ahti 2001; **PITHORAGARH DISTRICT**, Naher Devi to Mapang, en route to Milam, alt. 2,960 m, on soil, S. Joshi 07-010344 (LWG); Martoli, en route to Milam Glacier, alt. 3,390 m, on soil, Santosh Joshi 07-010464 (LWG); Munsiyari to Lilam en route to Milam Glacier, alt. 2,025 m, on soil, S. Joshi 07-010482 (LWG); Burfu, en route to Milam Glacier, alt. 3,250 m, on soil, S. Joshi 07-010466 (LWG); **RUDRAPRAYAG DISTRICT**, between Madmaheshwar and Gondar, alt. 3,000 m, on soil over rock, A. Singh and M. Ranjan 107010 (LWG), det. T. Ahti 2001; Tungnath, Chandrashila, alt. 3,750 m, on rock over soil, A. Singh and M. Ranjan 107150 (LWG), det. T. Ahti 2001; Kedarnath, on west side of the temple, alt. 3,603 m, on rock surface over soil, K. Dange 76.181 (LWG-LWU), det. T. Ahti 2001; Kedarnath, Hillside on east and north of the temple, alt. 3,650 m, on rock



surface over soil, K. Dange 76.213, 76.240, 76.247, 76.284, 76.318, 76.319, 76.320 (LWG-LWU), det. T. Ahti 2001; Kedarnath valley, Garurchatti towards Kedarnath Temple, alt. 2,200 m, on soil, D. K. Upreti, P. K. Divakar and B. Kumar 06-006211 (LWG); Kedarnath valley, Around Kedarnath Temple, alt. 3,500 m, on soil, D. K. Upreti, P. K. Divakar and B. Kumar 06-006223(LWG);on way from Chopta-Tungnath, alt. 3,000 m, on soil, D. K. Upreti and S. Nayaka 07-010169 (LWG), det. T. Ahti 2001; Tungnath, around Tungnath temple, alt. 3,250 m, on soil, Upreti and Nayaka 07-010195 (LWG); Tungnath, Tungnath Bugyal, alt. 3,400 m, on soil among moss, Himanshu Rai and Pramod Nag 08-0012207 (LWG); Tungnath, Tungnath Bugyal, alt. 3,400 m, on soil over rock, Himanshu Rai and Pramod Nag 08-0012210 (LWG);Tungnath, Tungnath Bugyal, alt. 3,400 m, on soil over rock, Himanshu Rai and Pramod Nag 08-0012217 (LWG); en route Chandrashila to Tungnath, alt. 3,800 m, on soil over rock along with decaying mosses, Himanshu Rai and Pramod Nag 08-0012221 (LWG); Chopta, alt. 2,850 m, on soil and ground vegetation in *Quercus-Rhododendron* woodland, 15 Oct 2008, Himanshu Rai and Pramod Nag 08-0012222 (LWG); Tungnath, on bridle approach path to Tungnath temple, alt. 3,400 m, on soil over rock, Himanshu Rai and Pramod Nag 08-0012231 (LWG); Chopta, alt. 2,850 m, on soil over rock among mosses and angiosperms, Himanshu Rai and Pramod Nag 08-0012214 (LWG); Chopta, alt. 3,000 m, on soil over rock, Himanshu Rai and Pramod Nag 08-0012224 (LWG); Chopta, alt. 2,850 m, on soil over rocks in *Quercus-Rhododendron* woodland, Himanshu Rai and Pramod Nag 08-0012225 (LWG); Tungnath, Tungnath Bugyal, alt. 3,400 m, soil in crevices between rock boulders, Himanshu Rai and Pramod Nag 08-0012236 (LWG); Chopta, alt. 3,000 m, Himanshu Rai and Pramod Nag 08-0012237 (LWG);Tungnath, Tungnath Bugyal, alt. 3,400 m, on soil over rock on moss tuft, Himanshu Rai and Pramod Nag 08-0012240 (LWG); Chopta, alt. 2,850 m, soil on rock among mosses, Himanshu Rai and Pramod Nag 08-0012243 (LWG). **UTTARKASHI DISTRICT**, Gomukh area, right bank third and fourth moraine, alt. 3,871 m, on soil, D. D. Awasthi and S. R. Singh 8457 (LWG-AWAS), det. T. Ahti 2001; Gomukh area, right bank sixth moraine, alt. 3,810 m, on mossy soil, D. D. Awasthi and S. R. Singh 8579 (LWG-AWAS), det. T. Ahti 2001;Gomukh area, right bank second moraine, alt. 3,901 m, on rocky soil, D. D. Awasthi and S. R. Singh 8389 (LWG-AWAS), det. T. Ahti 2001; Gangotri–Gomukh area, 2 km towards Chirwasa, alt. 3,600 m, on soil, S. Chatterjee and P. K. Divakar 02-000091, 02-000177, 02-000178 (LWG); Chirwasa, alt. 3,500 m, on soil, S. Chatterjee and P. K. Divakar 02-000183 (LWG); Bhojwasa, alt. 3,700 m, on soil, S. Chatterjee and P. K. Divakar 02-000202 (LWG); Gangotri towards Kedartal, alt. 3,100 m, on soil, S. Chatterjee and P. K. Divakar 02-000416 B, 02-000417 B, 02-000418, 02-000419, 02-000434, 02-000438 (LWG); Gangotri, alt. 3,123 m, on soil, Himanshu Rai and Pramod Nag 10-0014503, 10-0014508 (LWG); Gangotri, alt. 3,100 m, on ground, Himanshu Rai and Pramod Nag 10-0014511 (LWG); Gangotri, alt. 3,100 m, soil over rock, Himanshu Rai and Pramod Nag 10-0014519 (LWG); Gangotri, alt. 3,100 m, Gangotri, alt. 3,075 m, on soil, Himanshu Rai and Pramod Nag 10-0014520 (LWG); Gangotri, alt. 3,104 m, on ground, Himanshu Rai and Pramod Nag, 10-0014521 (LWG); Gangotri, alt. 3,123 m, soil on rocks, Himanshu Rai and Pramod Nag 10-0014525 (LWG); Gangotri, alt. 3,137 m, on soil, Himanshu Rai and Pramod Nag 10-0014526 (LWG); Gangotri, alt. 3,100 m, on soil, Himanshu Rai and Pramod Nag 10-0014527 (LWG); Gangotri, alt. 3,104 m, on ground over *Pinus* litter, Himanshu Rai and Pramod Nag 10-0014528 (LWG); Gangotri, alt. 3,100 m, soil over rock, Himanshu Rai and Pramod Nag 10-0014529 (LWG); Gangotri, alt. 3,137 m, on soil, Himanshu Rai and Pramod Nag 10-0014530 (LWG); Gangotri, alt. 3,078 m, on soil, Himanshu Rai and Pramod Nag 10-0014531 (LWG); Gangotri, alt. 3,100 m, on soil, Himanshu Rai and Pramod Nag 10-0014532 (LWG); Gangotri, alt. 3,123 m, soil on rocks, Himanshu Rai and Pramod Nag 10-0014533 (LWG); Gangotri, alt. 3,137 m, on soil, Himanshu Rai and Pramod Nag 10-0014536(LWG); Gangotri, alt. 3,133 m, on soil, Himanshu Rai and Pramod Nag 10-0014538 (LWG);Gangotri, alt. 3,128 m, on soil, Himanshu Rai and Pramod Nag 10-0014541 (LWG); Gangotri, alt. 3,123 m, on ground, Himanshu Rai and Pramod

Nag 10-0014542 (LWG); Gangotri, alt. 3,118 m, on soil, Himanshu Rai and Pramod Nag 10-0014544 (LWG); Gangotri, alt. 3,128 m, on soil, Himanshu Rai and Pramod Nag 10-0014546 (LWG).

***Cladonia ramulosa* (With.) J. R. Laundon (Fig. 2.11c; Fig. 2.42)**

Laundon, Lichenologist 16: 225. 1984.

Basionym: *Lichen ramulosus* With., Bot. Arr. Veg. Gr. Brit.: 723. 1776.

**Primary thallus:** squamulose; **squamules:** minute, persistent or evanescent; **podetia:** simple or rarely branched, escyphose, subulate, tipped with brown hymenial discs at maturity; **podetial surface:** loosely granulose or corticated, microsquamulose, granules may resemble soredia.

**Chemistry:** Podetia K<sup>-</sup>, P<sup>+</sup> orange-red, C<sup>-</sup>. Fumarprotocetraric and traces of protocetraric acids present.

**Ecology and distribution:** *Microhabitat occupied:* Terricolous; muscicolous-terricolous; terricolous-rupicolous; detriticolous-terricolous. In India the species exhibits its wide distribution to Arunachal Pradesh, Himachal Pradesh, Jammu and Kashmir, Karnataka, Kerala, Manipur, Meghalaya, Nagaland, Sikkim, Tamil Nadu, Uttarakhand and West Bengal hills. Outside India, the species is also known from Australia, Bhutan, Nepal, New Zealand and Sri Lanka; Pacific Islands; Africa, Europe, North and South America.

**SPECIMENS EXAMINED: INDIA: HIMACHAL PRADESH, KULLU DISTRICT,** Great Himalayan national park, Gusaini to Ropa, alt. 1,750 m, on decaying wood over soil, D. K. Upreti 99-52612 (LWG), det. T. Ahti 2001; Shilt, alt. 2,800 m, on soil, S. Nayaka and R. Srivastava 02-001040 (LWG), det. T. Ahti 2001; Great Himalayan national park, Sairopa, alt. 1,440 m, on dead wood, S. Nayaka and R. Srivastava 02-000533 (LWG); Parvati river valley, at pulga Rest House, alt. 2,190 m, on rock surface over soil, D. D. Awasthi and K. Dange 75187 B (LWG-LWU), det. T. Ahti 2001; **SHIMLA DISTRICT,** Rampur, Sarahan, 2 km towards Gaura, alt. 2,000 m, on rock over soil, S. Nayaka and R. Srivastava 02-11576 A (LWG); Rohru, Jubbal along Sandali naala, alt. 1,650 m, on rock over soil, S. Nayaka and R. Srivastava 02-101484 (LWG); **JAMMU AND KASHMIR, BARAMULLA DISTRICT,** Baba Rishi, alt. 2,286 m, on soil, K. N. Kaul s.n. (LWG), det. T. Ahti 2001; **KERALA, TRIVANDRUM DISTRICT,** Ponmudi, alt. 1,067 m, on soil, A. Singh and M. Ranjan 102390 (LWG), det. T. Ahti 2001; **MEGHALAYA, SHILLONG,** Mawlai, near roadside, alt. 1,500 m, on ground, D. D. Awasthi 7911 (LWG-AWAS), det. T. Ahti 2001; **SIKKIM, NORTH SIKKIM,** Near Yumthang, alt. 3,800 m, on soil, Upreti, Chatterjee, Divakar 04-004151 (LWG); Gangtok, alt. 1,437 m, on soil, K. P. Srivastava s.n. (LWG), det. T. Ahti 2001; Tashi view point, alt. 1,700 m, on soil, Chatterjee and Divakar 20-77164 (LWG), det. T. Ahti 2001; **EAST SIKKIM,** Hanuman Tok, alt. 1,450 m, on soil over rocks, Chatterjee and Divakar 20-77027 (LWG), det. T. Ahti 2001; **WEST SIKKIM,** Kacherpalri lake area, alt. 1,850 m, on ground, 5/14/1994, G. P. Sinha 283 (BSHC), det. T. Ahti 2001; **TAMIL NADU, KAMBAM DISTRICT,** Meghamalai Wildlife Sanctuary, Upper Manalar, alt. 1,570 m, on decaying wood of *Hydnocarpus alpina* in evergreen forest, S. Nayaka 99-75903 (LWG), det. T. Ahti 2001; **UTTARAKHAND, ALMORA DISTRICT,** alt. 1,651 m, on soil over rock, A. Singh 84616 (LWG), det. T. Ahti 2001; **CHAMOLI DISTRICT,** between Bagrigad and Wann, alt. 2,286 m, on soil covered rock, A. Singh and Party 90354 (LWG), det. T. Ahti 2001; **DEHRADUN DISTRICT,** Kathiyani in *Quercus* forest, alt. 1,800 m, over soil on base of tree, T. S. Rana s.n. (LWG), det. T. Ahti 2001; **PITHORAGARH DISTRICT,** Munsyari, Nain Singh, alt. 2,700 m, on soil over rock, Upreti and Tandon L104637 (LWG), det. T. Ahti 2001; on way from Merthi-Didihat, alt. 1,600 m, on soil, Upreti L-18351/B (LWG), det. T. Ahti 2001; Askot Langamkanta forest, alt. 1,900 m, on soil, Upreti 212971 B (LWG), det. T. Ahti 2001; **CHAMPAWAT DISTRICT,** alt. 1,650 m, on soil, A. Singh 102614 (LWG), det. T.

Ahti 2001; **NAINITAL DISTRICT**, Kainchi, alt. 1,200 m, on *Pinus roxburghii* tree trunk near base, S. Chatterjee 99-65567 (LWG), det. T. Ahti 2001; **RUDRAPRAYAG DISTRICT**, Mandakini river valley, on way from Gaurikund to Rambara, alt. 2,390 m, on rock surface over soil, K. Dange 76.127 (LWG-LWU), det. T. Ahti 2001; Kedarnath from Sonprayag, alt. 1,829 m, on soil, K. Dange 76.394 (LWG-LWU), det. T. Ahti 2001; Madmaheshwar and Gondar, alt. 3,000 m, on soil over rock, A. Singh and M. Ranjan 106995 (LWG), det. T. Ahti 2001; Guptakashi to Kalimath, alt. 1,200 m, on soil, A. Singh and M. Ranjan 107094(LWG), det. T. Ahti 2001; **WEST BENGAL, DARJEELING DISTRICT**, on way to Sandakhpoo to Tongloo, alt. 2,872 m, on ground near roadside, D. D. Awasthi and M. R. Agarwal 67.521 (LWG-LWU), det. T. Ahti 2001; Pashok road at about 6–8 miles from Darjeeling, alt. 1,829 m, on ground, D. D. Awasthi and M. R. Agarwal 67.103 (LWG-LWU), det. T. Ahti 2001; Tiger hills, Senchel lake, alt. 2,210 m, on soil, D. D. Awasthi 64.64 (LWG-AWAS), det. T. Ahti 2001.

***Cladonia rangiferina* (L.) F. H. Wigg.** (Fig. 2.11d; Fig. 2.42)

Wiggers, Prim. Fl. Holsat.: 90. 1780.

Basionym: *Lichen rangiferinus* L., Sp. Pl.: 1153. 1753.

Synonym: *Cladina rangiferina* (L.) Nyl., Sällsk Fauna Fl. Fenn. Förh. n.s. 5:110.1866.

**Primary thallus:** not seen; **podetia:** in mats or tufts, brownish black in basal dying part, bluish grey to brownish upwards, di-, tetra- (penta-) chotomously, repeatedly branched; **axils:** open; ultimate branchlets 3–5 in a whorl, usually deflexed on one surface; tips brown, blunt and thick hymenial discs; **podetial surface:** rough with glomerules of photobiont cells. **Apothecia:** forming apical at the tip of branches or stipes, moderately abundant; **hymenial disc:** plane to strongly convex; brown. **Conidiomata:** on podetia. **Pycnidia:** with hyaline ostiolar gel.

**Chemistry:** Podetia K+ yellow, P+ orange-red, C–, KC–. Atranorin and fumarprotocetraric acids present.

**Ecology and distribution:** *Microhabitat occupied:* Terricolous; terricolous-rupicolous; muscicolous-terricolous. In India the species exhibits its wide distribution to Arunachal Pradesh, Himachal Pradesh, Sikkim and Uttarakhand. Outside India, the species is also known from Bhutan and Nepal; Antarctica, Europe, North and South America.

**SPECIMENS EXAMINED: INDIA: ARUNACHAL PRADESH, WEST KAMENG DISTRICT**, Bomdila, alt. 3,800 m, on soil with mosses, Upreti and party 08-009409 A (LWG); Sella Pass, alt. 4,221 m, on soil with mosses, Upreti and Party 08-009410 (LWG); **HIMACHAL PRADESH, KULLU DISTRICT**, Great Himalayan National Park, around Soupdhar, alt. 3,900 m, on soil, D. K. Upreti 99-53685 (LWG); **SIKKIM, WEST SIKKIM**, Jongri, alt. 3,962 m, on soil with mosses, M. N. Bose 6299 (Heb AWAS-LWG), det. T. Ahti 2001; Phitang-Dzongri 3 km trek, alt. 3,963 m, on ground in open places, G. P. Sinha 261 (BSHC); **NORTH SIKKIM**, Yangdi above Thangu, alt. 4,250 m, on soil with mosses, Upreti and party 04-003984 (LWG); Chubuk above Thangu, alt. 4,100 m, on soil, D. K. Upreti, S. Chatterjee and P. K. Divakar 04-003915 (LWG); **UTTARAKHAND, PITHORAGARH DISTRICT**, on way to Milam Glacier from Bogudiyar to Naher Devi, alt. 2,578 m, on soil, S. Joshi 07-010462 (LWG); Sandev Botanical Hot Spot, alt. 1,600 m, on soil, Vikas Pant 02000949 (LWG); **UTTARKASHI DISTRICT**, Gangotri, alt. 3,128 m, on ground, Himanshu Rai and Pramod Nag 10-0014541 (LWG).

***Cladonia rei* Schaer.** (Fig. 2.11e; Fig. 2.42)

Schaerer, Lich. Helv. Spic.: 34. 1823.

**Primary thallus:** squamulose; **squamules:** small, disappearing; **podetia:** grey to olive-brown, to 40 mm tall, sparingly branched, subulate, escyphose or scyphose; **scyphi:** narrow, proliferating; **podetial surface:** corticated at base, furfuraceous-sorediate in upper parts; **soredia:** coarse or fine. **Hymenial discs:** brown on margin of scyphi or podetial tips.

**Chemistry:** Podetia K<sup>-</sup>, P<sup>+</sup> slowly red or P<sup>-</sup>, UV<sup>+</sup> pale white. Fumarprotocetraric acid present or absent, homosekikaic acid always present.

**Ecology and distribution:** *Microhabitat occupied:* Terricolous; terricolous-rupicolous; detriticolous-terrlicolous. In India the species exhibits its wide distribution to Arunachal Pradesh, Himachal Pradesh, Jammu and Kashmir and Uttarakhand. The species is also known from Bhutan and China; Australasia; Africa, Europe, North and South America.

**SPECIMENS EXAMINED:** **INDIA:** **HIMACHAL PRADESH, KULLU DISTRICT,** Parvati River valley, on way to Kheer Ganga, alt. 2,700 m, on rock surface over soil, D. D. Awasthi and K. Dange 75304 (LWG-LWU), det. T. Ahti 2001; **JAMMU AND KASHMIR, BARAMULLA DISTRICT,** Tangmarg, alt. 2,286 m, on soil covered rock, K. N. Kaul and Party s.n. (LWG), det. T. Ahti 2001; Gulmarg, on way from Gulmarg to Khilanmarg, alt. 2,655 m, on rock surface over soil, K. Dange 77.511 (LWG-LWU), det. T. Ahti 2001; Gulmarg, alt. 2,690 m, on decaying wood, A. Singh and D. K. Upreti 11660 (LWG-LWU), det. T. Ahti 2001; **UTTARAKHAND, PITHORAGARH DISTRICT,** Dharchula, Sobhla, on way to Sundung and Homchya village, alt. 2,200 m, on soil, Upreti and Hariharan 202069 (LWG), det. T. Ahti 2001; **UTTARKASHI DISTRICT,** Gangotri, alt. 3,200 m, on soil, D. D. Awasthi and S. R. Singh 3200.4 (LWG-AWAS), det. T. Ahti 2001.

*Cladonia scabriuscula* (Delise) Nyl. (Fig. 2.11f; Fig. 2.42)

Nylander, Compt. Rend. Hebd. Séances Acad. Sci. 83: 88. 1876.

Basionym: *Cenomoyce scabriuscula* Delise in Duby, Bot. Gall. ed.2: 623. 1830.

**Primary thallus:** squamulose, persistent or disappearing; **squamules:** small, 7–10 mm long, 5–7 mm wide, irregularly lobed to deeply lacinate; **podetia:** grey to brownish or blackish, 40–60(–80) mm tall, simple or branched, subulate, always escyphose; **axils:** open, more rarely closed; tips: subulate, never cup-forming; **podetial surface:** areolate, corticated to ecorticate, to granulose at tips; squamules and microsquamules formed by scaling off the cortex at right angles or upturned. **Apothecia:** infrequent, 0.5–2.0 mm wide, brown; **spores:** oblong to ellipsoid, 11–17 × 4–6 μm. **Pycnidia:** common, at tips of podetia, urn-shaped, constricted at base, with hyaline gelatin; **conidia:** 5–8 × 1–1.5 μm.

**Chemistry:** Podetia K<sup>-</sup> or K<sup>+</sup> yellow, P<sup>+</sup> red, C<sup>-</sup>, KC<sup>-</sup>. Fumarprotocetraric acid and atranorin present.

**Ecology and distribution:** *Microhabitat occupied:* Terricolous; muscicolous-terrlicolous; terricolous-rupicolous; detriticolous-terrlicolous. In India the species exhibits its wide distribution to Arunachal Pradesh, Assam, Himachal Pradesh, Jammu and Kashmir, Karnataka, Maharashtra, Nagaland, Sikkim, Tamil Nadu, Uttarakhand and West Bengal hills. The species is also known from Bhutan; Australasia; Africa, Europe, North and South America. *Cladonia scabriuscula* is very close to *C. furcata*, but is distinguished by the podetia being partially corticated and partially ecorticate and granulose, while in *C. furcata* podetia are corticate throughout.

**SPECIMENS EXAMINED: INDIA: ARUNACHAL PRADESH, WEST KAMENG DISTRICT**, en route from Bomdila to Sela, 7 km before Sela pass, alt. 3,962 m, on soil, Upreti and Party 08-009361 (LWG); **UPPER SIANG DISTRICT**, Apnavan, Jengging, alt. 1,014 m, on soil, Upreti and Party 08-009330(LWG); **ASSAM, NORTH CACHAR DISTRICT**, Haflong, alt. 1,014 m, on soil, Upreti and Party 05-003567 (LWG); **HIMACHAL PRADESH, KULLU DISTRICT**, Kothi forest near guest house, alt. 2,500 m, on soil, D. K. Upreti 213569 (LWG), det. T. Ahti 2001; **JAMMU AND KASHMIR, SRINAGAR DISTRICT**, Harwan, Dachigam National Park, alt. 2,150 m, on dead wood, M. Sheikh 05-006189 (LWG); **KARNATAKA, CHICLMAGALURE DISTRICT**, Chikmagalur way to Kummangundi, alt. 1,400 m, on soil with mosses, Awasthi, Upreti and Misra 79-432 A (LWG); **MAHARASHTRA, SATARA DISTRICT**, Mahabaleshwar, Wilson Point, alt. 1,470 m, on rocks with mosses over soil, R. Bajpai 10-013815 (LWG); **SIKKIM, EAST SIKKIM**, on way to Tashi view point to Kabri at 5 km, alt. 2,000 m, on soil over rocks in vertical face of road, Upreti and Chatterjee 01-26658 (LWG), det. T. Ahti 2001; **NORTH SIKKIM**, Lachung town near bridge, alt. 2,800 m, on soil, Upreti, Chatterjee and Divakar 04-004333 (LWG); **TAMIL NADU, NILGIRI HILLS**, Avalanche, on hills face above power house, alt. 2,286 m, on soil with mosses, Awasthi, Upreti and Misra 71-257 A (LWG); **UTTARAKHAND, BAGESHWAR DISTRICT**, en route to Pindari glacier, Dhakuri-Khati, alt. 2,100 m, on soil, Upreti, Chatterjee, Tandon L68991 (LWG); **CHAMPAWAT DISTRICT**, 7 km before Mayawati, alt. 2,000 m, on soil, D. K. Upreti, S. Joshi, H. Rai, R. Khare, G. K. Mishra and A. Dwivedi 09-012676 (LWG); **PAURI GARHWAL DISTRICT**, Khirsu, Khirsu reserve forest, alt. 1,835 m, on damp soil on inclined slope, Himanshu Rai 11-0014553 (LWG); Khirsu, Khirsu reserve forest, alt. 1,835 m, on soil (roadside), Himanshu Rai 11-0014554 (LWG); Khirsu, Khirsu reserve forest, alt. 1,934 m, on soil with mosses, Himanshu Rai 11-0014551 (LWG); **RUDRAPRAYAG DISTRICT**, Tungnath, alt. 3,250 m, on soil, D. K. Upreti and S. Nayaka 07-01084 (LWG); Tungnath, below the temple (6±2 m) on the right of the road to Chandrashila, alt. 3,400 m, on soil over rocky slope in open ground, Himanshu Rai and Pramod Nag 08-0012251 (LWG). **UTTARKASHI DISTRICT**, Govind Wild Life Sanctuary, Taluka to Osla, alt. 2,170 m, on Acer tree at base on soil, D. K. Upreti, S. Nayaka, R. Bajpai 11-015865 (LWG); Govind Wild Life Sanctuary, Taluka to Osla, alt. 2,174 m, on soil over rock, D. K. Upreti, S. Nayaka and R. Bajpai 11-016075 (LWG); **WEST BENGAL, DARJEELING DISTRICT**, Tiger Hill, alt. 2,362 m, on ground, D. D. Awasthi 3,898 B (LWG-AWAS); Kurseong, Dow Hill, on ground, alt. 2,362 m, D. D. Awasthi 66.267 (LWG-LWU); north face of the hill, alt. 2,591 m, on ground, D. D. Awasthi and M. R. Agarwal 66.57 (LWG-LWU), det. T. Ahti 2001; Senchal Lake, alt. 2,201 m, on soil, D. D. Awasthi 64-112 (LWG-AWAS), det. T. Ahti 2001; Siliguri, Sukhia forest, alt. 334 m, on soil, S. Chandra and M. Ranjan s.n. (LWG) T. Ahti 2001.

***Cladonia sinensis*** S. Stenroos and J. B. Chen (Fig. 2.11g; Fig. 2.42)

S. Stenroos and J. B. Chen, *J. Hattori Bot. Lab.* 75: 331. 1994.

**Primary thallus:** squamulose, persistent; **squamules:** of primary thallus minute; **podetia:** yellowish green to white, up to 20 mm tall and up to 1.5 mm thick at base, simple, scyphose or rarely escyphose, blunt; scyphi up to 1.5 mm wide proliferating into single or two scyphi from margin; **podetial surface:** granulose and microsquamulose, later disintegrating to expose medulla. **Hymenial discs:** red, on margin of scyphi.

**Chemistry:** Podetia K<sup>-</sup>, P<sup>-</sup>. Usnic, isousnic, rhodocladonic acids and zeorin present.

**Ecology and distribution:** *Microhabitat occupied:* Detriticolous-terricolous. In India, single specimen of the species reported from Western Himalaya and known to Uttarakhand. The species is also reported from Bhutan and China.

**SPECIMEN EXAMINED: INDIA: UTTARAKHAND, PITHORAGARH DISTRICT**, Dharchula, Sobhla on way to Sundung and Homchy village, alt. 2,200 m, on decaying wood, Upreti and Hariharan 202090 (LWG), det. T. Ahti 2001.

***Cladonia singhii*** Ahti and P. K. Dixit (Fig. 2.11h; Fig. 2.42)

In Ahti and al., *Lichenologist* 34: 306. 2002.

**Primary thallus:** squamulose, persistent or disappearing; **squamules:** small; **podetia:** grey to brownish, simple to sparingly branched, usually subulate, escyphose; rarely with narrow scyphi; **podetial surface:** corticated or ecorticated with sparse or dense microsquamules and granules. **Hymenial discs:** brown on margin of scyphi or terminal on podetia.

**Chemistry:** Podetia K–, P+ red. Fumarprotocetraric acid present.

**Ecology and distribution:** *Microhabitat occupied:* Terricolous; muscicolous-terricolous; terricolous-rupicolous; detriticolous-terricolous. In India, the species exhibits its wide distribution to Arunachal Pradesh, Himachal Pradesh, Meghalaya, Sikkim, Tamil Nadu, Uttarakhand and West Bengal hills. The species is also known from Nepal and Thailand. *Cladonia singhii* is close to *C. corniculata* and *C. subulata* but both the latter are sorediate. *C. cartilaginea* is also similar, but is distinguished by shorter podetia that are sparsely granular and slightly microsquamulose on surface.

**SPECIMENS EXAMINED: INDIA: HIMACHAL PRADESH, CHAMBA DISTRICT,** Dalhousie, forest rest house, alt. 1,524 m, on soil, D. D. Awasthi and S. Nayaka 01-75268 (LWG), det. T. Ahti 2001; **MEGHALAYA, UPPER SHILLONG DISTRICT,** 26 km from Shillong to Pynusla road, alt. 1,525 m, on soil, G. Panigrahi 4734 BSI, det. T. Ahti 2001; **SIKKIM, EAST SIKKIM DISTRICT,** Bhusuk area, alt. 2,000 m, on soil, Upreti and Chatterjee 01-26624 B (LWG), det. T. Ahti 2001; **TAMIL NADU, NILGIRI HILLS,** Avalanche, Hatchery Shola, alt. 2,134 m, on ground, K. P. Singh 71.682 (LWG-LWU), det. T. Ahti 2001; Avalanche, Emerald road, along roadside near forest rest house, alt. 2,134 m, on red soil with mosses, K. P. Singh 71.334 (LWG-LWU), det. T. Ahti 2001; Avalanche, Emerald road, along roadside near forest rest house, alt. 2,134 m, on hard sandy soil in moist places, K. P. Singh 71.326 (LWG-LWU), det. T. Ahti 2001; alt. 2,286 m, on ground, K. P. Singh 71.257 (LWG-LWU), det. T. Ahti 2001; Emerald road, along roadside, near forest rest house, alt. 2,134 m, on decaying wood stump, K. P. Singh 71.333 (LWG-LWU), det. T. Ahti 2001; **MADURAI,** Shenbaganur-Kodaikanal along heving's path, alt. 1,905 m, on ground with mosses, G. Foreau and D. D. Awasthi 4302 (LWG-AWAS), det. T. Ahti 2001; below SH College, along old Ghat road, alt. 1,737 m, on ground, D. D. Awasthi 4372 (LWG-AWAS), det. T. Ahti 2001; Dindigul district, Palni Hills, Kodaikanal, on Berijam road, near Paniyarapore, alt. 2,332 m, on ground, D. D. Awasthi and K. P. Singh 70.310 (LWG-LWU), det. T. Ahti 2001; Kodaikanal, Croaker's walk, along roadside, alt. 2,134 m, on soft sandy soil, D. D. Awasthi and K. P. Singh 69.32 (LWG-LWU), det. T. Ahti 2001; Sridumkanal, Shola, alt. 1,905 m, on ground, G. Foreau 4564 (LWG-AWAS), det. T. Ahti 2001; **UTTARAKHAND, BAGESHWAR DISTRICT,** Khati (en route to Pindari glacier), alt. 2,438 m, on soil, D. D. Awasthi and A. M. Awasthi 707 (LWG-AWAS), det. T. Ahti 2001; Dhajuri-Khati (en route to Pindari glacier), alt. 2,286 m, on Soil with mosses, D. D. Awasthi and A. M. Awasthi 699 (LWG-AWAS), det. T. Ahti 2001; Binsar, alt. 1,800 m, on soil, Upreti and Tandon 213358 (LWG), det. T. Ahti 2001; **NAINITAL DISTRICT,** Naina peak, alt. 2,377 m, on soil covered rock, D. D. Awasthi and A. M. Awasthi 90228 (LWG), det. T. Ahti 2001; Kilbury Forest area, alt. 2,200 m, on young *Quercus leucotrichophora* forest on soil along roadside, Upreti, Chatterjee and Tandon 217359 (LWG), det. T. Ahti 2001; **PITHORAGARH DISTRICT,** Dharchula, Sobhla, on way to Sundhung and Homchya village, alt. 2,200 m, on soil, Upreti and Hariharan 202080 (LWG), det. T. Ahti 2001; on way from Shan Dev to Didihat, alt. 1,900 m, on soil with mosses, D. K. Upreti 202973 (LWG), det. T. Ahti 2001; **RUDRAPRAYAG DISTRICT,** Kedarnath, on way from Sonprayag to Triyugarain, alt. 2,238 m, on rock surface over soil, K. Dange, 76.389 (LWG-LWU), det. T. Ahti 2001; **RUDRAPRAYAG DISTRICT,** Madmaheshwar, between Kalimath and Gupt Kashi, alt. 1,200 m, on rock over soil, A. Singh and M. Ranjan, 107093 (LWG-LWU), det. T. Ahti

2001; **WEST BENGAL, DARJEELING DISTRICT**, Kurseong, alt. 1,500 m, on soil, G. Saran and Party s.n. (LWG), det. T. Ahti 2001.

***Cladonia squamosa*** Hoffm. (Fig. 2.11i; Fig. 2.42)

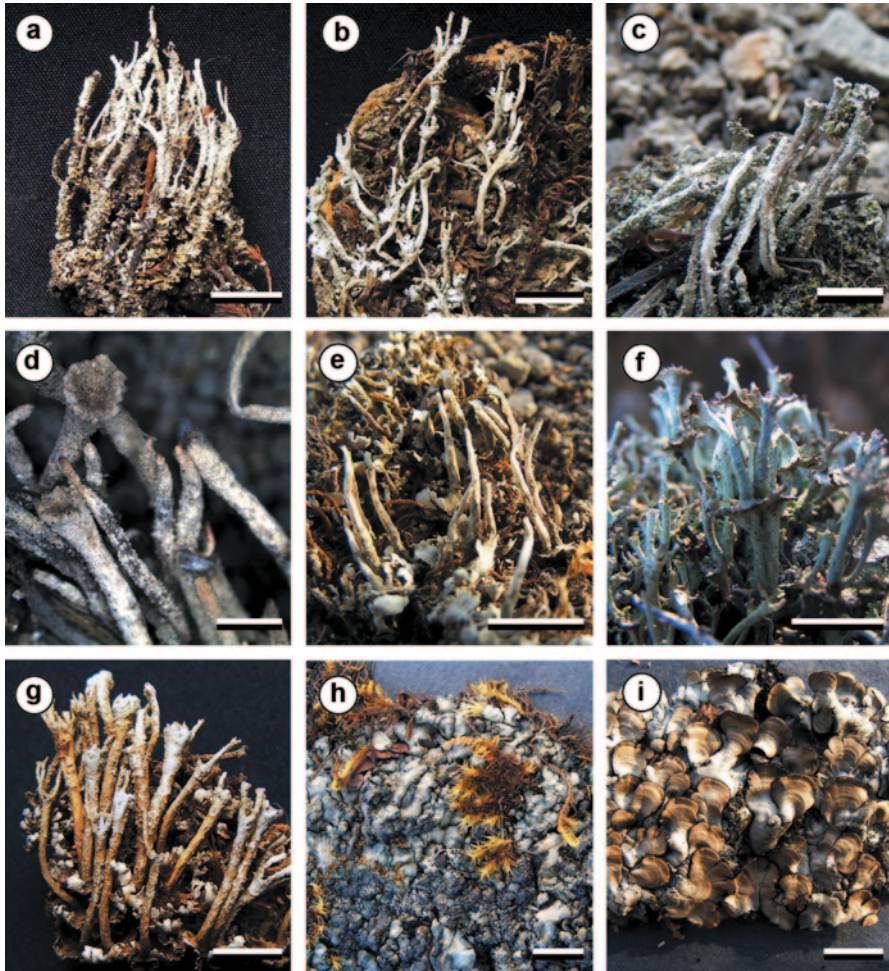
Hoffmann, *Deutschl. Fl.* 2: 125. 1796.

**Primary thallus:** squamulose, persistent; **squamules:** 2–6 mm long, 1–3 mm wide, deeply incised, narrow-lobed to coralloid, minute, crenate, greyish brown; **podetia:** 20–70 mm tall, unbranched to much-branched; grey to brownish in dense cushions, dying at base, scyphose or escyphose; **apices and axils:** perforated; **scyphi:** to 3 mm wide, 1–2 mm deep, opening into interior of podetia, marginally proliferating into scyphi; escyphose podetia simple to branched, tapering; axils open; **podetial surface:** areolate-verrucose and corticated at base; granulose and micro-squamulose in upper parts. **Apothecia:** uncommon, pruinose, later brown, in groups around margins of openings, 2–3 mm diam.; **hymenial discs:** brown-black at apices of podetia; **spores:** oblong to ellipsoid, (5–) 7–17 × 3–5  $\mu\text{m}$ . **Pycnidia:** on tips of podetia (rarely on basal squamules), barrel-shaped, slightly constricted at base, with pale red or hyaline gelatin; **conidia:** 3–8 × 0.5–1  $\mu\text{m}$ .

**Chemistry:** Podetia K<sup>+</sup> yellow, P<sup>+</sup> yellow, C<sup>-</sup>, KC<sup>-</sup>. Squamatic and barbatic acids.

**Ecology and distribution:** *Microhabitat occupied:* Terricolous; muscicolous-terricolous; terricolous-rupicolous; detriticolous-terricolous. In India, the species exhibits its wide distribution to Arunachal Pradesh, Himachal Pradesh, Meghalaya, Sikkim, Uttarakhand and West Bengal hills. The species is also known from Bhutan, Nepal, New Zealand, the Philippines and Sri Lanka; Africa, Europe, North and South America. *Cladonia squamosa* is distinguished by the abundant microsquamules in all parts.

**SPECIMENS EXAMINED:** **INDIA:** **ARUNACHAL PRADESH, WEST KAMENG DISTRICT**, Sela Pass, alt. 4,221 m, on soil with mosses, Upreti and party 08-009427 (LWG); **HIMACHAL PRADESH, KULLU DISTRICT**, Great Himalayan National Park, on way from Dhela to Lapah, alt. 3,000 m, on soil, D. K. Upreti 99-54093 (LWG), det. T. Ahti 2001; Pardi, alt. 3,140 m, on rock over soil, S. Nayaka and R. Srivastava 02-001125 (LWG); Dhela, alt. 3,000 m, on decaying wood of *Quercus smecarpifolia*, D. K. Upreti 99-54040 (LWG), T. Ahti 2001; Parvati river valley, above Kheer Ganga, alt. 3,150 m, on decaying wood, D. D. Awasthi and K. Dange 75322 (LWG-LWU), det. T. Ahti 2001; **SIKKIM, JONGRI**, alt. 2,962 m, on soil, M. N. Bose 6229 (LWG-AWAS); **EAST SIKKIM**, way to Tashi view point, alt. 1,800 m, on soil vertical face of road, Upreti and Chatterjee 01-26662 (LWG); Tumin area, alt. 1,800 m, on soil along roadside, Upreti and Chatterjee 01-67242 (LWG), det. T. Ahti 2001; **SOUTH SIKKIM**, Namchi 15 km towards Jorhang, alt. 1,000 m, on soil along vertical face of road, Upreti and Chatterjee 219573 (LWG), det. T. Ahti 2001; **WEST SIKKIM**, Yuksum, alt. 1,800 m, on soil, M. N. Bose 6277 (LWG-LWU); **UTTARAKHAND, BAGESHWAR DISTRICT**, en route to Sunderdhunga glacier, between Dhakuri and Jatoli, alt. 2,286 m, on soil, D. K. Upreti and Jyoti Tandon 213443 (LWG), det. T. Ahti 2001; **CHAMOLI DISTRICT**, Debal to Bagrigad, alt. 1,524 m, on soil, A. Singh and M. Ranjan 91537 (LWG), det. T. Ahti 2001; **PITHORAGARH DISTRICT**, Didihat, alt. 1,900 m, on soil, D. K. Upreti 201976 B (LWG); Askot Sandev Botanical Hot Spot, Adichaura area, alt. 2,150 m, on soil, Vikas Pant 02-103917 (LWG); Satgarh-Dhwaj, alt. 2,743 m, on soil, D. K. Upreti L/18431 (LWG), det. T. Ahti 2001; Munsiyari, Khaliya top, alt. 3,600 m, on stone over soil, N. C. Shah (LWG-AWAS), det. T. Ahti 2001; **UTTARAKASHI DISTRICT**, Phoolchatti and Narad Chatti, alt. 2,425 m, on soil, A. Singh 77532 A (LWG); Gangotri, alt. 3,118 m, on soil, Himanshu Rai and Pramod Nag 10-0014505 (LWG); Gangotri, alt. 3,100 m, on ground, Himanshu Rai and Pramod Nag 10-0014506 (LWG); Gangotri, alt. 3,123 m, on ground, Himanshu Rai and Pramod Nag



**Fig. 2.12** a *Cladonia stricta* (Nyl.) Nyl., b *C. subconistea* Asahina, c *C. subradiata* (Vain.) Sandst., d *C. subsquamosa* Kremp., e *C. subulata* (L.) F. H. Web. ex Wigg., f *C. verticillata* (Hoffm.) Schaer., g *C. yunnana* (Vain.) Abbayes ex J. C. Wei and Y. M. Jiang, h *Coccocarpia erythroxyli* (Spreng.) Swinsc. and Krog, i *C. palmicola* (Spreng.) Arv. and D. J. Galloway. Scale in d, f=2 mm; in c=5 mm; in a, b, e, g, h, i=10 mm

10-0014508 (LWG); Gangotri, alt. 3,104 m, on ground over *Pinus* litter, Himanshu Rai and Pramod Nag 10-0014528 (LWG); **WEST BENGAL, DARJEELING**, alt. 1,437 m, on soil, M. N. Bose 6375 (LWG-AWAS), det. T. Ahti 2001.

***Cladonia stricta*** (Nyl.) Nyl. (Fig. 2.12a; Fig. 2.42)

Nylander, Flora 52: 294. 1869.

Basionym: *Cladonia degenerans* var. *stricta* Nyl. in Middendorff, Reise Sibir. 4, Anh. 6(2): 4. 1867.

**Primary thallus:** squamulose, evanescent; **squamules:** small growing in humus-rich soil; **podetia:** grey to brown, 30–40 mm tall, 1.5–3 mm thick at base;



simple to sparingly branched with squamules at nodes, scyphose or escyphose; **scyphi**: up to 3 mm wide, marginally proliferating into scyphi or teeth-like structures; escyphose podetia subsubulate; **podetial surface**: with distinctly white-checked cortex, esorediate. **Apothecia**: forming along the margin of scyphi, sparse. **Hymenial discs**: brown, rare, weakly convex. **Conidiomata**: formed on margins of scyphi. **Pycnidia**: at tips of podetia.

**Chemistry**: Podetia K+ yellow, C<sup>-</sup>, KC<sup>-</sup>, P+ red. Atranorin, fumarprotocetraric acid present.

**Ecology and distribution**: *Microhabitat occupied*: Terricolous; muscicolous-terricolous. In India, the species exhibits its restricted distribution to Eastern Himalaya and known only from Sikkim. The species is also known from Nepal, Europe, North and South America.

**SPECIMENS EXAMINED**: **INDIA**: **SIKKIM, NORTH SIKKIM**, 2 km before Shingbo Rhododendron Sanctuary, near Yamthang, alt. 3,300 m, on soil, Upreti, Chatterjee and Divakar 04-004077 (LWG); near Yumthang, alt. 3,800 m, on soil, Upreti, Chatterjee and Divakar 04-004200 (LWG); near Changu, alt. 3,353 m, on soil among mosses, D. D. Awasthi 120 (LWG-AWAS), det. T. Ahti 2001.

***Cladonia subconistea*** Asahina (Fig. 2.12b; Fig. 2.42)

Asahina, J. Jap. Bot. 17: 433. 1941.

**Primary thallus**: squamulose; **squamules**: of primary thallus medium sized, thick, ascending; **podetia**: 10–15 mm tall, 1.5–2 mm thick at base, always scyphose; **scyphi**: narrow, verruculose-granulose on inner surface; **podetial surface**: areolate, verruculose, corticated, esorediate. **Hymenial discs**: brown, on margin of scyphi.

**Chemistry**: Podetia K+ yellow, C<sup>-</sup>, P+ yellow. Atranorin and psoromic acid present.

**Ecology and distribution**: *Microhabitat occupied*: Terricolous; muscicolous-terricolous. In India, the species exhibits its restricted distribution to Arunachal Pradesh and Uttarakhand. The species is also known from Nepal, Europe, North and South America. *Cladonia subconistea* is close to *C. chlorophaea* and *C. pyxidata*, but differs in the presence of psoromic acid, while the latter two have fumarprotocetraric acid.

**SPECIMENS EXAMINED**: **INDIA**: **ARUNACHAL PRADESH, UPPER SIANG DISTRICT**, near circuit house, Jenging, alt. 795 m, on soil, Upreti and party 08-009339 (LWG); **UTTARAKHAND, PITHORAGARH DISTRICT**, Sandev Botanical Hot-spot, alt. 1,875 m, on soil, Vikas Pant 0223521 (LWG).

***Cladonia submultiformis*** Asahina (Fig. 2.42)

Asahina, J. Jap. Bot. 18: 624.1942.

**Primary thallus**: squamulose, evanescent; **squamules**: large, lacinate, crenate, 1–4 mm long, up to 0.5 mm wide, digitately lobed, esorediate; **podetia**: grey, 20–60 mm tall, 1–2 mm thick at base, repeatedly branched, tips bluish; **scyphi**: sometimes with irregular, perforated; main axis angular or flattened, longitudinally fissured; **podetial surface**: corticate, esorediate and abundantly squamulose. **Apothecia**: common, numerous but small (up to 1 mm) at ends of the long, apical proliferations, dark brown; **spores**: not observed. **Pycnidia**: mainly produced on short

teeth at cup margins, conical to subspherical, often somewhat constricted at base, with hyaline gelatin.

**Chemistry:** Podetia K+ yellow, C-, P+ red. Atranorin, fumarprotocetraric and homosekikaic acids present.

**Ecology and distribution:** In India, the species exhibits its restricted distribution to Eastern Himalayas and known to Arunachal Pradesh, Mizoram, Sikkim, West Bengal, Darjeeling district (Awasthi 2007; Singh and Sinha 2010). No material of *Cladonia submultiformis* has been examined by us; the description is based on Awasthi (2007). The species is also known from China, Taiwan and Thailand.

*Cladonia subradiata* (Vain.) Sandst. (Fig. 2.12c; Fig. 2.42)

Sandstede, Abh. Naturwiss. Vereine Bremen. 25: 230. 1922.

Basionym: *Cladonia fimbriata* var. *chondroides* subvar. *subradiata* Vain., Acta Soc. Fauna Fl. Fenn. 10: 338.1894.

**Primary thallus:** squamulose, persistent to evanescent; **squamules:** 2–4 × 1–2 mm, small, greenish brown on upper surface, white cottony on lower surface, crenulate to lacinate, esorediate to granular below and at margins; **podetia:** greenish white, up to 20 mm tall, 0.5–1 mm thick at base, simple to sparingly branched, scyphose when mature, tips: blunt to acute in young podetia; **scyphi:** scarcely distinct, to 2 mm wide, corticated on inner surface; **podetial surface:** corticated and with large squamules at base, upwards granulose soresiate or with isidioid granules and microsquamules. **Apothecia:** uncommon, dark brown (but the more frequent primordia pale brown), 2–3 mm wide; **hymenial discs:** brown on margins; **spores:** fusiform, 10–12 × 2 μm. **Pycnidia:** common, either on young basal squamules or at tips of podetia, bell-shaped to pyriform, strongly constricted at base, with hyaline gelatin; **conidia:** 7–10 × 1 μm.

**Chemistry:** Podetia K-, P+ orange-red. Fumarprotocetraric acid complex present.

**Ecology and distribution:** *Microhabitat occupied:* Terricolous; detriticolous-terricolous; muscicolous-terricolous; terricolous-rupicolous. In India, the species exhibits its wide distribution to Himachal Pradesh, Jammu and Kashmir, Sikkim, Tamil Nadu and Uttarakhand. The species is also known from Africa, Asia, North and South America.

**SPECIMENS EXAMINED: INDIA: HIMACHAL PRADESH, KULLU DISTRICT,** Great Himalayan National Park, Maraur, altitude 2,600 m, on rock over soil, R. Srivastava 04-003285 (LWG); En route to Jalori Lake, altitude 3,180 m, on soil, D. K. Upreti and Y. Joshi 08-006995 (LWG); **JAMMU AND KASHMIR, ANANTNAG DISTRICT,** Pahalgam, west side, altitude 2,400 m, on dead wood among mosses, M. Sheikh 05-006142 (LWG); **SIKKIM, NORTH SIKKIM,** above Lachen, altitude 3,000 m, on soil, Upreti, Chatterjee and Divakar 04-003750 (LWG); near Yumthang, altitude 3,800 m, on soil, Upreti, Chatterjee and Divakar 04-004172 (LWG); **TAMIL NADU, NILGIRI HILLS,** Konada to Kilkotagiri, in shola, altitude 1,829 m, on ground on mosses, D. K. Upreti and K. P. Singh 71-71 (LWG-LWU), det. T. Ahti 2001; Upper Bhavani road from Avalanche on way to Deverbetta, altitude 2,439 m, on hard soil, K. P. Singh 71-693 (LWG-LWU), det. T. Ahti 2001; **UTTARAKHAND, PAURI GARHWAL DISTRICT,** Pauri, Pauri-Devprayag road, near circuit house, altitude 1,379 m, on soil, V. Shukla and Y. Joshi 05-005319 (LWG); Khirsu, Khirsu reserve forest, altitude 1,911 m, on soil at base of tree trunk, Himanshu Rai 11-0014547 (LWG); **UTTARAKASHI DISTRICT,** Gangotri,

altitude 3,133 m, on ground, Himanshu Rai and Pramod Nag 10-0014511, 10-0014513, 10-0014538 (LWG); Gangotri, altitude 3,104 m, on ground over *Pinus* litter, Himanshu Rai and Pramod Nag 10-0014528 (LWG).

***Cladonia subsquamosa*** Kremp. (Fig. 2.12d; Fig. 2.42)

In Warming, Vidensk. Meddel. Dansk. Naturhist. Foren. Kjøbenhavn 5: 366.1873 (1874)

**Primary thallus:** squamulose, persistent or evanescent; **squamules:** 1–3 × 1–2 mm, soft, fragile, convex to imbricate, fluffy below but sometimes granular or sorediate, small, fragile; **podetia:** grey-green to brownish, 10–20 mm tall, 1–2 mm thick at base, always scyphose; **scyphi:** up to 5 mm wide, inner side granular; marginally proliferating into scyphi or subulate structures and with brown hymenial discs; **podetial surface:** ecorticate or at base corticate, finely to coarsely sorediate, sorediate throughout along with microsquamules. **Apothecia:** rather common, 1–5 mm wide, light to dark brown, on long (4–7 mm) stalks; **spores:** fusiform, 8.5–12.5 × 2–3.5 μm. **Pycnidia:** infrequent, semiglobose to pyriform, with hyaline gelatin; **conidia:** not observed

**Chemistry:** Podetia K–, or K+ yellow, P+ yellow-red. Fumarprotocetraric acid present.

**Ecology and distribution:** *Microhabitat occupied:* Terricolous; detriticolous-terricolous. In India, the species exhibits its restricted distribution to Eastern Himalaya and Deccan Plateau and known only from Tamil Nadu. The species is also known from Australasia, Africa, North and South America.

**SPECIMENS EXAMINED:** **INDIA:** **TAMIL NADU, PALNI HILLS, DINDIGUL,** Kodaikanal, on Berjam road, near Paniyarapore, altitude 2,332 m, on ground, D. D. Awsathi and K. P. Singh 70.309 (LWG-LWU); Ootacamund on way to Doddabetta peak, altitude 2,567 m, on soil, G. Awasthi 82-12 (LWG-LWU), det. T. Ahti 2001; Kodaikanal, on way to bear Shola, along road shola, alt. 2,134 m, on decaying wood stump, D. D. Awasthi and K. P. Singh 70.29 (LWG-LWU), det. T. Ahti 2001; Shenbaganur, near silver cascade, altitude 1,829 m, on decaying wood, D. D. Awasthi and K. P. Singh 70-61 B (LWG-LWU), det. T. Ahti 2001; on way to Bear-Shola by roadside, altitude 2,134 m, on ground, D. D. Awsathi and K. P. Singh 70.4 (LWG-LWU), det. T. Ahti 2001.

***Cladonia subulata*** (L.) F. H. Wigg. (Fig. 2.12e; Fig. 2.42)

Wiggers, Prim. Fl. Holsat.: 90. 1780.

Basionym: *Lichen subulatus* L., Sp. Pl.: 1153. 1753.

Synonyms: *Cladonia fimbriata* var. *subulata* (L.) Vain., Acta Soc. Fauna Fl. Fenn. 10: 252. 1894. -*Cladonia cornutoradiata* (Coem.) Sandst., Abhandl. Naturw. Ver. Bremen 21: 373. 1912.

**Primary thallus:** squamulose, persistent; **squamules:** small, grey-white to dark, thick, involute; **podetia:** greyish green to grey-brown (–5)10–20 mm tall, esorediate or barely sorediate beneath margins, usually escyphose, sparingly branched, subulate, unbranched to sparingly branched, branching angle often wide (to 90°); rarely scyphose; **scyphi:** irregular 2 mm wide; **podetial surface:** corticated to decorticated, granulose and microsquamulose at base, upwards farinose-sorediate. **Apothecia:** infrequent, at cup margins, stalked, dark brown; **hymenial discs:** brown on margin of scyphi; **spores:** not observed. **Pycnidia:** at tips of subulate podetia or cup margins, ovoid to conical, slightly constricted at base, gelatin hyaline; **conidia:** 5–8 × 1 μm.

**Chemistry:** Podetia K<sup>-</sup>, P<sup>+</sup> red, C<sup>-</sup>, KC<sup>-</sup>. Fumarprotocetraric acid present.

**Ecology and distribution:** *Microhabitat occupied:* Detriticolous-terricolous; terricolous-rupicolous; muscicolous-terricolous. In India, the species is widely distributed to Jammu and Kashmir, Sikkim and Uttarakhand. The species is also known from Nepal, Australasia, Antarctica, Europe, North and South America.

**SPECIMENS EXAMINED:** **INDIA: JAMMU AND KASHMIR, ANANTNAG DISTRICT,** Pahalgam, near Mamal village, alt. 2,100 m, on decaying wood, A. Singh and D. K. Upreti 11611 (LWG), det. T. Ahti 2001; **BARAMULLA DISTRICT,** on way from Gulmarg to Khilanmarg, alt. 2,655 m, on decaying wood, K. Dange 77.486 (LWG-LWU), det. T. Ahti 2001; **SIKKIM, NORTH SIKKIM,** Lachen, Gumpa side forest, alt. 2,700 m, on soil over rock, Sinha 1537 (BSHC); **UTTARAKHAND, RUDRAPRAYAG DISTRICT,** Chopta, alt. 3,000 m, on soil over rock with decaying mosses, Himanshu Rai and Pramod Nag 08-0012252, 08-0012254 (LWG); Chopta, alt. 2,850 m, on soil over rock with mosses, Himanshu Rai and Pramod Nag 08-0012255 (LWG); **BAGESHWAR DISTRICT,** en route to Pindari glacier from Dwali to Phurkiya, alt. 2,972 m, on soil, S. Joshi and Y. Joshi 07-008877 (LWG).

*Cladonia verticillata* (Hoffm.) Schaer.<sup>1</sup> (Fig. 2.12f; Fig. 2.42)

Schaerer, Lich. Helvet. Spic.: 31'.1823.

Basionym: *Cladonia pyxidata* \* *C. verticillata* Hoffm., Deutschl. Fl. 2: 122. 1196.

Synonym: *Cladonia cervicornis* (Ach.) Flotow subsp. *verticillata* (Hoffm.) Ahti, Lichenologist 12: 126. 1980.

**Primary thallus:** squamulose, persistent; **squamules:** small, brown, lobed, persistent; **podetia:** grey-green, always scyphose; **scyphi:** gradually flaring, 3–5 mm wide, shallow, closed, proliferating from centre into 2–5(–6) tiers of scyphi with 1–4 proliferations in each tier; primary scyphus with few or more squamules from margin; secondary and tertiary tiers with few or none squamules from margin; **margin:** scyphi usually dentate with brown hymenial discs; **podetial surface:** as well as outer surface of scyphi areolate-subcorticate with fine white intertices.

**Chemistry:** Podetia K<sup>-</sup>, P<sup>+</sup> red, KC<sup>-</sup>. Fumarprotocetraric acid present.

**Ecology and distribution:** *Microhabitat occupied:* Terricolous; detriticolous-terricolous, terricolous-rupicolous; muscicolous-terricolous. In India, the species exhibits its wide distribution to Manipur, Meghalaya, Sikkim, Uttarakhand and West Bengal, Darjeeling district. The species is also known from Asia, Australasia, Europe and North America.

**SPECIMENS EXAMINED:** **INDIA: MEGHALAYA, SHILLONG,** Upper Shillong peak, alt. 1,982 m, on soil with mosses, D. D. Awasthi 6466 (LWG-AWAS), det. T. Ahti 2001; Botanical Gardens, alt. 1,525 m, on ground, B. N. Prasad 3439 (LWG-AWAS); **EAST KHASI HILLS DISTRICT,** Shora, Cherapunji, alt. 1,500 m, on soil, D. K. Upreti 20-67504 A (LWG); 10 km away towards Cherapunji from Mueleum, alt. 1,177 m, on soil vertical slope along road, D. K. Upreti 09-015823 (LWG); **WEST KHASI HILLS DISTRICT,** Nongstoin village, alt. 1,409, on soil over big boulders, G. Panigrahi 16480 (LWG-AWAS); **SIKKIM, NORTH SIKKIM,** Chukbuk, above Thangu, alt. 4,100 m, on soil, Upreti, Chatterjee and Divakar 04-003944 B (LWG); **UTTARAKHAND, ALMORA DISTRICT,** Askot, Dharamghar near school, alt. 1,676, on

<sup>1</sup> The status of Indian material is not clear and molecular comparison of European and Indian samples is being considered to ascertain the heterogeneity. Meanwhile, the Indian material must be considered as *Cladonia verticillata* sensu lato (Personal communications with T. Ahti 2013).

ground in shade, D. D. Awasthi 2655 (Herb LWU-LWG); **CHAMPAWAT DISTRICT**, Lohaghat to Mayawati, alt. 1,890 m, on soil, D. K. D. K. Upreti, S. Joshi, H. Rai, R. Khare, G. K. Mishra and A. Dwivedi 09-0126450 (LWG); Dunaghat on way to Lohaghat, alt. 1,750 m, on soil, G. K. Mishra 10-015293 (LWG); Lalwapani, alt. 1,700 m, on decaying wood, D. K. Upreti 201879 (LWG); **DEHRADUN DISTRICT**, Mussoorie, alt. 2,134 m, on ground, O. A. Höeg 3389 A(LWG-AWAS); **PAURI GARHWAL DISTRICT**, Pauri, Kandoliya, alt. 1,401 m, on soil, V. Shukla and Y. Joshi 05-004896 (LWG); **PITHORAGARH DISTRICT**, Sandev Botanical Hot-Spot, alt. 1,875, on soil, Vikas Pant 02 000964 (LWG); Dharchula, before Naraim Swami Ashram, alt. 2,400 m, on soil, D. K. Upreti L 18406 (LWG).

*Cladonia yunnana* (Vain.) Abbayes ex J. C. Wei and Y. M. Jiang (Fig. 2.12g; Fig. 2.42)

Wei and Jiang, Lich. Xizang: 84. 1986.

Basionym: *Cladonia transcendens* var. *yunnana* Vain. in Hue, Nouv. Arch. Mus. Hist: Nat. Paris, ser. 3, 10: 262. 1898.

**Primary thallus:** squamulose, persistent; **squamules:** large, irregularly lobed, greenish brown, upturned or reflexed; **podetia:** yellowish grey to brownish, 5–25(–45) mm tall, 1.5–2 mm thick at base, always scyphose; **scyphi:** up to 5 mm wide, 2 mm deep, closed; inner side: corticated, esorediate; outer side granular to farinose soresdiate; margins entire or proliferating into 2–3 tiers of scyphi; **podetial surface:** smooth, corticated at base, rarely squamulose; upper part granular soresdiate in patches or rarely furfuraceous soresdiate. **Hymenial discs:** red, on margin of scyphi.

**Chemistry:** Podetia K–, C–, KC– or KC+ yellow, P–. Squamatic and rhodocladonic acids present.

**Ecology and distribution:** *Microhabitat occupied:* Terricolous; muscicolous-terricolous; detriticolous-terricolous. In India, the species exhibits its restricted distribution to Sikkim. The species is also known from Bhutan, China, Indonesia, Japan, Malaysia, Nepal and Papua New Guinea.

**SPECIMENS EXAMINED:** **INDIA:** **SIKKIM, NORTH SIKKIM**, near Changu, alt. 3,353 m, on soil with mosses, D. D. Awasthi 117-A (LWG-AWAS), det. T. Ahti 2001; near Yumthang, alt. 3,800 m, on soil, Upreti, Chatterjee and Divakar 04-004152 (LWG); 2 km before Shingbho Rhododendron Sanctuary, alt. 3,300 m, on decaying wood, Upreti, Chatterjee and Divakar 04-004076 (LWG); **WEST SIKKIM**, Yukshum, alt. 1,800 m, on soil, M. N. Bose 6274 (LWG-AWAS); Pithang-Dzongri, 3 km trek, alt. 3,963 m, on ground in open places, G. P. Sinha 259 (BSHC), det. T. Ahti 2001.

## **COCCOCARPIA** Pers. (*Coccocarpiaceae*)

In Gaudich., Voy. Uranie : 206. 1826.

**Thallus:** foliose, adnate, orbicular, dorsiventral, dichotomously lobate; **lobes:** usually flabellate or cuneate, heteromerous, corticated on both surfaces; **photobiont:** (*Scytonema*); **upper surface:** leaden grey, bluish grey to brownish black, smooth or transverse concentric ridges, with or without isidia; **lower surface:** creamish or black, densely rhizinate, often rhizines projecting beyond lobe margins; **medulla:** colourless or pigmented. **Apothecia:** laminal, biatorine, often with marginal hair; **disc:** reddish to black; **asci:** unitunicate with an ocular chamber; **asci:** 8-spored; **spores:** hyaline, often with two oil droplets, simple or two celled.

Out of 24 species known from world; 8 species known from India, of which 3 are terricolous.

**Key to the terricolous species of *Coccocarpia*:**

1.	Thallus lacking isidia, lobes 1–3(–4) mm wide, with distinct concentric rings, red brown to black, spores simple to two celled, 7–13 (–15) × 3–5 μm.....	<i>C. erythroxyli</i>
1a.	Thallus isidiate.....	2
2.	Isidia terete, simple or coralloid branched.....	<i>C. palmicola</i>
2a.	Isidia microphylline to squamiform.....	<i>C. pellita</i>

***Coccocarpia erythroxyli* (Spreng.) Swinsc. and Krog (Fig. 2.12h; Fig. 2.43)**

Swinscow and Krog, *Norweg. J. Bot.* 23: 256. 1976.

Basionym: *Lecidea erythroxyli* Spreng., *K. Vet. Acad. Nya Handl.* 1: 47.1820.

Synonyms: *Coccocarpia pellita* var. *pannosa* Müll. Arg., *Flora* 65: 320. 1882. *Coccocarpia incisa* Pers. in Gaudich., *Voy. Uranie*: 206. 1827. *Coccocarpia pellita* var. *incisa* (Pers.) Müll. Arg., *Flora* 65: 321. 1882. *Lecidea parmelioides* Hook. in Kunth, *Syn. Pl.*: 15. 1822. *Coccocarpia pellita* var. *atrocaesia* Räsänen, *Arch. Soc. Zool. Bot. Fenn.* ‘Vanamo’ 6(2): 84. 1952.

**Thallus:** orbicular, sometimes irregular, usually ± loosely attached, adnate to 7 (–12) cm across; **lobes:** 1–3 (–4) mm wide, ± imbricate or adjacent; lobes apex round with deflexed margins; **upper surface:** bluish grey to brown black, glossy, shiny, usually with transverse concentric rings; **medulla:** white; **lower surface:** pale ceamish, brownish or almost black, rhizinate. **Apothecia:** common scattered to crowded, sometimes fused to form irregular aggregates to 2.5 (–5) mm in diam., adnate, hairs projecting from base, exciple hairs usually hidden under the disc; **disc:** plane to strongly convex, brownish red to blackish; **asci:** narrowly clavate to almost cylindrical; **spores:** 8 per ascus, ellipsoid to fusiform, usually with 2 oil droplets, 8–13 × 3–5 μm.

**Chemistry:** Thallus K–, C–, KC–, P–; no secondary metabolites in TLC.

**Ecology and distribution:** *Microhabitat occupied:* Terricolous; muscicolous-terricolous; terricolous-rupicolous. In India the species is widely distributed to Andaman and Nicobar Islands, Arunachal Pradesh, Assam, Himachal Pradesh, Karnataka, Kerala, Madhya Pradesh, Maharashtra, Manipur, Meghalaya, Nagaland, Sikkim, Tamil Nadu, Uttarakhand and West Bengal while species growing on soil is known from different localities of Himachal Pradesh, Meghalaya, Sikkim, Tamil Nadu and Uttarakhand. Outside India, the species is also reported Australia, Bhutan, China, Japan and New Zealand; Central, North and South America.

**SPECIMENS EXAMINED:** **INDIA:** **HIMACHAL PRADESH,** KULLU DISTRICT, Marhi, alt. 3,200 m, on exposed rocks over soil, Upreti and Divakar 02-000016 (LWG); **MEGHALAYA,** SHILLONG, area front of Nirala bungalow, on rocks over soil, G. Panigrahi 3825 (LWG-AWAS); **SIKKIM,** **NORTH SIKKIM,** Kalep before Thangu, alt. 3,900 m, on soil over rocks, Upreti, Chatterjee and Divakar 04-003867 (LWG); Giagaon after Thangu, alt. 4,600 m, on soil over rock, D. K. Upreti, S. Chatterjee, P. K. Divakar 04-004023 (LWG); Thangu, alt. 4,000 m, on rocks over soil, Upreti, Chatterjee and Divakar 04-003906 (LWG); Changu, alt. 3,505 m, on moist stones among mosses over soil, D. D. Awasthi 07 (LWG-AWAS); Chubuk above Thangu, alt. 4,100 m, on soil, Upreti, Chatterjee and Divakar 04-003934, 04-003943 (LWG); **TAMIL NADU,** **MADURAI** Shaebaganur forest, alt. 1,829 m, on rocks over soil, G. Foreau 3775 (LWG-AWAS); Kodaikanal along heving path, alt. 1,905 m, over stone over soil, G. Foreau

and D. D. Awasthi 4321 (LWG-AWAS); **UTTARAKHAND, BAGESHWAR DISTRICT**, Dwali to Phurkiya, (en route to Pindari Glacier), alt. 2,896 m, on mossy hard soil, D. D. Awasthi and A. M. Awasthi s.n. (LWG-AWAS); alt. 3,200 m, on stone over soil, D. D. Awasthi 7649 (LWG-AWAS); Phurkiya to Mirtoli, en route to Pindari glacier, alt. 3,444 m, over boulders on soil, D. D. Awasthi 7765 (LWG-AWAS); Phurkiya to Pindari glacier near Mirtoli, alt. 3,658 m, on ground, D. D. Awasthi 7686 (LWG-AWAS); **CHAMOLI DISTRICT**, between Ghanghariya and Hemkund, alt. 4,115 m, on rock over soil, A. Singh, 85812 (LWG); Ghanghariya to Hemkund, on rock over soil, A. Singh, s.n. (LWG); Patar Nachauni, alt. 3,658 m, on rock over soil, A. Singh, 91509 (LWG); way to Nanda Devi Biosphere reserve, Srenikhal, alt. 3,700 m, on soil, Shobha Rawat, 08-011272 (LWG); **PITHORAGARH DISTRICT**, Nhaerdevi to Mapang en route to Milam glacier, alt. 2,933 m, on rock over soil, S. Joshi 07-010503, 07-010504 (LWG); en route to Milam glacier, alt. 3,750 m, on rock over soil, B. S. Kholia s.n (LWG); Munsiyari, on way to Khaliya top, after Bhujwani, alt. 3,050 m, on rock over soil, D. K. Upreti 212939 (LWG); Lilam to Bugudiyar en route to Milam glacier, alt. 2,125 m, on rock over soil, S. Joshi 07-010343 (LWG); **RUDRAPRAYAG DISTRICT**, Tungnath, Chandrashila, alt. 3,750 m, on rock over soil, A. Singh and M. Ranjan, 107143 (LWG); Tungnath, Chandrashila, alt. 3,750 m, on rock over soil, M. Ranjan, 107143 Dup (LWG); Mandakini river valley, on way to Rambara from Kedarnath, alt. 3,165 m, on boulders along with mossy soil, K. Dange, 76.352 (LWG-LWU); Mandakini river valley on way to Rambara from Kedarnath, alt. 3,165 m, on exposed boulders over soil, K. Dange, 71.380 (LWG-LWU); on way from Chopta to Tungnath, alt. 3,000 m, on rocks over soil, Upreti and Nayaka, 07-010164 (LWG); Tungnath, alt. 3,300 m, on exposed rock over soil, D. K. Upreti and S. Nayaka, 07-010200 (LWG).

***Coccocarpia palmicola*** (Spreng.) Arv. and D. J. Galloway (Fig. 2.12i; Fig. 2.43)  
Arvidsson and Galloway, Bot. Not. 132: 242. 1979.

Basionym: *Lecidea palmicola* Spreng., Kongl. Vetensk. Acad. Nya Handl. 1: 46. 1820.

Synonyms: *Coccocarpia pellita* var. *cronia* (Tuck.) Müll. Arg., Flora 65: 320. 1882. – *Coccocarpia cronia* (Tuck.) Vain., Ann. Acad. Sci. Fenn. ser. 2. 6:103. 1914. – *Coccocarpia pellita* var. *tenuoir* (Nyl.) Müll. Arg., Flora 65: 32. 1882.

**Thallus:** orbicular, attached to ± closely adnate, foliose, lobate, 6–15 cm across; **lobes:** ± imbricte or adjacent, lobes apex rounded with deflexed margins, 1–5 (–8) mm wide, usually convex; **upper surface:** leaden grey to brown black, glossy, matt, with or without transverse concentric rings, isidiate; **isidia:** simple to coralloid branched concolorous with surface or darker, terete, globular to cylindrical, laminar, scattered or forming a dense crust; **medulla:** colourless to yellowish; **lower surface:** pale ceamish, brownish or almost black, rhizinate. **Apothecia:** seen in very less specimen examined, scattered, rarely crowded, ± irregular, up to 4 mm in diam., ± adnate or sometimes slightly raised above the surface of the lobes by white hairs projecting from the base; **disc:** ± plane to strongly convex; **asci:** narrowly clavate to almost cylindrical; **spores:** 8 per ascus, ellipsoid to fusiform, usually with 2 oil droplets, 5–10 (–15) × 3–5 µm in size.

**Chemistry:** Thallus K–, C–, KC–, P–; no secondary metabolites in TLC.

**Ecology and distribution:** *Microhabitat occupied:* Terricolous; terricolous-rupicolous; muscicolous-terricolous. In India the species is widely distributed to Andaman and Nicobar Islands, Arunachal Pradesh, Assam, Karnataka, Kerala, Madhya Pradesh, Maharashtra, Manipur, Meghalaya, Nagaland, Sikkim, Tamil Nadu, Uttarakhand and West Bengal while species growing on soil is known from

different localities of Arunachal Pradesh, Kerala, Meghalaya, Sikkim, Tamil Nadu, Uttarakhand and West Bengal. The species is also reported from Bhutan; tropical and subtropical regions of the world.

**SPECIMENS EXAMINED:** **INDIA:** **ARUNACHAL PRADESH**, near Riga, on rock over soil, Upreti, Dubey, Khare and Mishra 08-009352 (LWG); **KERALA**, **IDUKKI DISTRICT**, Munnar, way to Anayirangal Dam, alt. 1,600 m, on rock over soil, Biju Haridas 06-014639 (LWG); **ODISHA**, **GANJAM**, foot hills of Mahendragiri, Nurukhat area, on rock over soil, D. D. Awasthi, G. Awasthi, R. Mathur, P. Srivastava 86.176 (LWG-LWU); **MEGHALAYA**, **SHILLONG**, near upper Shillong peak, alt. 1,900 m, over stones on soil, D. D. Awasthi 7875 (LWG-AWAS); **TAMIL NADU**, **KODAIKANAL**, Croaker's walk, on way to Pambampuram, alt. 2,134 m, over stone on mossy soil, K. P. Singh 70.491 (LWG-LWU); **NILGIRI HILLS**, Avalanche power house area, EB Department on banks of lake, alt. 1,829 m, over rocks on soil, K. P. Singh 71.764 (LWG-LWU); **DINDIGUL DISTRICT**, Kodaikanal along leaning path, alt. 6,750 m, on rock over soil, G. Foreau 3764 (LWG-AWAS); **SIKKIM**, **EAST SIKKIM**, Tumin area, alt. 2,000 m, on soil, Upreti and Chatterjee 01-26604 (LWG); **NORTH SIKKIM**, Kabi, before Mangan, alt. 1,660 m, on soil, Upreti, Chatterjee and Divakar 08-009352 (LWG); above Lachung towards Yumthang, alt. 3,000 m, on rocks over soil, Upreti, Chatterjee and Divakar 04-004256 (LWG); Mangan, alt. 1,219 m, on rock over mossy soil, V. S. Sharma and M. Ranjan 76734 A (LWG); **SOUTH SIKKIM**, Namchi 20 km towards Namthang, alt. 1,800 m, on soil and rocks along roadside, Upreti and Chatterjee 219581 (LWG); **UTTARAKHAND**, **PITHORAGARH DISTRICT**, Gori Ganga catchment area, East Ghandhura, alt. 1,800 m, on rock over soil, V. Pant 02000875 (LWG); Sandev Botanical hotspot, Deochula, Shantikunj, alt. 2,200 m, on rock over soil, V. Pant 02000469 (LWG); Tharedhar, en route to Narain Swami Ashram, alt. 1,750 m, on soil, D. K. Upreti L 18401 (LWG); Gori-Ganga catchment area, Thakala forest, alt. 1,500 m, on rock over soil, V. Pant 02000639 (LWG); **RUDRAPRAYAG DISTRICT**, Madmaheshwar to Guptkashi, alt. 1,200 m, on soil, A. Singh and M. Ranjan, 106810 (LWG); between Kalimath and Laink, alt. 1,300 m, on rock over soil, A. Singh and M. Ranjan, 106874, 106878 (LWG); **WEST BENGAL**, **DARJEELING DISTRICT**, Kurseong, near Mahanadi, towards north side, tea garden area, alt. 1,219 m, on stones over soil, D. D. Awasthi, M. R. Agarwal 66.295 (LWG-LWU); alt. 1,524 m, on stones over soil, D. D. Awasthi, M. R. Agarwal 66.340 (LWG-LWU).

*Coccocarpia pellita* (Ach.) Müll. Arg., Flora 65: 320. 1882. (Fig. 2.13a; Fig. 2.43)  
R. Santesson, Symb. Bot. Upsal. 12(1):420. 1952.

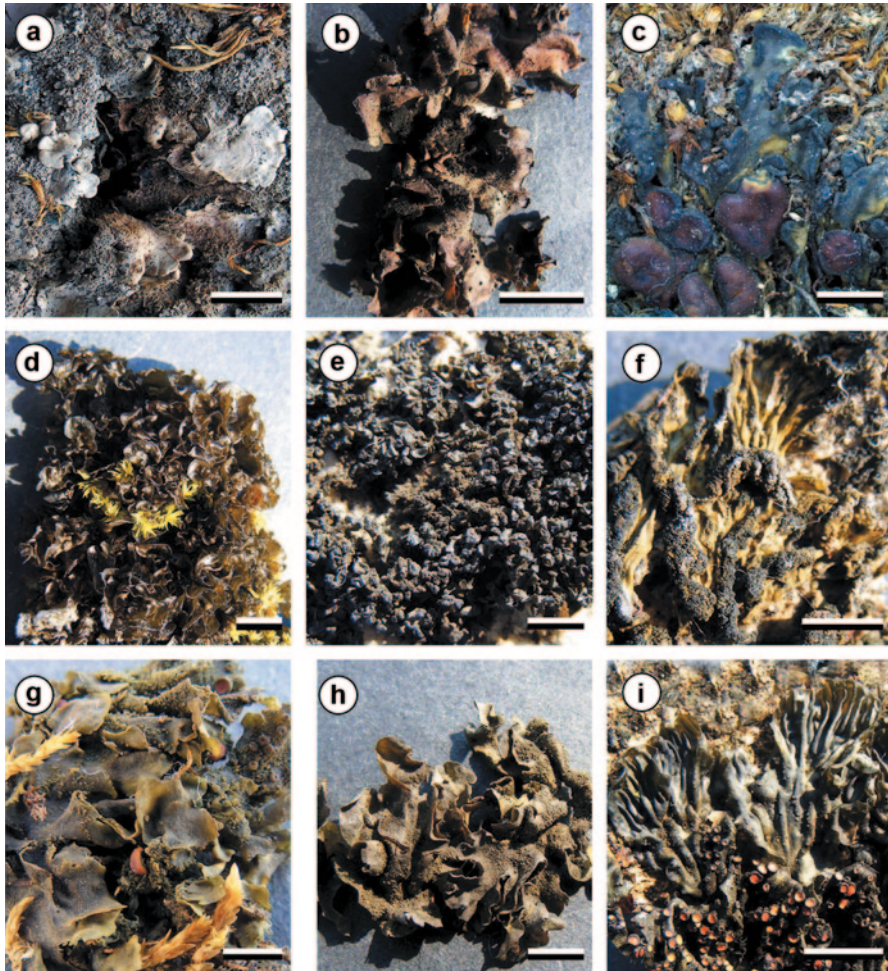
Basionym: *Parmelia pellita* Ach., Lichenogr. Universalis: 468. 1810.

**Thallus:** orbicular, loosely attached, lobate, 10 cm across; **lobes:** ± imbricte or adjacent, lobes apex rounded with deflexed margins, 2–3(–6) mm wide; usually convex; **upper surface:** leaden grey to brownish grey, with or without transverse concentric ridges, isidiate; **isidia:** flattened, microphylline to squamiform; **lower surface:** pale ceamish, brownish or almost black, rhizinate. **Apothecia:** very rare, to 2 mm in diam., scattered, ± irregular; **disc:** ± convex, pale yellowish red to reddish brown; **asci:** narrowly clavate to subcylindrical, amyloid internal and external structure cap and ring structure present; **spores:** 8 per ascus, fusiform, usually with 2 oil droplets, 7–10 (–15) × 3–5 µm.

**Chemistry:** Thallus K<sup>-</sup>, C<sup>-</sup>, KC<sup>-</sup>, P<sup>-</sup>; no secondary metabolites in TLC.

**Ecology and distribution:** *Microhabitat occupied:* Terricolous; terricolous-rupicolous; muscicolous-terricolous. In India the species is pantropical in distribution and widely distributed to Andaman and Nicobar Islands, Arunachal Pradesh, Himachal Pradesh, Karnataka, Kerala, Manipur, Meghalaya, Nagaland, Sikkim, Tamil





**Fig. 2.13** **a** *Coccocarpia pellita* (Ach.) Müll. Arg. em. R. Sant., **b** *Collema auriculiforme* (With.) Coppins and J. R. Laundon, **c** *C. coccophorum* Tuck., **d** *C. crispum* (Huds.) G. H. Web., **e** *C. cristatum* (L.) G. H. Web., **f** *C. furfuraceum* (Arn.) Du Rietz, **g** *C. furfureolum* Müll. Arg., **h** *C. fuscovirens* (With.) J. R. Laundon, **i** *C. japonicum* (Müll. Arg.) Hue. Scale in **c**=2 mm; in **a**, **e**, **g**, **i**=5 mm; in **b**, **d**, **f**, **h**=10 mm

Nadu, Uttarakhand and West Bengal while species growing on soil is reported from localities of Arunachal Pradesh, Kerala, Sikkim and Uttarakhand. The species is also reported from Bhutan.

**SPECIMENS EXAMINED:** **INDIA:** **ARUNACHAL PRADESH**, near Riga, on rock over soil, Upreti, Dubey, Khare and Mishra 08-009352 A (LWG); **KERALA, IDUKKI DISTRICT**, Kallar Munnar hills, alt. 840 m, on soil, A. Singh and M. Ranjan 103050 (LWG); Athirumala, Agasthyamala Biosphere Reserve, alt. 1,000 m, on soil, Biju Haridas 06-014701 (LWG); **SIKKIM, NORTH SIKKIM**, Phangir, between Lachen and Thangu, alt. 3,500 m, on soil, Upreti, Chat-

terjee and Divakar 04-004025 (LWG); **UTTARAKHAND, PITHORAGARH DISTRICT**, Askot, near village Naret, alt. 1,341 m, over stone on soil, D. D. Awasthi 3304 (LWG-AWAS); Sandev Botanical hotspot, alt. 1,875 m, on soil, Vikas Pant 02-000966 (LWG); Gori Ganga cathment area, Kauli, alt. 1,450 m, on soil, V. Pant 02000899 (LWG); Sandev botanical Hot-Spot, Dochula, Shantikunj, alt. 2,200 m, on rock over soil, Vikas Pant 02000469 (LWG); **RUDRAPRAYAG DISTRICT**, Madmaheshwar, between Kalimath and Laink, alt. 1,321 m, on rock over soil, M. Ranjan, 106874 (LWG); Madmaheshwar, between Kalimath and Laink, alt. 1,300 m, on rock over soil, A. Singh and M. Ranjan, 106878 (LWG).

**COLLEMA** F. H. Wigg. (*Collemataceae*)

Wiggers, Prim. Fl. Holsat: 89. 1780.

**Thallus:** foliose, subfoliose, subfruticose, lobate, gelatinous and swollen when wet; homoiomerous, ecorticated or rarely a pseudocortex present on one or both surfaces **upper surface:** pale olivaceous green, bluish or blackish, smooth or ridged, isidiate or not; **lower surface:** with or without rhizines sometimes haptera or umbilicus; **isidia:** granular, globular, teretiform, simple, coralloid branched or squamiform, soredia absent; **photobiont:** a cyanobacterium *Nostoc* dispersed throughout thallus; **apothecia:** laminal, sessile, substipitate to pedicellate; **disc:** pale red, red brown to darker; **asci:** usually 8-spored; **spores:** colourless, transversely septate, submuriform or muriform.

Out of 78 species known from world, 31 species are known from India, of which 18 are terricolous.

**Key to the terricolous species of *Collema*:**

1.	Thallus with isidia.....	2
1a.	Thallus without isidia.....	11
2.	Isidia globular, teretiform, simple or coralloid branched.....	3
2a.	Isidia squamiform .....	9
3a.	Thallus umbilicate, subfruticose .....	<i>C. thamnodes</i>
3b.	Thallus large with rhizines or haptera.....	4
4.	Thallus smooth, lacking ridges and pustules .....	5
4a.	Thallus with ridges or pustules .....	6
5.	Apex of lobes swollen, plicate, globular isidia .....	<i>C. tenax</i>
5a.	Apex of lobes not swollen, uniformly thick or thin lobes, isidia globular to terete coralloid branchd, apothecial margin not reddish brown thalline exciple lacking distinct pseudocortex.....	<i>C. subflaccidum</i>
6.	Thallus wrinkled, striate, isidia globular to clavate, becoming flattened when mature .....	<i>C. auriculiforme</i>
6a.	Thallus ridged or postulate.....	7
7.	Spores submuriform,.....	<i>C. fuscovirens</i>
7a.	Spores transversely septate .....	8
8.	Thallus <i>japonicum</i> type, thalline exciple with scleroplectenchymatous pseudocortex.....	<i>C. rugosum</i>
8a.	Thallus <i>nigrescens</i> type, thalline exciple with thin walled pseudocortex, isidia teretiform, spores 5–6 celled .....	<i>C. furfuraceum</i>
9.	Thallus without apothecia .....	10
9a.	Thallus with apothecia .....	11
10.	Thallus rugose.....	<i>C. auriculiforme</i>
10a.	Thallus smooth.....	<i>C. crispum</i>
11.	Spores muriform .....	<i>C. furfureolum</i>

11a.	Spores transversely septate .....	<i>C. texanum</i>
12.	Thallus lacking apothecia, crustose-subfoliose, 100–150 I-lm thick..	<i>C. limosum</i>
12a.	Thallus with apothecia .....	13
13.	Spores transversely septate .....	14
13a.	Spores submuriform to muriform .....	19
14.	Spores usually 2 celled.....	15
14a.	Spores usually more than 2 celled .....	16
15.	Thallus lobes expanded fan shaped at apices, spores 2 celled.....	<i>C. texanum</i>
15a.	Thallus apices not fan shaped, subfoliose, terricolous.....	<i>C. coccophorum</i>
16.	Spores typically 4 celled, oblong-fusiform.....	<i>C. polycarpon</i>
16a.	Spores more than 4 celled.....	17
17.	Thalline exciple with cellular pseudocortex .....	18
17a.	Thalline exciple lacking cellular pseudocortex, thallus not fenestrate, spores acicular, straight to curved, 4–8 celled .....	<i>C. pulcellum</i> var. <i>nigrescens</i>
18.	Thallus <i>nigrescens</i> type.....	<i>C. ryssoleum</i>
18a.	Thallus <i>japonicum</i> type, apothecial disc pruinose .....	<i>C. japonicum</i>
19.	Thallus lobes <i>japonicum</i> type ridged, 4–8 mm wide, ca. 200 µm thick.....	<i>C. subconveniense</i>
19a.	Thallus smooth not ridged, lobes narrower.....	20
20.	Lobes swollen, plicate at apices.....	<i>C. tenax</i>
20a.	Lobes not swollen at apices .....	<i>C. cristatum</i>

***Collema auriculiforme*** (With.) Coppins and J. R. Laundon (Fig. 2.13b; Fig. 2.43)

In J. R. Laundon. Lichenologist 16: 228. 1984.

Basionym: *Riccia auriformis* With., Bot. Arr. Veg. Gr. Brit. 1, 2: 704. 1776.

Synonym: *Collema auriculatum* Hoffm., Deutschl. Fl.: 98.1796.

**Thallus:** foliose, to 4 cm across; **lobes:** orbicular, 0.5–1.2 cm wide, shallowly divided; **upper surface:** olive green to bluish, rugose, isidiate; **isidia:** dense, globose-clavate, becoming flattened squamiform later; **lower surface:** with haptera. Thallus 200–500 µm thick. **Apothecia:** absent.

**Chemistry:** Thallus K–, C–, KC–, P–; no secondary metabolites in TLC.

**Ecology and distribution:** *Microhabitat occupied:* Terricolous-rupicolous; muscicolous-terricolous. In India the species is widely distributed to Himachal Pradesh, Kerala, Nagaland, Tamil Nadu and Uttarakhand while species growing on soil is known from localities of Himachal Pradesh. The species is also reported from Japan; Africa, Europe.

**SPECIMENS EXAMINED: INDIA: HIMACHAL PRADESH, KULLU DISTRICT,** Great Himalayan National Park, alt. 2,135 m, on rock over soil, S. Nayaka and R. Srivastava 02-001090 (LWG); Sainj wildlife sanctuary, Maraur, alt. 2,600 m, on rock over soil, R. Srivastava 04-003272 (LWG); **SHIMLA DISTRICT,** Chaupal, Ghadal, alt. 2,500 m, on rock over soil, R. Srivastava and S. Nayaka 02-77738 (LWG).

***Collema coccophorum*** Tuck. (Fig. 2.13c; Fig. 2.43)

Tuckerman, Proc. Amer. Acad. Arts 5: 385. 1862.

**Thallus:** small, subfoliose, adnate to erect, to 2.5 cm across; **lobes:** up to 2 mm wide, swollen, incised; **upper surface:** olive-green to brown-black, smooth to plicate; **lower surface:** with haptera or rhizines. **Apothecia:** numerous or sparse, upto 3 mm in diam, sessile or appressed; **disc:** plane to convex, light or dark reddish

black, smooth, epruinose; **thalline exciple**: thick, lacking pseudocortex; **proper exciple**: euthyplectenchymatous; **hymenium**: 70–90  $\mu\text{m}$  high; **paraphyses**: thickened at apices, 1.5–2  $\mu\text{m}$  thick; **asci**: clavate, 8-spored; **spores**: transversely 1(2–3) septate, ellipsoid to oblong, with acute or obtuse ends, 15–25  $\times$  7  $\mu\text{m}$ .

**Chemistry**: Thallus K<sup>-</sup>, C<sup>-</sup>, KC<sup>-</sup>, P<sup>-</sup>; no secondary metabolites in TLC.

**Ecology and distribution**: *Microhabitat occupied*: Terricolous; terricolous-rupicolous; muscicolous-terricolous. In India the species is exclusive terricolous and restrictedly distributed to Western Himalaya and known only from Uttarakhand. The species is also reported from Australia, New Zealand; Africa, North and South America.

**SPECIMENS EXAMINED**: **INDIA**: **UTTARAKHAND**, **BAGESHWAR DISTRICT**, on way Phurkiya to Mirtoli, alt. 3,505.2 m, on soil over stones and boulders, D. D. Awasthi 7738 (LWG-AWAS); en route to Pindari Glacier, around Loharkhet, alt. 1,700 m, on rock over soil, Upreti, Chatterjee, Tandon L 69724 (LWG).

*Collema crispum* (Huds.) F. H. Wigg. (Fig. 2.13d; Fig. 2.43)

In Wiggers, Prim. Fl. Holsat.: 89.1780

Basionym: *Lichen crispus* Huds., Fl. Angl.: 447. 1762.

**Thallus**: usually small to medium sized, deeply and broadly lobate; **lobes**: often crowded and imbricate, 0.5–1(–5) mm wide, rounded, flat or concave; **margins**: thin, entire or crenate; **upper surface**: smooth, dark green, olive or black, bright green in shaded habitats, occasionally pruinose; **isidia**: at first globose but soon scale-like, 0.1–0.3 mm wide; **lower surface**: concolorous with white rhizines. **Apothecia**: appressed to sessile with slightly constricted base, 1–2(–2.5) mm broad; **disc**: plane, light to dark red-brown, smooth; **asci**: narrowly clavate, 8-spored; **spores**: hyaline, ovoid to subellipsoid, with rounded ends, 4-celled, 19–34  $\times$  12–18  $\mu\text{m}$  in size.

**Chemistry**: Thallus K<sup>-</sup>, C<sup>-</sup>, KC<sup>-</sup>, P<sup>-</sup>; no secondary metabolites in TLC.

**Ecology and distribution**: *Microhabitat occupied*: Terricolous–rupicolous; muscicolous–rupicolous. In India, the species is widely distributed in Madhya Pradesh, Tamil Nadu and Uttarakhand, whereas species growing on soil is known from localities of Uttarakhand. The species is also reported from Asia and North America.

**SPECIMENS EXAMINED**: **INDIA**: **UTTARAKHAND**, **BAGESHWAR DISTRICT**, on way from Phurkiya to Mirtoli, en route to Pindari Glacier, alt. 3,505 m, on soil with mosses in crevices of boulders in sheltered places, D. D. Awasthi 7,740 (LWG-AWAS); **PITHORAGARH DISTRICT**, Musiyari to Lilam en route to Milam Glacier, alt. 2,025 m, on stones over soil, S. Joshi 07-010396 (LWG).

*Collema cristatum* (L.) F. H. Wigg. (Fig. 2.13e; Fig. 2.43)

In Wiggers, Prim. Fl. Holsat.: 89. 1780.

Basionym: *Lichen cristatus* L., Sp. Pl.: 1143. 1753.

**Thallus**: foliose, up to 20 cm wide, rounded or irregular; **lobes**: extended, furcate, usually deeply concave and distinctly channeled with ascending, wavy or sinuose margins; **margins**: thin or slightly swollen, entire or incised; **upper surface**: dark olive-green or black,  $\pm$  smooth, dull or somewhat glossy; **isidia**: absent or present, marginal, globose to broad clavate; **lower surface**: concolorous or paler

than upper surface. **Apothecia:** usually marginal, sessile to finally stipitate; **disc:** plane, concave or convex, red to dark red-brown or black, smooth, epruinose, dull or slightly glossy; **hymenium:** hyaline, 90–130  $\mu\text{m}$  high; **asci:** narrowly clavate, 8-spored; **spores:** hyaline, ellipsoid, with  $\pm$  acute ends, usually submuriform, 18–32(–40)  $\times$  8–13  $\mu\text{m}$  in size.

**Chemistry:** Thallus K–, C–, KC–, P–; no secondary metabolites in TLC.

**Ecology and distribution:** *Microhabitat occupied:* Muscicolous–rupicolous. In India, the species is widely distributed in Uttarakhand, whereas species growing on soil is known from localities of Uttarakhand. The species is also reported from Europe and Central and North America.

**SPECIMEN EXAMINED:** INDIA: UTTARAKHAND, PITHORAGARH DISTRICT, Bugdiyar–Rilkot, alt. 3,048 m, on soil-covered rocks among mosses, A. Singh 102802 (LWG).

*Collema furfuraceum* (Arn.) Du Rietz (Fig. 2.13f; Fig. 2.43)

Du Rietz, Ark. Bot. 22A 1 (3): 3. 1929 em. Degel., Symb. Bot. Upsal. 20(2): 178. 1974.

Basionym: *Synechoblastus nigrescens* f. *furfuraceum* Arn., Flora 64: 115. 1881.

**Thallus:** medium-sized to large, (1–)3–6(–10) cm across, membrane-like, closely adnate, deeply and broadly lobate; **lobes:** (0.2–)0.5(–1) cm broad, thin, apically rotund or extended,  $\pm$  overlapping; **upper surface:** dark olive-green to brownish black, strongly but broadly ridged (wrinkled); **ridges:** radiate, becoming long, narrow and flexuous, 0.1–0.3 mm wide, up to 1.5 mm tall, simple or branched; **isidia:** very numerous, mainly on ridges and older pustules, mostly terete, concolorous with thallus or slightly darker; **lower surface:** dark olive-green to brownish black but paler than upper surface, smooth. **Apothecia:** rare to very rare, 0.5–1.5 mm wide; **disc:** plane; **hymenium:** hyaline, 85–110  $\mu\text{m}$  high; **asci:** clavate, 8-spored; **spores:** hyaline, bacilliform, narrow fusiform or acicular, 5–6-celled, 40–75  $\times$  3–7  $\mu\text{m}$ .

**Chemistry:** Thallus K–, C–, KC–, P–; no secondary metabolites in TLC.

**Ecology and distribution:** *Microhabitat occupied:* Terricolous. In India, the species is widely distributed in Jammu and Kashmir, Nagaland, Sikkim, Tamil Nadu, Uttarakhand and West Bengal, whereas species growing on soil is reported from single locality of Uttarakhand. The species is also reported from Japan and Thailand as well as from Africa, Europe and North, Central and South America.

**SPECIMEN EXAMINED:** INDIA: UTTARAKHAND, UTTARKASHI DISTRICT, Gangotri, towards Kedartal, alt. 3,100 m, on soil, S. Chatterjee and P. K. Divakar, 02-000292 B (LWG).

*Collema furfureolum* Müll. Arg. (Fig. 2.13g; Fig. 2.43)

Müller Arg., Flora 72: 142. 1889

**Thallus:** growing among mosses, foliose, greyish black; **lobes:** 0.2–0.5 cm wide; **upper surface:** smooth, isidiate; **isidia:** dense, globular to squamiform or minutely lobulate. **Apothecia:** 0.1–0.5 mm in diam.; **thaline exciple:** entire, 193–235  $\mu\text{m}$  thick; **proper exciple:** subparaplectenchymatous, rarely euparaplectenchymatous, 51–57  $\mu\text{m}$  thick; **spores:** muriform, ellipsoid, transversely 2–4-septate, longitudinally 1-septate, 13–18  $\times$  10–12  $\mu\text{m}$ .

**Chemistry:** Thallus K–, C–, KC–, P–; no secondary metabolites in TLC.

**Ecology and distribution:** *Microhabitat occupied:* Muscicolous-rupicolous. In India, the species is distributed in Maharashtra and Uttarakhand, whereas species growing on soil is known from a single locality of Uttarakhand. The species is also reported from Japan and Thailand as well as from Africa, Europe and North, Central and South America.

**SPECIMEN EXAMINED: INDIA: UTTARAKHAND, DEHRADUN DISTRICT,** Chakrata, Deoban, alt. 2,804 m, on stones among mosses over soil, D. D. Awasthi and M. Joshi, 76.91 (LWG-LWU).

*Collema fuscovirens* (With.) J. R. Laundon (Fig. 2.13h; Fig. 2.43)

Laundon, Lichenologist 16(3): 219.1984

Basionym: *Lichen fuscovirens* With., Bot. Arr. Veg. Gr. Brit.: 717. 1776.

Synonym: *Collema tuniforme* (Ach.) Ach., Lichenogr. Universalis: 649. 1810 em. Degel., Symb. Bot. Upsal. 13(2): 330. 1954 and 20(2): 93. 1974. -*Collema furvum* (Ach.) DC. in Lamarck and De Candolle, Fl. France, ed. 3, 2: 385. 1805, *nom. illeg.*

**Thallus:** medium-sized to large, 3–5 cm wide, ± rounded or irregular, deeply and broadly lobate; **lobes:** 2–5 mm wide, extended, often repeatedly branched, broadly canaliculated; **tips:** ± rounded, entire to slightly crenate; **upper surface:** dark olive-green to black, paler and ± transparent when moist, smooth to somewhat pustulate, usually dull; **isidia:** laminal, rarely marginal, often numerous, globular, up to 0.3 mm broad, concolorous with thallus or somewhat darker; **lower surface:** paler, grayish or bluish, with scattered or confluent hapters or rhizines fanning a down. **Apothecia:** numerous or sparse, laminal, sessile; **disc:** plane or concave to convex, red-brown or dark red, smooth; **hymenium:** hyaline, 85–130 µm high; **asci:** clavate, 8-spored; **spores:** hyaline, ellipsoid to ovoid or subglobose, submuriform to muriform, often with 3 transverse and 1 longitudinal septa, 15–26 × 7–14 µm.

**Chemistry:** Thallus K–, C–, KC–, P–; no secondary metabolites in TLC.

**Ecology and distribution:** *Microhabitat occupied:* Terricoous-rupicolous. In India, the species growing on soil is known from different localities of Uttarakhand. The species is also reported from Alaska, Canada and Europe.

**SPECIMENS EXAMINED: INDIA: UTTARAKHAND, PITHORAGARH DISTRICT,** Birju, alt. 3,353 m, on rock over soil, A. Singh 102812, 102814 (LWG); Milam, Mirtoli, alt. 3,200 m, on rock over soil, A. Singh 102847 (LWG); Bugdiar–Rilkot, alt. 3,048 m, on rock over soil, A. Singh 102803 (LWG).

*Collema japonicum* (Müll. Arg.) Hue (Fig. 2.13i; Fig. 2.43)

Hue. Nouv. Arch. Mus. Hist. Nat. ser. 3, 10: 220. 1898.

Basionym: *Synechoblastus japonicus* Müll. Arg., Flora 63: 17. 1880.

**Thallus:** lead grey to black and distinctly postulate when dry, distinctly postulate; **lobes:** orbicular, contiguous, 1–1.5 cm wide, 75–90 µm thick; **upper surface:** smooth; **Apothecia:** 0.5–1 mm across; **thalline exciple:** smooth, excluded at maturity, 40–60 µm thick, pseudocortex 2–3 cell layered 2–3 cell layered; **proper exciple:** euparaplectenchmatous, 5–7 cell layered; **spores:** fusiform, acicular, transversely 4–5(–6) septate, 24–41 × 6–8 µm in size.

**Chemistry:** Thallus K–, C–, KC–, P–; no secondary metabolites in TLC.

**Ecology and distribution:** *Microhabitat occupied:* Terricolous-rupicolous. In India the species is widely distributed in Sikkim, Uttarakhand and West Bengal hills while species growing on soil is known from single locality of Uttarakhand. The species is also reported from Australia, Nepal and New Zealand; Pacific Ocean Islands.

**SPECIMEN EXAMINED: INDIA: UTTARAKHAND, CHAMPAWAT,** before Gurauli, on rock over soil, G. K. Mishra 10-015389 (LWG).

*Collema limosum* (Ach.) Ach. (Fig. 2.43)

Acharius, Lichenogr. Universalis: 629. 1810.

Basionym: *Lichen limosus* Ach., Lichenogr. Suec. Prodr.: 126. 1798.

**Thallus:** crustose-subfoliose, sub lobate or without lobes; **upper surface:** olive-green to brownish, rugose, lacking isidia; **lower surface:** often with pseudocortex. Thallus 100–150  $\mu\text{m}$  thick. Indian specimens sterile.

**Chemistry:** Thallus K<sup>-</sup>, C<sup>-</sup>, KC<sup>-</sup>, P<sup>-</sup>; no secondary metabolites in TLC.

**Ecology and distribution:** *Microhabitat occupied:* Terricoous. In India the species is terricolous only and reported from Jammu and Kashmir (Awasthi 2007). The specimen pertaining to the species is untraceable during study. The species is also reported from China; Europe, North America.

*Collema polycarpon* Hoffm. (Fig. 2.14a; Fig. 2.43)

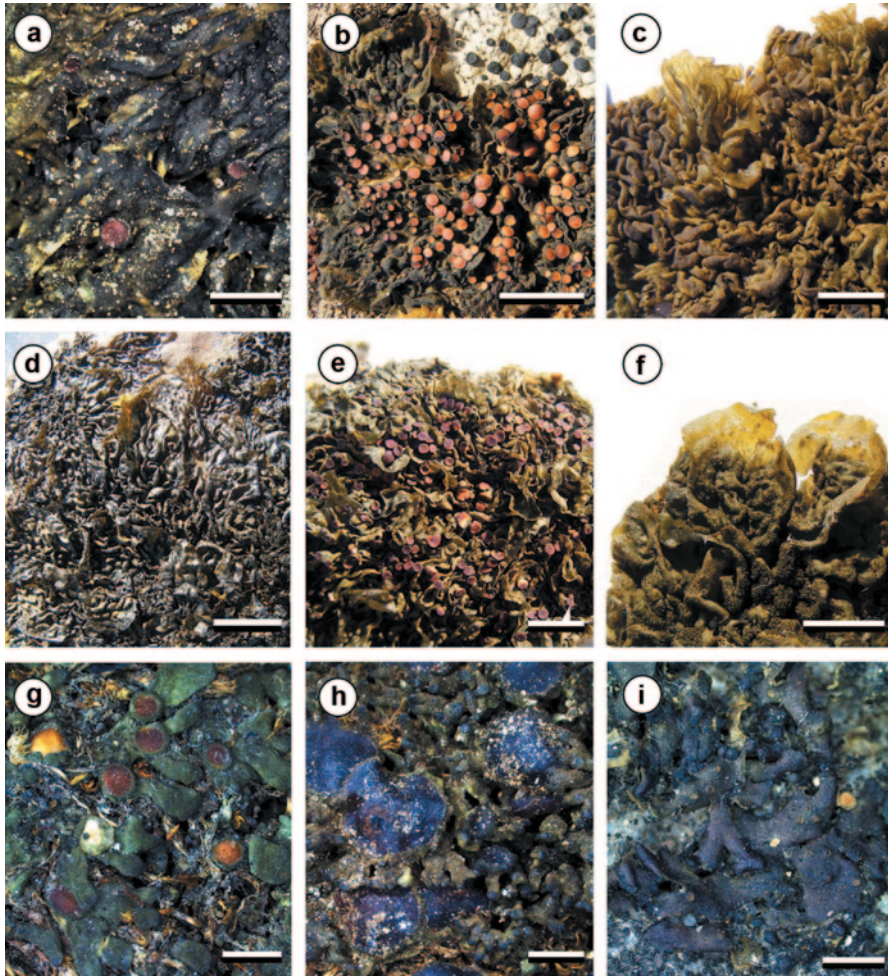
Hoffm., Deutschl. Fl.: 102. 1796.

**Thallus:** forming rosette-like cushions, medium-sized to large, 2–6(–10) cm wide, rounded; **lobes:** radiating, elongated, 1–2.5 mm wide; **lobules:** numerous,  $\pm$  flattened, contiguous, ascending or erect towards the centre of thallus; **tips:** swollen and plicate; **upper surface:** dark olive-green to black; **lower surface:** usually somewhat paler than upper surface, with whitish tufts of rhizines. **Apothecia:** numerous, crowded towards thallus centre, terminal on tip of lobules or marginal on lobes, sessile, with constricted base to stipitate, mostly appearing stalked, 0.5–1.5 mm wide; **disc:** plane to slightly convex, red, red-brown or black, smooth, generally glossy, epruinose; **hymenium:** hyaline, 65–106  $\mu\text{m}$  tall; **asci:** subcylindrical to clavate, 8-spored; **spores:** hyaline, fusiform, rarely sub oblong, ends acute to rarely somewhat rounded, (2–3) 4-celled, (13–)18–28(–30)  $\times$  (5–)6.5–8.5  $\mu\text{m}$  in size.

**Chemistry:** Thallus K<sup>-</sup>, C<sup>-</sup>, KC<sup>-</sup>, P<sup>-</sup>; no secondary metabolites in TLC.

**Ecology and distribution:** *Microhabitat occupied:* Terricolous; terricolous-rupicolous. In India the species is widely distributed in Himachal Pradesh, Jammu and Kashmir and Uttarakhand while species growing on soil is known from localities of Himachal Pradesh and Uttarakhand. The species is also reported from Arctic Islands; Africa, Asia.

**SPECIMENS EXAMINED: INDIA: HIMACHAL PRADESH, KULLU DISTRICT,** Great Himalayan National Park, Sairopa, alt. 1,440 m, on rock over soil, S. Nayaka and R. Srivastava 02-001075 (LWG); **UTTARAKHAND, PITHORAGARH DISTRICT,** Birju, alt. 3,353 m, on rock over soil, A. Singh 102813 (LWG); **UTTARKASHI DISTRICT,** Gangotri National Park, 2 km after Chirwasa, alt. 3,660 m, on soil, 05 Sep 2002, S. Chatterjee and P. K. Divakar, 02-000190



**Fig. 2.14** a *Collema polycarpon* Hoffm., b *C. pulcellum* var. *subnigrescens* (Müll. Arg.) Degel., c *C. rugosum* Krep., d *C. rysssoleum* (Tuck.) Schneid., e *C. subconveniense* Nyl., f *C. subflaccidum* Degel., g *C. tenax* var. *tenax* (Sw.) Ach., h *C. tenax* var. *corallinum* (A. Massal.), i *C. texanum* Tuck. Scale in i = 1 mm; in a, g, h = 2 mm; in b, c, e, f = 5 mm; in d = 10 mm

(LWG); Gangotri National Park, 2 km after Chirwasa, alt. 3,660 m, on soil, S. Chatterjee and P. K. Divakar, 02-000199 (LWG).

***Collema pulcellum* var. *subnigrescens*** (Müll. Arg.) Degel. (Fig. 2.14b; Fig. 2.43) Degelius. Symb. Bot. Upsal. 20(2): 173. 1974.

Basionym: *Synechoblastus flaccidus* v. *subnigrescens* Müll. Arg., Proc. Roy. Soc. Edinburgh 4: 456. 1882.

**Thallus:** up to 10 cm across; **lobes:** 0.3–1.5 cm wide; **upper surface:** heavily and longitudinally deeply ridged, blackish olive-green to greyish, radially plicate,



lacking isidia. Thallus 45–150  $\mu\text{m}$  thick. **Apothecia:** 0.5–1.5 mm in diam., numerous; **thalline exciple:** smooth, 93–155  $\mu\text{m}$  thick but usually lacking pseudocortex; **proper exciple:** subparaplectenchymatous, 24–40  $\mu\text{m}$  thick, 4–6 cell layered; **spores:** fusiform, transversely (3) 6–8-septate, straight or curved, 24–55  $\times$  5–8  $\mu\text{m}$ .

**Chemistry:** Thallus K<sup>-</sup>, C<sup>-</sup>, KC<sup>-</sup>, P<sup>-</sup>; no secondary metabolites in TLC.

**Ecology and distribution:** *Microhabitat occupied:* Terricolous; terricolous-rupicolous; muscicolous-rupicolous. In India the species is widely distributed in Arunachal Pradesh, Himachal Pradesh, Jammu and Kashmir, Madhya Pradesh, Maharashtra, Manipur, Nagaland, Rajasthan, Sikkim, Tamil Nadu, Uttar Pradesh, Uttarakhand and West Bengal while species growing on soil is known from different localities of Uttarakhand. The species is widely distributed in tropical to sub-temperate regions of Africa, America and Asia.

**SPECIMENS EXAMINED: INDIA: UTTARAKHAND, CHAMOLI DISTRICT,** Govind Ghat, alt. 1,829 m, on rock over soil, A. Singh, 86981 (LWG); Bagrigad-Debal, alt. 1,524 m, on rock over soil, A. Singh, 91172 (LWG); Bagrigad-Debal, alt. 1,676 m, on rock over soil, A. Singh, 90333 (LWG); Bagrigad-Debal, alt. 1,676 m, on rock over soil along with mosses, A. Singh, 90338 (LWG); Bagrigad-Debal, alt. 1,524 m, on rock over soil, 20 Oct 1967, A. Singh, 91165 (LWG); **PITHORAGARH DISTRICT,** Ticksan-Leelam, alt. 1,676 m, on rock over soil, A. Singh 102754, 102755, 102764 (LWG); **RUDRAPRAYAG DISTRICT,** Guptakashi, alt. 1,100 m, on rock over soil, A. Singh and M. Ranjan, 106803 (LWG); Guptakashi, alt. 1,200 m, on rock over soil, A. Singh and M. Ranjan, 106806 (LWG); between Kalimath and Lank, alt. 1,200 m, on rock over soil, A. Singh and M. Ranjan, 106868 (LWG); between Kalimath and Lank, alt. 1,300 m, on rock over soil, A. Singh and M. Ranjan, 106877 (LWG); between Kalimath and Lank, alt. 1,350 m, on rock over soil, A. Singh and M. Ranjan, 106882 (LWG); **UTTARKASHI DISTRICT,** Sayan Chatti-Hanuman Chatti, alt. 2,300 m, on rock over soil, A. Singh and Ram Pher, 70638 (LWG).

***Collema rugosum* Kremp. (Fig. 2.14c; Fig. 2.43)**

In Fenzl, Reise Novara Bot. 1: 128. 1870.

**Thallus:** foliose, to 6 cm across; **lobes:** 0.5–1.5 cm wide; **upper surface:** pale olive-green,  $\pm$  *japonicum* type, irregularly ridged, isidiate; **isidia:** globular, simple or branched, rarely elongated. Thallus 40–150  $\mu\text{m}$  thick, pseudocortex 1–4(5) cell layered (9–12  $\mu\text{m}$  thick). **Apothecia:** rare, 0.5–1 mm in diam.; **thalline exciple:** densely isidiate with 5–7 cell layered scleroplectenchymatous cortex at the base, 1–2 cell layered at margins, cells 3–9  $\mu\text{m}$  in size; **proper exciple:** euthyplectenchymatous, 30–42  $\mu\text{m}$  thick; **spores:** acicular, fusiform, rarely ellipsoid, transversely 3–5-septate, 38–64  $\times$  5–7  $\mu\text{m}$ .

**Chemistry:** Thallus K<sup>-</sup>, C<sup>-</sup>, KC<sup>-</sup>, P<sup>-</sup>; no secondary metabolites in TLC.

**Ecology and distribution:** *Microhabitat occupied:* Terricolous; terricolous-rupicolous. In India the species is widely distributed in Andaman and Nicobar Islands, Jammu and Kashmir, Manipur, Nagaland, Tamil Nadu, Uttarakhand and West Bengal hills while species growing on soil is known from different localities of Tamil Nadu. The species is also reported from Australia; Indian Ocean Islands, Pacific Ocean Islands; Africa.

**SPECIMENS EXAMINED: INDIA: TAMIL NADU, PALNI HILLS,** Kodaikanal, Shenbaganur, below silver cascade to Tiger shoal, alt. 1,676 m, on ground, D. D. Awasthi and K. P. Singh 70.84 (LWG-LWU); Tiger Shola, lower edge, alt. 1,615 m, on ground, D. D. Awasthi and K. P. Singh 70.440 (LWG-LWU).

***Collema rysssoleum*** (Tuck.) Schneid. (Fig. 2.14d; Fig. 2.43)

Schneider, Guide Study Lich.: 181. 1898.

Basionym: *Collema nigrescens* subsp. *rysssoleum* Tuckerman, Lich. Calif.: 34. 1866.

**Thallus:** foliose, to 6 cm across; **lobes:** orbicular, 0.3–0.6 cm wide; **upper surface:** olive green to blackish brown, distinctly postulate, *nigrescens* type, lacking isidia. Thallus 45–100 µm thick, pseudocortex seen on upper and lower surfaces, 1–3 cell layered. **Apothecia:** absent.

**Chemistry:** Thallus K–, C–, KC–, P–; no secondary metabolites in TLC.

**Ecology and distribution:** *Microhabitat occupied:* Terricolous; terricolous-rupicolous; muscicolous-rupicolous. In India the species is widely distributed in Rajasthan, Uttarakhand and Tamil Nadu while species growing on soil is known from different localities of Rajasthan, Tamil Nadu and Uttarakhand. The species is also reported from Africa, Europe, North America.

**SPECIMENS EXAMINED: INDIA: RAJASTHAN, SIROHI DISTRICT,** Mt. Abu. Near Nakki lake, alt. 1,219 m, on mossy soil over rock, S. R. Singh 78.69, 78.70, 78.31 (LWG-LWU); Honey-moon point, alt. 1,372 m, on rock over soil, S. R. Singh 78.139 (LWG-LWU); (Waylay's walk), alt. 1,189 m, on rock over soil with mosses, A. Singh 101407 (LWG); **TAMIL NADU, PALNI HILLS,** Kodaikanal, Shenbaganur, Tiger Shola, alt. 1,676 m, on hard ground, D. D. Awasthi and K. P. Singh 70.167 (LWGLWU); **UTTARAKHAND, RUDRAPRAYAG DISTRICT,** on way to Kedarnath from Sonprayag to Gaurikund, alt. 1,890 m, on rock over soil, K. Dange, 76.5 (LWG-LWU); Mandakini river valley, on way from Sonprayag to Gaurikund, alt. 1,798 m, on rock over soil, K. Dange, 76.68 (LWG-LWU).

***Collema subconveniense*** Nyl. (Fig. 2.14e; Fig. 2.43)

Nylander, Lich. Nov. Zel.: 4. 1888.

**Thallus:** *japonicum* type; **lobes:** 0.3–1.3 cm wide; **upper surface:** distinctly postulate to ridged, brownish black to greenish black; **isidia:** absent. **Apothecia:** up to 2 mm in diam.; **thalline exciple:** 90–124 µm thick with a distinct pseudocortex in the margin, cortical cells 6–9 µm in size; **proper exciple:** subparaplectenchymatous to euthyplectenchymatous, 43–60 µm thick at base and narrow in margins; **spores:** ellipsoid, muriform, transversely 3–5-septate and longitudinally 1(–2)-septate, 18–31 × 6–10 µm.

**Chemistry:** Thallus K–, C–, KC–, P–; no secondary metabolites in TLC.

**Ecology and distribution:** *Microhabitat occupied:* Terricolous-rupicolous. In India the species is widely distributed in Himachal Pradesh and Uttarakhand while species growing on soil is reported from different localities of Uttarakhand. The species is also reported from Australia, Japan, Nepal, New Zealand and Paraguay.

**SPECIMENS EXAMINED: INDIA: UTTARAKHAND, BAGESHWAR DISTRICT,** on way to Loharkhet to Dhakuri, alt. 2,743 m, on rock over soil, D. K. Upreti and J. Tandon 213384(LWG); **RUDRAPRAYAG DISTRICT,** Mandakini river valley, on way from Sonprayag to Gaurikund, alt. 1,890 m, on rock surface over soil, K. Dange, 76.43 (LWG-LWU); Mandal, alt. 1,000 m, on rock over soil, S. Rawat, 07-008698 (LWG).

***Collema subflaccidum*** Degel. (Fig. 2.14f; Fig. 2.43)

Degelius, Symb. Bot. Upsal. 20(2): 140. 1974.

**Thallus:** foliose, medium-sized to large, 3–6 cm wide, thin, membrane-like, loosely attached, broadly and ± deeply lobate; **lobes:** 0.5–1.5(–3) cm wide, when moist, not swollen, few, ± imbricate, not or indistinctly folded; **upper surface:** smooth, dark olive-green, black, dull; **isidia:** numerous, often evenly spreading over the lobes, laminal, simple, globose, becoming short-teretiform and sometimes branched with age; **lower surface:** usually somewhat paler than the upper surface. **Apothecia:** rare, laminal, sessile with constricted base, 1.5(–2.5) mm wide; **disc:** fiat to slightly convex, pale or dark red, usually not glossy, smooth; **hymenium:** hyaline, 90–130 µm high; **asci:** narrowly clavate, 8-spored; **spores:** hyaline, fusiform to broadly acicular, (4–)6–8-celled, 42–60(–65) × (3–)4.5–6.5 µm in size.

**Chemistry:** Thallus K–, C–, KC–, P–; no secondary metabolites in TLC.

**Ecology and distribution:** *Microhabitat occupied:* Terricolous-rupicolous; muscicolous-terricolous. In India the species is widely distributed in Himachal Pradesh, Jammu and Kashmir, Tamil Nadu, Uttarakhand and West Bengal hills while species growing on soil is known from different localities of Himachal Pradesh and Uttarakhand. The species is also reported from Australia, China, Japan, New Zealand; South East Africa; Europe, North and Central America.

**SPECIMENS EXAMINED:** **INDIA: HIMACHAL PRADESH, SHIMLA,** Narkanda, 3–4 km towards Hatu peak, alt. 2,800 m, on rock over soil, S. Nayaka and R. Srivastava 02-67196 (LWG-LWU); **UTTARAKHAND, DEHRADUN DISTRICT,** Chakrata hills, Deoban, alt. 2,804 m, over soil among mosses in moist place, D. D. Awasthi and M. Joshi, 76.148 (LWG-LWU).

***Collema tenax*** (Sw.) Ach

Acharius, Lichenogr. Universalis: 635. 1810; em. Degel., Symb. Bot. Upsal. 13(2): 161. 1954 and 20(2): 46. 1974.

Basionym: *Lichen tenax* Swartz, Nova Acta R. Soc. Scient. Upsal. 4: 249. 1784. var. *tenax* (Fig. 2.14g; Fig. 2.43).

**Thallus:** foliose, small to large, up to 8 cm wide, loosely attached or somewhat ascending, much swollen when moist, deeply lobate; **lobes:** variable in size, 0.1–1 mm thick when moist, usually broader towards tips, crenate to lobulate, usually with a few coarse, simple to branched folds; **upper surface:** smooth to slightly rugulose or coarsely folded, light or dark olive-green to blackish brown; **isidia:** absent or present, globose, sometimes elongated; **lower surface:** usually somewhat paler; **rhizines:** white; **Apothecia:** laminal or sometimes marginal, sessile with constricted base, 1.5–3(–6) mm wide; **disc:** light or dark red to red-brown or black, dull or somewhat glossy, smooth; **hymenium:** hyaline, 85–110 µm high; **asci:** narrowly clavate to subcylindrical, 8-spored; **spores:** hyaline, straight, fusiform to narrowly ovoid with ± acute ends, (2–3–)4-celled, 18–23 × 7–9 µm with 3–5 transverse and 1 longitudinal septa.

**Chemistry:** Thallus K–, C–, KC–, P–; no secondary metabolites in TLC.

**Ecology and distribution:** *Microhabitat occupied:* Terricolous-rupicolous; muscicolous-rupicolous; muscicolous-terricolous. In India the species is widely distributed in Himachal Pradesh, Madhya Pradesh, Maharashtra and Uttarakhand while species growing on soil is known from different localities of Uttarakhand.

**SPECIMENS EXAMINED: INDIA: UTTARAKHAND, DEHRADUN DISTRICT,** Chakrata, on way to Deoban, alt. 2,591 m, on stones over soil with mosses, D. D. Awasthi and M. Joshi, 76.75 (LWG-LWU); Chakrata hills, Deoban, alt. 2,804 m, on stones among mosses over soil, D. D. Awasthi and M. Joshi, 76.115 (LWG-LWU); Chakrata hills, Deoban, alt. 2,804 m, over soil among mosses in moist place, D. D. Awasthi and M. Joshi, 76.148 (LWG-LWU); **RUDRAPRAYAG DISTRICT,** Kalimath-Lank, alt. 1,200 m, on rock over soil, A. Singh, 106870 (LWG); **PITHORAGARH DISTRICT,** Bugdiyar-Lilam, alt. 2,438 m, on rock over soil, A. Singh 102859 (LWG); Ticksan-Leelam, alt. 1,676 m, on rock over soil, A. Singh 102753 (LWG); **UTTARKASHI DISTRICT,** Harsil, alt. 2,560 m, on soil covered rock, A. Singh, 97252 (LWG).

var. *corallinum* (A. Massal.) (Fig. 2.14h; Fig. 2.44)

Degelius, Symb. Bot. Upsal. 13(2): 165. 1954, and 20(2): 46. 1974.

Basionym: *Collema pulposum* var. *coranninum* A. Massal., Sched. Crit. 10: 180. 1856.

**Thallus:** small in size, appearance nearly crustose, but on enlarging it appears distinctive foliose, dark or blackish in colour, up to 2 cm. in diam. but generally smaller; **lobes:** few or very few, of a ± irregular appearance, linear or much broader towards the ends or rounded, flattened or canaliculated, 2–4 × 0.3–3 mm, knotty to verrucose, finally clustered together to small erect coralloid groups. **Apothecia:** absent.

**Chemistry:** Thallus K–, C–, KC–, P–; no secondary metabolites in TLC.

**Ecology and distribution:** *Microhabitat occupied:* Terricolous-rupicolous. In India the species is restrictedly distributed to Western Himalaya and known only from Uttarakhand.

**SPECIMEN EXAMINED: INDIA: UTTARAKHAND, UTTARKASHI DISTRICT,** Yamunotri-Janki Chatti, alt. 3,000 m, on soil covered rock, A. Singh and Ram Pher 76078 (LWG).

var. *vulgare* (Schaer.) Degel. (Fig. 2.44)

Degelius, Symb. Bot. Upsal. 13(2): 163. 1954 and 20(2): 46. 1974.

Basionym: *Collema pulposum* var. *vulgare* Schaerer, Enum. Critic. Lich. Europ.: 259.1850.

This variety differs from the var. *tenax* in the presence of elongated lobes (up to 6 mm long and 1 mm wide), with fan shaped furcated ends, usually uniformly thickened throughout, flat to undulate margins, upper surface nonisidiate and convex.

**Chemistry:** Thallus K–, C–, KC–, P–; no secondary metabolites in TLC.

**Ecology and distribution:** *Microhabitat occupied:* Terricolous-rupicolous. In India the species is restrictedly distributed to Western Himalaya and known only from Uttarakhand.

**SPECIMEN EXAMINED: INDIA: UTTARAKHAND, UTTARKASHI DISTRICT,** Yamunotri-Janki Chatti, alt. 3,000 m, on soil covered rock, A. Singh and Ram Pher, 76078 (LWG).

*Collema texanum* Tuck. (Fig. 2.14i; Fig. 2.44)

Tuckerman, Amer. J. Sci. Arts, ser. 2, 28: 200. 1859.

**Thallus:** foliose, to 5 cm across, thin to thick, deeply lobed; **lobes:** fan shaped at apices elongated, 1–3 mm long and 0.5–1.5 mm wide; **margins:** entire revolute and sometimes lobulate; **upper surface:** convex, usually smooth, dark olive green to brownish, isidiate or not; 0.4–0.6 mm long and 3–4.5 µm thick white hyphal hairs

are seen under surface; **isidia**: sparse to dense, globular to occasionally minutely squamiform. Thallus 90–250  $\mu\text{m}$  thick. **Apothecia**: common, 0.3–1  $\mu\text{m}$  in diam.; **spores**: oval to ellipsoid, transversely single septate,  $10\text{--}20 \times 4\text{--}7 \mu\text{m}$ .

**Chemistry**: Thallus K–, C–, KC–, P–; no secondary metabolites in TLC.

**Ecology and distribution**: *Microhabitat occupied*: Terricolous-rupicolous. In India the species is widely distributed in Madhya Pradesh, Maharashtra, Rajasthan and Uttarakhand, while species growing on soil is known from different localities of Rajasthan. The species is also reported from China, Cuba, Dominican Republic, Japan, Lesser Antilles, Mexico, Paraguay and the USA.

**SPECIMENS EXAMINED**: **INDIA**: **RAJASTHAN**, **SIROHI DISTRICT**, Mt. Abu near Nakki lake, alt. 1,219 m, on soil over rock, S. R. Singh 78.87 (LWG-LWU); Mt. Abu (Aravali hills), alt. 1,158 m, on rock over soil, A. Singh 101303, 101329, 101317, 101373 (LWG).

***Collema thamnodes*** Tuck. ex Riddle (Fig. 2.15a; Fig. 2.44)

Riddle, Bull. Torrey Bot. Lab. 43: 155. 1916.

**Thallus**: small, subfruticose to pulvinate, umbilicate, suberect to erect, in small tufts, umbilicate, lobate; **lobes**: to 1 mm wide; **upper side**: darker olive-green to bluish, isidiate; **isidia**: numerous, globular to granular or teretiform, simple or branched. Thallus 200–500  $\mu\text{m}$  thick. **Apothecia**: absent.

**Chemistry**: Thallus K–, C–, KC–, P–; no secondary metabolites in TLC.

**Ecology and distribution**: *Microhabitat occupied*: Terricolous-rupicolous. In India the species is widely distributed in Madhya Pradesh, Maharashtra, Rajasthan and Uttarakhand while species growing on soil is known from single locality of Rajasthan. The species is also reported from China, Cuba, Dominican Republic, Japan, Lesser Antilles, Mexico, Paraguay and the U.S.A.

**SPECIMEN EXAMINED**: **INDIA**: **RAJASTHAN**, **SIROHI DISTRICT**, Mt. Abu (Aravali hills), alt. 1,158 m, on rock over soil, A. Singh 101474 (LWG).

**DERMATOCARPON** Eschw. (*Verrucariaceae*)

Eschweiler, Syst. Lich.: 21. 1824.

**Thallus**: foliose, monophyllous to polyphyllous, umbilicate; **upper surface**: grey to brownish; **lower surface**: brown to brown-black, erhizinate or rhizinate; **rhizines**: simple or thick, stumpy and branched referred to rhizinomorphs. **Photobiont**: a green alga (*Pleurococcus*); dense. **Perithecia**: immersed in the thallus, with punctiform ostiole; **exciple**: (periderm) colourless to brown, usually globose; **asci**: 8–16-spored; **spores**: colourless, simple.

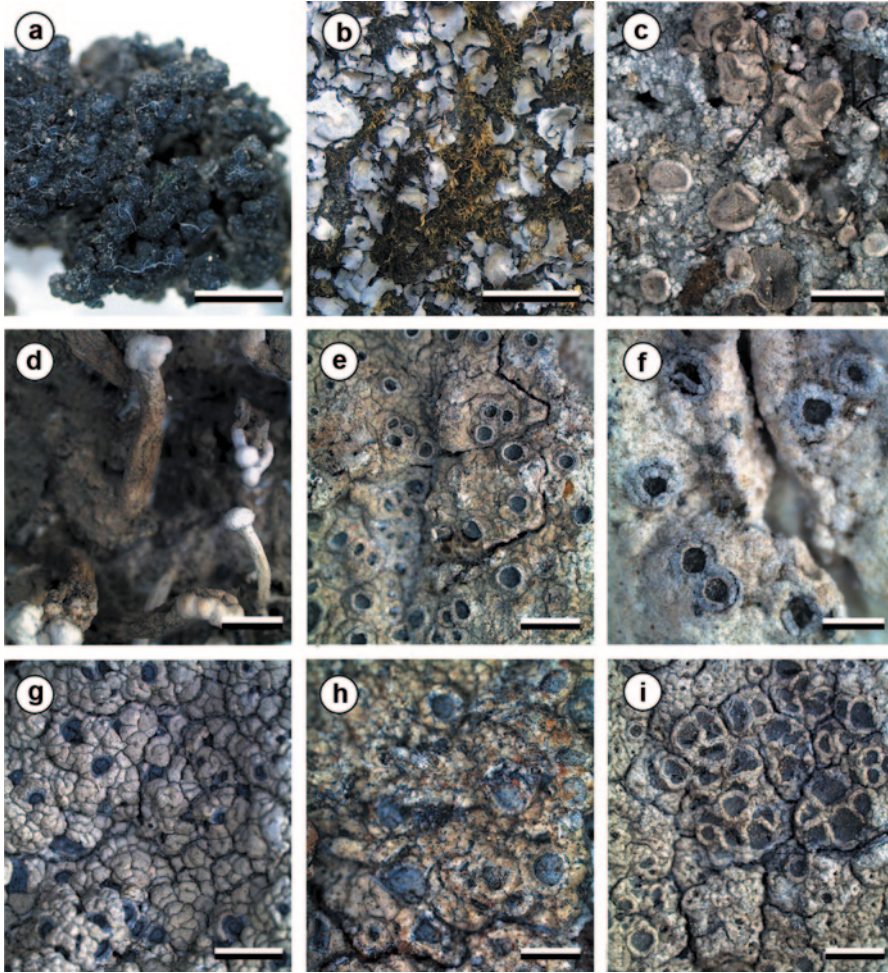
Out of 17 species known from world, 3 are from India, of which 1 is terricolous.

***Dermatocarpon vellereum*** Zschacke (Fig. 2.15b; Fig. 2.44)

In Rabenhorst, Krypt. -Fl., ed. 2, 9(1): 638. 1934.

Synonym: *Dermatocarpon rhizinosum* M. Choisy, Bull. Soc. Bot. France 78: 455. 1931, non *D. rhizinosum* (Müll. Arg.) Zahlbr.

**Thallus**: foliose, usually monophyllous, to 12 cm across, umbilicate, rather thick, leathery; **upper surface**: light brownish to brownish red, white to dark pruinose; **lower surface**: black, with dense, thick, stumpy, coralloid rhizinomorphs.



**Fig. 2.15** **a** *Collema thamnodes* Tuck. ex Riddle, **b** *Dermatocarpon vellereum* Zschacke, **c** *Dibaeis baeomyces* (L.f.) Rambold and Hertel, **d** *D. pulogensis* (Vain.) Kalb and Gierl, **e** *Diploschistes cinereo-caesius* (Sw. ex Ach.) Vain., **f** *D. dicapsis* (Ach.) Lumbsch, **g** *D. muscorum* subsp. *bartlettii* Lumbsch, **h** *D. muscorum* subsp. *muscorum* (Scop.) R. Sant., **i** *D. scruposus* (Schreb.) Norman. Scale in **f, g** = 1 mm; in **a, c, d, e, h, i** = 2 mm; in **b** = 50  $\mu$ m

Thallus 200–450  $\mu$ m thick in marginal area, 600–1000  $\mu$ m thick in central part. **Perithecia:** pale red; **spores:** ellipsoid, 9–12  $\times$  (5–)6–9  $\mu$ m.

**Chemistry:** Thallus K–, C–, KC–, P–; no secondary metabolites in TLC.

**Ecology and distribution:** *Microhabitat occupied:* Terricolous-rupicolous. In India the species is widely distributed in Himachal Pradesh, Jammu and Kashmir, Madhya Pradesh, Maharashtra, Rajasthan, Tamil Nadu and Uttarakhand while species growing on soil is reported from different localities of Uttarakhand. The species is also reported from China, Nepal and Eastern Europe.

**SPECIMENS EXAMINED:** INDIA: UTTARAKHAND, ALMORA DISTRICT, alt. 1,600 m, on soil over rocks, P.C. Pandey 81-54340 (LWG); UTTARKASHI DISTRICT, Dhampur, alt. 3,000 m, on rock over soil, A. Singh and Ram Pher, s.n. (LWG).

**DIBAEIS** Clem. (*Icmadophilaceae*)

Clement, Gen. Fungi: 78, 175. 1909.

**Thallus:** sparingly lichenized, dimorphic; **primary thallus:** crustose to squamulose; **secondary thallus:** ± erect, with or without, simple or branched podetiid stipes. **Apothecia:** terminal on stipes, solitary or clustered, rosered; **asci:** with I+ blue apical cap, 8-spored; **spores:** colourless, simple or rarely single septate.

Out of the 14 species known from the world; 2 terricolous species are from India.

**Key to the terricolous species of *Dibaeis*:**

- 
1. Primary thallus sorediate..... *D. pulogensis*  
 1a. Primary thallus lacking soredia..... *D. baeomyces*
- 

***Dibaeis baeomyces*** (L. f.) Rambold and Hertel (Fig. 2.15c; Fig. 2.44)

Rambold and Hertel, Biblioth. Lichenol. 53: 231. 1993.

Basionym: *Lichen baeomyces* L. f. Suppl. Pl.: 450. 1781 (1782).

Synonym: *Baeomyces roseus* Pers., Ann. Bot. Usteri, 1: 19. 1794.

**Primary thallus:** crustose-verruculose, grey; **podetia:** to 5 mm tall, 1.5 mm thick, ecorticated, furrowed. **Apothecia:** terminal, flesh coloured to red, to 2.5 mm in diam., subspherical to flexuous; **disc:** concave, K+ yellow; **epithecium:** 7–12 µm; **hymenium:** 83–100 µm high, I+ blue; **spores:** simple, spindle-form 16–20 × 2–3 µm.

**Chemistry:** Primary thallus and podetiid stipes K+ yellow, C–, P+ yellow. Baeomycesic, squamatic, and barbatic acids reported.

**Ecology and distribution:** *Microhabitat occupied:* Terricolous. In India the species exhibits restricted distribution to Eastern Himalaya and known from Sikkim and West Bengal hills. The species is widely distributed in temperate regions of the world, Taiwan and Thailand.

**SPECIMEN EXAMINED:** INDIA: WEST BENGAL, DARJEELING DISTRICT, Tiger hill, Senchal lake area, alt. 2,400 m, on soil, Awasthi 64–140 (LWG-AWAS).

***Dibaeis pulogensis*** (Vain.) Kalb and Gierl (Fig. 2.15d; Fig. 2.44)

In Gierl and Kalb, Herzogia 9: 628. 1993.

Basionym: *Baeomyces pulogensis* Vain., Ann. Acad. Sci. Fenn., ser. A, 15, 6: 59. 1921.

*Baeomyces fungoides* sensu Upreti, Geophytology 15(2): 160. 1985.

**Primary thallus:** crustose-verruculose, yellowish grey, sorediate; **podetia:** 4–8 mm tall, to 2.5 mm thick, white, simple, cylindrical, smooth, ecorticated, non-translucent. **Apothecia:** red, 2–4 mm in diam., subglobose to globose; **disc:** convex, K+ yellow; **epithecium:** 7–12 µm; **hymenium:** 75–100 µm high, I+ blue; **spores:** simple, spindle form, (13–)16–18 × 3–5 µm.

**Chemistry:** Apothecia K+ yellow. Baeomycesic and squamatic acids reported.

**Ecology and distribution:** *Microhabitat occupied:* Terricolous. In India the species exhibits restricted distribution to Eastern Himalaya and known from Meghalaya and West Bengal hills. The species is widely distributed in temperate regions of the world, Bhutan, the Philippines and Taiwan.

**SPECIMENS EXAMINED: INDIA: WEST BENGAL, DARJEELING DISTRICT,** near Palmajua, alt. 2,100 m, on hard soil, Awasthi 105 (LWG-AWAS); near Manibhanganj, alt. 2,100 m, on hard soil by roadside, Awasthi 2510 (LWG-AWAS); Tiger hill, Senchal, alt. 2,250–2,400 m, on ground from vertical side of road, Awasthi 3899 (LWG-AWAS); north face of the hill, alt. 2,560 m, on hard sandy soil on exposed vertical side of road, Awasthi and Agarwal 67–1 (LWG-LWU).

## DIPLOSCHISTES Norman

Nyt. Mag. Naturvidensk. 7: 232.1853

**Thallus:** superficial on the substratum, grey, with greenish, pale brown, yellowish or whitish tones, with brownish or yellowish tones when shaded; **photobiont:** trebouxoid; **prothallus:** thin to indistinct, white. **Apothecia:** ± rounded, perithecioid, urceolate or apothecioid; **proper exciple:** free, dark brown, non-amyloid; **hymenium:** non-amyloid; paraphyses straight, unbranched; tips not or slightly thickened; **lateral paraphyses:** conspicuous, usually clearly separated from the proper exciple; **asci:** 1–8-spored, clavate, non-amyloid; **spores:** 1–4-seriate, submuriform to muriform, hyaline to brown, non-amyloid to strongly amyloid, non-halonate. **Conidiomata:** pycnidial, with bacilliform conidia.

Out of about 43 species known from the world, 12 are from India, of which 4 are terricolous.

### Key to the terricolous species of *Diploschistes*:

- 
- |  |   |
|--|---|
| 1. Asci consistently 4-spored, thallus parasitic on <i>Cladonia</i> spp. ....                      | <i>D. muscorum</i> ssp. <i>muscorum</i>   |
| 1a. Asci consistently 8-spored or 4–8-spored in the same ascoma.....                               | 2   |
| 2. Thallus parasitic on <i>Cladonia</i> spp., lecanoric and diploschistic acids.....               | <i>D. muscorum</i> ssp. <i>bartlettii</i> |
| 2a. Thallus not parasitic on <i>Cladonia</i> spp.....  | 3   |
| 3. Ascomata up to 2 mm in diam., asci 4–8 spored, spores (21)–24–36(–45) × (9–) 12–18(–21) µm..... | <i>D. scruposus</i>                       |
| 3a. Ascomata up to 1.5 mm in diam., asci consistently 8-spored, spores up to 33 × 18 µm.....       | 4   |
| 4. Thallus whitish, pruinose.....  | <i>D. diacapsis</i>                       |
| 4a. Thallus yellowish or grayish, epruinose .....  | <i>D. cinereocaesius</i>                  |
- 

### *Diploschistes cinereocaesius* (Sw. ex Ach.) Vain. (Fig.2.15e; Fig. 2.44)

Ann. Acad. Sci. Fenn., ser. A 15(6): 172. 1921.

Basionym: *Lichen cinereocaesius* Sw. ex Ach., Lichenogr. Suec. Prodr.: 34. 1798.

**Thallus:** verrucose, thick, subcontinuous to diffract areolate. **Ascomata:** 0.5–2 mm in diam.; **disc:** pruinose; **asci:** 8-spored; **spores:** oblong, fusiform (16–)18–28 × 8–13 µm.

**Chemistry:** Lecanoric and traces of diploschistesic acids.



**Ecology and distribution:** *Microhabitat occupied:* Terricolous; muscicolous-terricolous. The species is exclusively terricolous and distributed in Himachal Pradesh, Kerala, Meghalaya, Sikkim, Tamil Nadu and Uttarakhand. The species is widely distributed in tropical and subtropical regions of the world (Zahlbruckner, 1924).

**SPECIMENS EXAMINED:** **INDIA:** **KERALA,** IDUKKI DISTRICT, Munnar, Devicolam, alt. 1,500–1,600 m, Awasthi, Tewari and Mathur, on soil, 85.163 (LWG-LWU); **MEGHALAYA,** SHILONG, near Mawlai, by roadside, Awasthi 7930 b (LWG-AWAS); **TAMIL NADU,** NILGIRI HILLS, Konad tea estate area by roadside, Awasthi and Singh 71.13 (LWG-LWU); Emerald road, Fern hill, on vertical side soil, Awasthi and Singh 73.464 (LWG-LWU); Sholas at 8–9 miles, Ootacamund–Mysore road, alt. 2,100 m, on soil, Awasthi 4543 (LWG-AWAS); **PALNI HILLS,** near Mannavanur, alt. 1,800 m, on soil, Singh 73.24 (LWG-LWU); **UTTARAKHAND,** PITHORAGARH DISTRICT, Askot, near Primary School, alt. 1,350 m, on soil among mosses, Awasthi 201 (LWG-AWAS).

***Diploschistes dicapsis* (Ach.) Lumbsch (Fig. 2.15f; Fig. 2.44)**

Lumbsch, Lichenologist 20: 20.1998

Basionym: *Urceolaria diacapsis* Ach., Lichenogr. Universalis: 339. 1810.

**Thallus:** rimose- to verrucose-areolate; **areoles:** 0.5–2.5 mm in diam., plane to subconvex, thick; **upper surface:** whitish to whitish gray, rough, dull, scarcely to abundantly grayish or whitish pruinose. **Ascomata:** urceolate, sessile, slightly pruinose, up to 2.5 mm in diam.; **disc:** blackish, concave; **hymenium:** 110–80  $\mu\text{m}$  high; **asci:** subclavate to cylindrical, 4–8-spored; **spores:** brown, muriform, broadly ellipsoid, 20–38  $\times$  9–17  $\mu\text{m}$ ; transverse septa 3–6; longitudinal septa 1–2 per transverse segment. **Pycnidia:** immersed; **conidia:** bacilliform, 4–6  $\times$  1.0–1.5  $\mu\text{m}$

**Chemistry:** K+ yellow to red, C+ red, KC–, P–, UV–. Diploschistic and lecanoric acids (both major) and orsellinic acid (minor).

**Ecology and distribution:** *Microhabitat occupied:* Terricolous; muscicolous-terricolous. The species is exclusively terricolous and distributed in Himachal Pradesh and Uttarakhand while the species growing over soil is reported from Uttarakhand. The species is widely distributed in Mediterranean regions of the world (Lumbsch, 1989).

**SPECIMENS EXAMINED:** **INDIA:** **UTTARAKHAND,** BAGESHWAR DISTRICT, above Phurkia, towards Pindari glacier, alt. 3,300 m, on soil, Awasthi and Awasthi 201 (LWG-AWAS); near Phurkia, alt. 3,300 m, on vertical side of boulder (along with mosses), Awasthi 7637 (LWG-AWAS).

***Diploschistes muscorum* (Scop.) R. Sant. In D. Hawksw. and al., Lichenologist 12(1): 106. 1980.**

Basionym: *Lichen muscorum* Scop., Fl. Carniol., ed. 2, 2: 365. 1772.

subsp. ***bartlettii*** Lumbsch (Fig. 2.15g; Fig. 2.44)

Herzogia 7: 602. 1987.

**Thallus:** to c. 2 mm thick, grey to whitish grey, dull or glossy, rimose-areolate, epruinose or whitish-pruinose. **Ascomata:** conspicuous, blackish, to c. 1.6 mm diam., urceolate, solitary, immersed; **disc:** blackish brown, epruinose to greyish-pruinose; **hymenium:** 120–140  $\mu\text{m}$  thick, not inspersed, moderately conglutinated; **lateral paraphyses:** conspicuous, to c. 30  $\mu\text{m}$  long; **asci:** 8-spored; **spores:** ellipsoidal to broadly ellipsoidal, with  $\pm$  rounded to subacute ends, brown, non-amyloid, 19–30  $\times$  5–14  $\mu\text{m}$ , with 4–6  $\times$  1–2 locules, locules  $\pm$  rounded to angular, septa thick, regular, spore wall thin to thick; endospore thick.

**Chemistry:** Thallus K<sup>+</sup> yellowish to red, C<sup>+</sup> red, P<sup>-</sup>; diploschistesic acid (major), lecanoric acid (major), orsellinic acid (minor).

**Ecology and distribution:** *Microhabitat occupied:* Terricolous; muscicolous-terricolous. The species is distributed in Karnataka, Meghalaya, Tamil Nadu, Uttarakhand and West Bengal while the species growing over soil is reported from Kerala, Tamil Nadu and Uttarakhand. The species is palaeotropical in distribution and widely distributed in Argentina, Australia, Brazil, Chile, East Africa, Easter Island, Ecuador, Indonesia, Madagascar, Nepal, New Guinea, New Zealand, South Africa and Tasmania. The taxon grows on soil or mosses together with *Cladonia* spp.

**SPECIMENS EXAMINED:** **INDIA:** **KARNATAKA, CHIKMAGALUR DISTRICT,** Chikmagalur, on way to Kummangundi, alt. 1,400 m, on soil, Awasthi, Upreti and Misra 79.434 (LWG-LWU); **TAMIL NADU, NILGIRI HILLS,** Coonoor, alt. 1,680 m, on soil, Awasthi and Singh 70.1330 (LWG-LWU); Kodanad to Kilkotagiri, in Shola, alt. 1,800 m, on soil among mosses, Awasthi and Singh 71.72 (LWG-LWU); **PALNI HILLS,** Kodaikanal, Croaker's walk, along roadside, alt. 2,100 m, on soil, Awasthi and Singh 69.17 (LWG-LWU); **UTTARAKHAND, BAGESHWAR DISTRICT,** Dhakuri-Khati (en route to Pindari Glacier), alt. 2,400 m, on soil, Awasthi and Awasthi 687 (LWG-AWAS); **RUDRAPRAYAG DISTRICT,** Mandakini River Valley, on way from Sonprayag to Gaurikund, alt. 1,800–1,980 m, on soil, Dange 76.57 (LWG-LWU); **WEST BENGAL, DARJEELING,** Kurseong, alt. 1,440–1,560 m, on soil, Awasthi and Agarwal 66.321 (LWG-LWU).

subsp. *muscorum* (Fig. 2.15h; Fig. 2.44)

**Thallus:** rimose-to verrucose-areolate; **areoles:** 0.2–0.6 mm in diam., plane to subconvex, thin or thick; **upper surface:** white or whitish gray, rough, shiny or dull, scarcely or abundantly grayish or whitish pruinose. **Ascomata:** urceolate, sessile, slightly pruinose, up to 1.8 mm in diam.; disc: blackish, concave; proper exciple: up to 70 µm thick; hymenium: 80–120 µm high; **asci:** subclavate to cylindrical, 4-spored; **spores:** brown, muriform, ellipsoid, 18–32 × 6–15 µm; transverse septa 4–6, longitudinal septa 1–2 per transverse segment.

**Chemistry:** K<sup>+</sup> yellow to red, C<sup>+</sup> red, KC<sup>-</sup>, P<sup>-</sup>, UV<sup>-</sup>. Diploschistesic and lecanoric acids (both major) and orsellinic acid (minor).

**Ecology and distribution:** *Microhabitat occupied:* Terricolous. The species is exclusively terricolous and distributed in Jammu and Kashmir, Himachal Pradesh, Kerala and Uttarakhand while the species growing over soil is reported from Jammu and Kashmir, Kerala and Uttarakhand. The species is cosmopolitan, but rare in Southern hemisphere, widespread in Northern hemisphere and widely distributed in Bhutan, Great Britain, Nepal and New Zealand; Africa, North and South America. The taxon grows on soil or mosses together with *Cladonia* spp.

**SPECIMENS EXAMINED:** **INDIA:** **JAMMU AND KASHMIR, SRINAGAR,** Shankaracharya hill, on soil, Awasthi 2644 (LWG-AWAS); **KERALA, IDUKKI DISTRICT,** Munnar, Rajamallay area, along border of tree plantation, alt. 1,500–1,600 m, Awasthi, on vertical slope of soil, Tewari and Mathur 85.89 (LWG-LWU); **UTTARAKHAND, CHAMOLI DISTRICT,** Badrinath, east of temple, on way to Devadarshini, alt. 3,150 m, on soil, Dange 76.777 (LWG-LWU).

*Diploschistes scruposus* (Schreb.) Norman (Fig. 2.15i; Fig. 2.44)

Norman, *Nyt Mag. Naturvidensk.* 7: 232. 1853.

Basionym: *Lichen scruposus* Schreb., *Spic. Fl. Lips.*: 133. 1771.

**Thallus:** rimose-to verrucose-areolate; areoles: 0.4–1.5 mm in diam., plane to subconvex, thin or thick; **upper surface:** greenish or brownish gray, smooth, shiny or dull, epruinose. **Ascomata:** urceolate, sessile, slightly pruinose, up to 2.0 mm in diam.; **disc:** blackish, concave; **hymenium:** 100–140  $\mu\text{m}$  high; **asci:** subclavate to cylindrical, (4–)8-spored; **spores:** brown, muriform, ellipsoid, 25–40  $\times$  10–20  $\mu\text{m}$ ; transverse septa 4–7, longitudinal septa 1–3 per transverse segment. **Pycnidia:** immersed; **conidia:** bacilliform, 4–6  $\times$  1.0  $\mu\text{m}$ .

**Chemistry:** K– or + yellow to red, C+ red, KC–, P–, UV–. Diploschistesic acid (major or absent), lecanoric acid (major), and orsellinic acid (minor).

**Ecology and distribution:** *Microhabitat occupied:* Terricolous. The species is distributed in Arunachal Pradesh, Himachal Pradesh, Jammu and Kashmir, Madhya Pradesh, Maharashtra, Meghalaya, Sikkim, Tamil Nadu, Uttarakhand and West Bengal hills while the species growing over soil is known from Arunachal Pradesh and Uttarakhand. The species is widely distributed in Sri Lanka and Nepal.

**SPECIMENS EXAMINED:** **INDIA:** **ARUNACHAL PRADESH, WEST KAMENG DISTRICT,** 61 Labour camp, 3 km before Bomdila, on soil, D. K. Upreti, U. Dubey, R. Khare and G. K. Mishra 08-009273 (LWG); **UTTARAKHAND, CHAMPAWAT DISTRICT,** Mayawati to Lohaghat, on soil, D. K. Upreti, S. Joshi, H. Rai, R. Khare, G. K. Mishra and A. Dwivedi 09-012607 (LWG); **PITHORAGARH DISTRICT,** Narayan Swami Ashram, alt. 2,743 m, on soil, D. K. Upreti, S. Joshi, H. Rai, R. Khare, G. K. Mishra and A. Dwivedi 09-012151 (LWG).

## **ENDOCARPON** Hedw. (*Verrucariaceae*)

Descr. Adumbr. Muscor. Frond. 2: 56. 1789.

**Thallus:** minutely foliose, squamulose, or occasionally crustose, both surfaces or only upper **surface** paraplectenchymatously corticated; **photobiont:** green, layer composed of compactly arranged hyphae as well as green alga; **medulla:** consists of lax hyphae. **Perithecia:** generally immersed; **ostioles:** indistinct or prominent, like a protuberance; **perithecial cavity:** with hymenial photobiont in its upper part and at ostiole lined with dense; **periphyses:** simple; **paraphyses:** gelatinized; asci: 1–16-spored; **spores:** brown, muriform multi-celled.

Out of 50 species known from world, 7 species are known from India, of which 1 is terricolous.

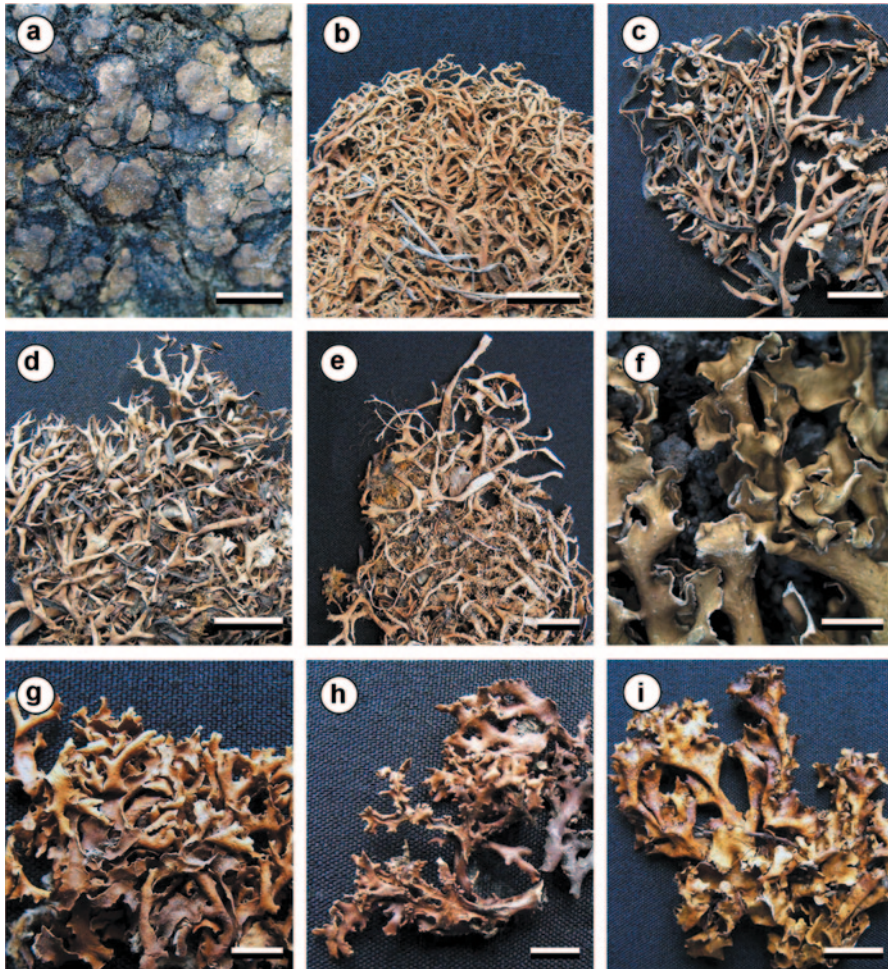
### *Endocarpon subrosetum* Ajay Singh and Upreti (Fig. 2.16a; Fig. 2.44)

Candollea 39: 547. 1984.

**Thallus:** squamulose, irregular in outline; **squamules:** crowded or sometimes imbricate,  $\pm$  adnate, round to irregular in outline, olive-grey when dry, greenish grey when wet, margin crenate to lobulate; **lobules:** whitish, 0.4 mm broad,  $\pm$  ascending, under surface black. **Perithecia:** 1–6(–15) per squamules, immersed, ostioles round, black, plane; **spores:** brown, oblong-ellipsoid, not constricted in the middle, multi-celled muriform, cells arranged in 7–10 transverse tiers, with 2–3 cells in each, 30–40  $\times$  12–14  $\mu\text{m}$ .

**Chemistry:** Thallus K–, C–, KC–, P–; no secondary metabolites in TLC.

**Ecology and distribution:** *Microhabitat occupied:* Terricolous; terricolous-rupicolous. In India the species is widely distributed in Himachal Pradesh, Jammu and Kashmir, Madhya Pradesh, Uttarakhand and Uttar Pradesh while species growing on soil is known from different localities of Uttarakhand. The species is endemic in India.



**Fig. 2.16** **a** *Endocarpon subrosettum* Ajay Singh and Upreti, **b** *Evernia mesomorpha* Nyl., **c** *Everniastrum cirrhatum* (Fr.) Hale ex Sipman, **d** *E. nepalense* (Taylor) Hale ex Sipman, **e** *E. vexans* (Zahlbr.) Hale ex Sipman, **f** *Flavocetraria cucullata* (Bellardi) Kärnefelt and A. Thell, **g** *F. nivalis* (L.) Kärnefelt and A. Thell, **h** *Flavocetrariella leucostigma* (Lév.) D. D. Awasthi, **i** *F. melaloma* (Nyl.) D. D. Awasthi. Scale in **a**, **f**=2 mm; in **g**, **h**, **i**=5 mm; in **b**, **c**, **d**, **e**=10 mm

**SPECIMENS EXAMINED: INDIA: UTTARAKHAND, CHAMOLI DISTRICT**, on way to Vasudhara from Mana, alt. 3,340 m, on soil over rocks, D.K. Upreti and S Nayaka 07-010157 (LWG); **UTTARKASHI DISTRICT**, Gomukh area, right bank, 3rd and 4th moraine, alt. 3,871 m, on soil, D. D. Awasthi and SR Singh 8415 (LWG-AWAS).

#### **EVERNIA** Ach. (*Parmeliaceae*)

In Luyken, Tent. Hist. Lich.: 90. 1809.

**Thallus:** fruticose, erect or pendulous, dichotomously or irregularly branched and flattened, heteromerous, corticated on all surfaces; **photobiont:** a green alga; **medulla:** white, of loose hyphae. **Apothecia:** marginal or terminal, lecanorine;

paraphyses thick, articulate; **asci**: globular, 8-spored; **spores**: colourless, simple. Usnic acid present.

Out of 10 species known from the world, 3 are from India, of which 1 is terricolous.

***Evernia mesomorpha*** Nyl. (Fig.2.16b; Fig. 2.44)

Nylander, Lich. Scand.: 74. 1860.

**Thallus**: fruticose, suberect to pendulous, up to 13 cm long; **branches**: up to 3 mm wide, tapering, brownish near base, yellowish green to grey upwards; **surface**: wrinkled, isidiate sorediate throughout the upper part; **soredia**: granular; **medulla**: arachnoid; **Apothecia**: not seen.

**Chemistry**: Medulla K-, C-, KC-, P-. Divaricatic, evernic and sekikaic acids present.

**Ecology and distribution**: *Microhabitat occupied*: Terricolous; detriticolous-terricolous. In India, the species is widely distributed in Himachal Pradesh, Sikkim and Uttarakhand, while species growing on soil is known from localities of Uttarakhand. Outside India, the species is also reported from Bhutan, China, Nepal and Northern Europe.

**SPECIMENS EXAMINED**: **INDIA**: **SIKKIM**, NORTH SIKKIM, Kalep, before Thangu, alt. 3,900 m, on soil Upreti, Chatterjee and Divakar 04-003854 (LWG); **UTTARAKHAND**, **UTTARAKASHI DISTRICT**, Gomukh area, right bank, 2nd moraine, alt. 3,901 m, on rocky soil, 02 Jul 1976, D. D. Awasthi and S. R. Singh, 8408 (LWG-AWAS); Gomukh area, right bank, 3rd and 4th moraine, alt. 3,871 m, on gravelly ground, 04 Jul 1976, D. D. Awasthi and S. R. Singh, 8421 (LWG-AWAS); Gangotri, alt. 3,128 m, on soil, Himanshu Rai and Pramod Nag, 10-0014546 (LWG); Gangotri, alt. 3,104 m, on ground (over degrading *Pinus* needles), Himanshu Rai and Pramod Nag, 10-0014515 (LWG).

**EVERNIASTRUM** Hale ex Sipman (*Parmeliaceae*)

Sipman, Mycotaxon 26: 237. 1986.

**Thallus**: foliose, dichotomously or subdichotomously branched; **lobes**: often canaliculate with ciliate margins; **upper surface**: convex, grey to grey-green, with or without isidia and soredia; **lower surface**: brown-black, usually with rhizines; **photobiont**: a green alga; **medulla**: white. **Apothecia**: laminal, lecanorine, often pedicellate; **asci**: 8-spored; **spores**: colourless, simple. Atranorin always present in upper cortex.

Out of 33 species known from the world, 7 are from India, of which 3 are terricolous.

**Key to the terricolous species of *Everniastrum***:

1.	Thallus isidiate.....	<i>E. vexans</i>
1a.	Thallus lacking isidia and soredia.....	2
2.	Lower surface uniformly rhizinate, rhizines short.....	<i>E. nepalense</i>
2a.	Lower surface nude or with irregular scattered long rhizines, irregular or elongate.....	<i>E. cirrhatum</i>

***Everniastrum cirrhatum*** (Fr.) Hale ex Sipman (Fig. 2.16c; Fig. 2.44)

In Sipman, Mycotaxon 26: 239. 1986.

Basionym: *Parmelia cirrhata* Fries, Syst. Orb. Veg. 1: 383. 1825.

Synonym: *Cetrariastrum cirrhatum* (Fr.) W. L. Culb. and C. F. Culb., Bryologist 84: 283. 1981.

**Thallus:** foliose, loosely attached to the substratum, suberect to pendulous, to 12 cm across, dichotomously lacinate lobate; **lobes:** canaliculated, linear, elongate, much variable in width, apically tapering, 2–4 mm wide; lateral margins much involute, ciliate; **cilia:** black, simple to branched; **upper surface:** grey to dark grey, maculate, smooth, convex, lacking soredia and isidia; **medulla:** white; **lower surface:** black-brown rarely with much elongated rhizinal structures. **Apothecia:** apical to laminal, substipitate to stipitate, to 6 mm in diam., with hollow stalk; **disc:** dark brown, plane to concave; **asci:** clavate, 8-spored; **spores:** large, oval-ellipsoid, 15–18(–30) × 7–12 μm.

**Chemistry:** Cortex K<sup>+</sup> yellow; medulla K<sup>+</sup> yellow turning red to brown-red, C<sup>-</sup>, P<sup>+</sup> orange-red. Salazinic and protolichesterinic acids present.

**Ecology and distribution:** *Microhabitat occupied:* Terricolous; terricolous-rupicolous. In India, the species is widely distributed in the regions of Arunachal Pradesh, Assam, Himachal Pradesh, Jammu and Kashmir, Kerala, Karnataka, Manipur, Meghalaya, Nagaland, Sikkim, Tamil Nadu, Uttarakhand and West Bengal hills, while the species growing over soil is known from localities of Arunachal Pradesh, Himachal Pradesh, Sikkim and Uttarakhand. It is also reported from Bhutan, China, Japan, Korea, Nepal, Sri Lanka and Taiwan; Central and South America.

**SPECIMEN EXAMINED:** **INDIA: ARUNACHAL PRADESH, WEST KAMENG DISTRICT,** Tawang, alt. 3,962 m, on soil over rocks, Ashish Kar 04-009726 (LWG); Bomdila, alt. 2,400 m, on soil, B. Dutt and Party s.n. (LWG); **HIMACHAL PRADESH, KULLU DISTRICT,** Greater Himalayan National Park, on way from Dhela-Lapah, alt. 3,000 m, on soil, D. K. Upreti 99-54051 A (LWG); Soudphar, alt. 3,900 m, on soil among mosses, D. K. Upreti 99-53682 (LWG); **SIKKIM, NORTH SIKKIM,** above Lachung, towards Yumthang, alt. 3,000 m, on soil, D. K. Upreti, S. Chatterjee and P. K. Divakar 04-004247 (LWG); Lachen, alt. 3,000 m, on soil, D. K. Upreti, S. Chatterjee and P. K. Divakar 04-003803 A (LWG); Singhbo Rhododendron Sanctuary, near Yumthang, alt. 3,300 m, on soil, D. K. Upreti, S. Chatterjee and P. K. Divakar 04-004079 (LWG); **UTTARAKHAND, PITHORAGARH DISTRICT,** Sandev Botanical Hotspot, Deochula, alt. 2,000 m, on soil, Vikas Pant 02-223430 (LWG); **RUDRAPRAYAG DISTRICT,** Mandakini river valley, on way from Gaurikund to Rambara, alt. 2,390 m, on sloping road surface ground, K. Dange 76.162 (LWG-LWU); Chopta, alt. 2,896 m, on soil, Ajay Rawat, 104863 (LWG); Tungnath Bugyal, alt. 3,400 m, on ground in open grassland, Himanshu Rai and Pramod Nag 08-0012201 (LWG); Chopta, alt. 2,850 m, on ground in *Rhododendron* forest along with decaying leaves and other organic debris, Himanshu Rai and Pramod Nag 08-0012248 (LWG); **UTTARKASHI DISTRICT,** Gangotri, alt. 3,123 m, soil on rock, Himanshu Rai and Pramod Nag 10-0014542 (LWG).

***Everniastrum nepalense*** (Taylor) Hale ex Sipman (Fig. 2.16d; Fig. 2.44)

In Sipman, Mycotaxon 26: 241. 1986.

Basionym: *Parmelia nepalensis* Taylor. London J. Bot. 6: 172. 1847.

Synonym: *Cetrariastrum nepalense* (Taylor) W. L. Culb. and C. F. Culb., Bryologist 84: 301. 1981.

**Thallus:** loosely attached to the substratum, suberect to pendulous, to 10 cm across, dichotomous laciniate lobate; **lobes:** linear, elongate, tapering at apices, much variable in width, up to 4 mm wide; margin black, ciliate; **cilia:** simple to branched, short; **upper surface:** grey to dark grey, rarely brownish, maculate, smooth, convex, lacking isidia and soredia; **medulla:** white; **lower surface:** black-brown, concave, canaliculate, moderate to dense rhizinate; **rhizines:** simple or branched. **Apothecia:** laminal, sessile to substipitate, margins entire to cracked; **disc:** brown to dark tan; concave to plane, up to 10 mm in diam.; **asci:** clavate, 8-spored; **spores:** hyaline, simple, oval-ellipsoid, (11–)15–22 × 5–9 μm, epispore 1.0–1.5 μm. **Pycnidia:** black, immersed; **conidia:** bifusiform.

**Chemistry:** Cortex K<sup>+</sup> yellow; medulla K<sup>+</sup> yellow turning red, C<sup>-</sup>, P<sup>+</sup> orange-red. Atranorin, salazinic and protolichesterinic acids present.

**Ecology and distribution:** *Microhabitat occupied:* Terricolous. In India, the species is widely distributed in the regions of Arunachal Pradesh, Assam, Chhattisgarh, Himachal Pradesh, Kerala, Karnataka, Madhya Pradesh, Manipur, Meghalaya, Nagaland, Sikkim, Tamil Nadu, Uttarakhand and West Bengal hills, while the species growing over soil in alpine regions of Tamil Nadu and West Bengal hills. It is also reported from Bhutan and Nepal; widely distributed in pantropical to temperate parts of Asia as China, Jawa, Taiwan and Thailand (Kurokawa and Lai 2001).

**SPECIMENS EXAMINED:** **INDIA:** **TAMIL NADU,** NILGIRI HILLS, Ootacamund–Kotagiri road, on way to Mayani, 3 miles from Doddabetta, alt. 2,134 m, on ground, K. P. Singh 71.1122 (LWG-LWU); **WEST BENGAL,** **DARJEELING,** Pashhok road, at about 4 miles from Darjeeling, alt. 2,057 m, on soil, D. D. Awasthi and M. R. Agarwal 67.177 (LWG-LWU).

*Everniastrum vexans* (Zahlbr.) Hale ex Sipman (Fig. 2.16e; Fig. 2.44)

In Sipman, Mycotaxon 26: 242. 1986.

Basionym: *Parmelia vexans* Zahlbr., Repert. Spec. Nov. Regni Veg. Beih. 33:55. 1933.

Synonym: *Cetrariastrum vexans* Zahlbr. in W. L. Culb. and C. F. Culb., Bryologist 84:294. 1981.

**Thallus:** loosely attached or pendulous to the substratum, up to 6 cm across, laciniate lobate; **lobes:** 2.5(–) mm wide, divaricately branched, linear, tapering, margin involute, ciliate; **cilia:** black, originated from lateral involute margins, simple to dichotomously branched; **upper surface:** grey to dark grey, convex, maculate, dense isidiate; **isidia:** initially cylindrical or filiform, becoming dorsiventrally lacinate and apically ciliate; **lower surface:** black, concave, canaliculated, shining and sparsely rhizinate; **rhizines:** simple to dichotomously branched present in centre, black. **Apothecia:** up to 6 mm in diam., often isidiate; **spores:** 10–18 × 6–8 μm.

**Chemistry:** Cortex K<sup>+</sup> yellow; medulla K<sup>+</sup> yellow turning red, C<sup>-</sup>, P<sup>+</sup> orange-red. Atranorin and salazinic acid present.

**Ecology and distribution:** *Microhabitat occupied:* Terricolous. In India, the species is widely distributed in the regions of Arunachal Pradesh, Kerala, Manipur, Nagaland, Sikkim, Tamil Nadu, and West Bengal hills, while species growing over soil is known from single locality of Tamil Nadu. It is also reported from China, Taiwan, tropical America—Mexico, Columbia and Venezuela.

**SPECIMENS EXAMINED: INDIA: TAMIL NADU, NILGIRI HILLS, Avalanche, Emerald road, along roadside near forest rest house, alt. 2,134 m, on soft sandy soil, K. P. Singh 71.321, 71.570 (LWG-LWU).**

**FLAVOCETRARIA** Kärnefelt and A. Thell (*Parmeliaceae*)

In Kärnefelt et al., *Acta Bot. Fenn.* 150: 81. 1994.

**Thallus:** foliose to subfruticose, flat to canaliculate-subtubular, lacking marginal papillae or fibrils; **upper surface:** yellow; **lower surface:** yellow with minute pseudocyphellae (distinct under 10× lens); **photobiont:** a green alga; **medulla:** white. **Apothecia:** marginal, lecanorine; **asci:** 8-spored; **spores:** colourless, simple, ellipsoid. Usnic acid present in upper cortex.

Out of 2 species known from the world; 2 terricolous species are known from India.

**Key to the terricolous species of *Flavocetraria*:**

- 
- |     |  |                     |
|-----|--|---------------------|
| 1.  | Thallus erect, yellow, lobes tubular .....                     | <i>F. cucullata</i> |
| 1a. | Thallus erect, lobes rather flat, yellow to darker yellow..... | <i>F. nivalis</i>   |
- 

***Flavocetraria cucullata*** (Bellardi) Kärnefelt and A. Thell (Fig. 2.16f; Fig. 44)

In Kärnefelt and al., *Acta Bot. Fenn.* 150: 81. 1994.

Basionym: *Lichen cucullatus* Bellardi, *Osserv. Bot.* 1: 54. 1788.

Synonyms: *Cetraria cucullata* (Bell.) Ach., *Methodus*: 293. 1803. *Allocetraria cucullata* (Bell.) Randle and Saag, *Mycotaxon* 44: 492. 1992.

**Thallus:** suberect to erect, up to 3 cm tall, subdichotomously branched, yellow, basal parts reddish; **lobes:** up to 4 mm wide, canaliculate by connivent margins, isidia and soredia absent; **lower surface:** pale yellow, minutely pseudocyphellate. **Apothecia:** absent.

**Chemistry:** Medulla K<sup>-</sup>, C<sup>-</sup>, KC<sup>-</sup>, P<sup>-</sup>. Lichesterinic and protolichesterinic acids present.

**Ecology and distribution:** *Microhabitat occupied:* Terricolous. In India, the species is exclusively terricolous and distributed in the regions of Sikkim (Singh and Sinha 2010) and Uttarakhand. The species is also reported from China, Japan, Mongolia and Nepal; arctic region of Northern hemisphere and southernmost South America.

**SPECIMEN EXAMINED: INDIA: UTTARAKHAND, UTTARKASHI DISTRICT, Gomukh area, right bank, 5th moraine, alt. 3,840 m, on soil, D. D. Awasthi and S. R. Singh, 8493 B (LWG-AWAS).**

***Flavocetraria nivalis*** (L.) Kärnefelt and A. Thell (Fig. 2.16g; Fig. 2.44)

In Kärnefelt et al., *Acta Bot. Fenn.* 150: 84. 1994.

Basionym: *Lichen nivalis* L., *Sp. Pl.*: 1145. 1753.

Synonym: *Cetraria nivalis* (L.) Ach., *Meth. Lich.*: 295. 1803. *Allocetraria nivalis* (L.) Randle and Saag, *Mycotaxon* 44: 492. 1992.

**Thallus:** terricolous, flat to erect, 5 cm across; **lobes:** to 7 mm wide, lacking marginal papillae, isidia and soredia; **lower surface:** foveolate, with minute pseudocyphellae. **Apothecia:** not observed in specimen.



**Chemistry:** Thallus and medulla K<sup>-</sup>, C<sup>-</sup>, KC<sup>-</sup>, P<sup>-</sup>; no secondary metabolites in TLC.

**Ecology and distribution:** *Microhabitat occupied:* Terricolous; terricolous-rupicolous. In India, the species is exclusively terricolous and exhibits restricted distribution to Western Himalaya and known only from Uttarakhand. The species is also reported from China, Japan, Mongolia, Nepal and Russia; South America.

**SPECIMEN EXAMINED:** **INDIA:** UTTARAKHAND, UTTARKASHI DISTRICT, Gomukh area, right bank 5th moraine, alt. 3,840 m, on soil, D. D. Awasthi and S. R. Singh 8473, 8493 A (LWG-AWAS).

**FLAVOCETRARIELLA** D. D. Awasthi (*Parmeliaceae*)

D. D. Awasthi, *Comp. Macrolich. India, Nepal and Sri Lanka:* 161. 2007.

**Thallus:** fruticose, suberect to erect, usually branched, yellow to yellow-castaneous; **lobes:** plane to involute-subcanaliculate on upper surface; **lower surface:** distinctly pseudocyphellate; **pseudocyphellae:** depressed, 0.1–0.2(–0.5) mm across, round to irregular in outline; **photobiont:** a green alga; **medulla:** white. **Apothecia:** marginal, peltate to subnephromoid, lecanorine; **paraphyses:** simple, capitate; **asci:** with minute ocular chamber (up to 1.5  $\mu$ m) in the region of tholus, 8-spored; **spores:** colourless, simple, thin-walled, ovoid. **Pycnidia:** on tips of marginal fibrils.

Out of 2 species known from the world, 2 terricolous species are known from India.

**Key to the terricolous species of *Flavocetrariella*:**

- 
- |     |   |                       |
|-----|---|-----------------------|
| 1.  | Thallus yellow castaneous, lobes widened upwards, involutely compact..... | <i>F. leucostigma</i> |
| 1a. | Thallus yellow with brown margins, lobes uniform, narrow.....             | <i>F. melaloma</i>    |
- 

***Flavocetrariella leucostigma*** (Lév.) D. D. Awasthi (Fig. 2.16h; Fig. 2.45) *Comp. Macrolich. India, Nepal & Sri Lanka:* 162. 2007.

Basionym: *Cetraria leucostigma* Lév. in Jacq., *Voy. Inde:* 180. 1841–44.

Synonym: *Cetraria sikkimensis* Räsänen, *Arch. Soc. Zoo J. Bot.* ‘Vanamo’ 5 (1): 25. 1950.

**Thallus:** ascending on small shrubs, suberect to erect, 3–5(–8) cm tall; **lobes:** widening upwards, apically rounded, 5–10 mm wide, plane to involute subcanaliculate towards apices, undulate along margins; **upper surface:** yellow-brown to pale brown (castaneous), smooth; **margins:** irregular, with sparse, 0.2–0.4 mm long, black fibrils tipped with pycnidium; **lower surface:** pale brown to darker castaneous, smooth to slightly lacunose-rugose, pseudocyphellate; **pseudocyphellae:** white, depressed, round to somewhat irregular in outline, with brown rim when thallus yellow; **rhizines:** sometimes present, black, in clusters; **medulla:** white.

**Chemistry:** Cortex and medulla K<sup>-</sup>, C<sup>-</sup>, KC<sup>-</sup>, P<sup>-</sup>. Usnic, lichesterinic and protolichesterinic acids present.

**Ecology and distribution:** *Microhabitat occupied:* Terricolous. In India the species is distributed in Himachal Pradesh, Sikkim and Uttarakhand, while species growing on soil is known from single locality of Uttarakhand. Outside India, the species is also reported from Bhutan and Nepal.

**SPECIMEN EXAMINED: INDIA: UTTARAKHAND, BAGESHWAR DISTRICT**, near zero mile of Pindari Glacier, on the moraine ridge, alt. 3,658 m, on ground, D. D. Awasthi 7683 (LWG-AWAS).

***Flavocetrariella melaloma*** (Nyl.) D. D. Awasthi (Fig. 2.16i; Fig. 2.45) Comp. Macrolich. India, Nepal & Sri Lanka: 162. 2007.

Basionym: *Platysma melalomum* Nyl., Syn. Lich. 1:303. 1860.

Synonyms: *Cetraria melaloma* (Nyl.) Kremp. Verh. K. K. Zool. -Bot. Ges. Wien 18: 315. 1868. *Nephromopsis melaloma* (Nyl.) A. Thell and Randle in A. Thell et al., Mycol. Res. 4(4): 311. 2005.

**Thallus:** growing along with mosses, erect to suberect, 2–3.5 cm tall, irregularly to dichotomously branched; **lobes:** uniformly 2–5 mm wide, not widened upwards, plane to involute-subcanaliculate on upper surface; **margins:** undulate; **upper surface:** yellow to yellowish grey to mottled brown at base, smooth to faintly lacunose; **margins:** brown lined, with 0.1–0.2 mm long black fibrils; **lower surface:** paler than upper, pseudocypheolate; **pseudocypheae:** round, brown rimmed, up to 0.5 mm across, or confluent into linear or irregular streaks; **medulla:** white. **Apothecia:** not seen.

**Chemistry:** Cortex and medulla K–, C–, KC–, P–. Usnic, lichesterinic and protolichesterinic acids present; rarely stictic acid present.

**Ecology and distribution:** *Microhabitat occupied:* Terricolous. In India, the species is exclusively terricolous and distributed in Himachal Pradesh, Sikkim and Uttarakhand. Outside India, the species is also reported from Bhutan, China and Nepal.

**SPECIMENS EXAMINED: INDIA: HIMACHAL PRADESH, KULLU DISTRICT**, Great Himalayan National Park, around Soupdhara, alt. 3,900 m, on soil along with *Cladonia* under *Rhododendron*, D. K. Upreti 99-53675 A (LWG); **UTTARAKHAND, BAGESHWAR DISTRICT**, Phurkia to Pindari Glacier, near Mirtoli, alt. 3,505 m, on ground under *Rhododendron*, D. D. Awasthi 7695 (LWG).

## **FLAVOPARMELIA** Hale (*Parmeliaceae*)

Hale, Mycotaxon 25: 604. 1986.

**Thallus:** foliose, closely adnate; **lobes:** rotund to subrotund with eciliate margins; **upper surface:** yellow-green to green with or without isidia, soredia and pustules; **lower surface:** black with simple to dichotomously branched rhizines; upper cortex palisade plectenchymatous; **medulla:** white to yellow-orange. **Apothecia:** laminal, lecanorine, imperforate; **asci:** 8-spored; **spores:** colourless, simple. **Pycnoconidia:** bifusiform or bacilliform.

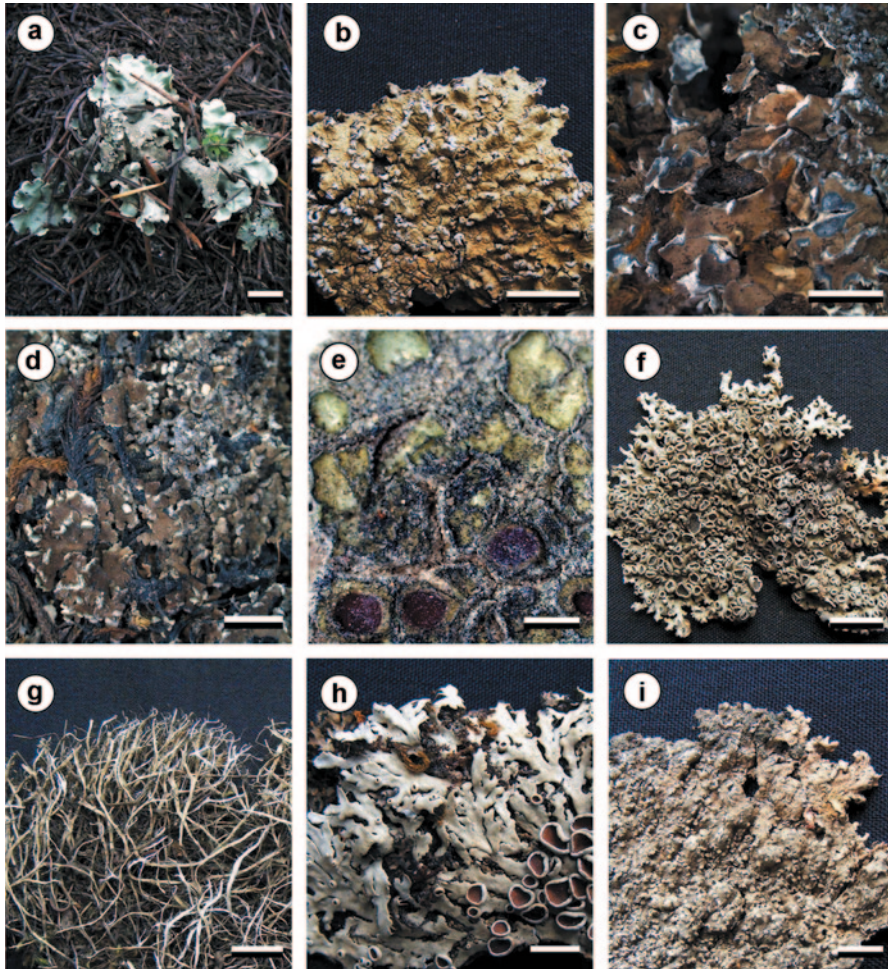
Out of 32 species known from the world; 1 terricolous species is known from India.

### ***Flavoparmelia caperata*** (L.) Hale (Fig. 2.17a; Fig. 2.45)

Hale, Mycotaxon 25: 604. 1986.

Basionym: *Lichen caperatus* L., Sp. Pl.: 1147. 1753.

Synonyms: *Parmelia caperata* (L.) Ach., Methodus: 216. 1803. *Pseudoparmelia caperata* (L.) Hale, Phytologia 29: 189. 1974.



**Fig. 2.17** **a** *Flavoparmelia caperata* (L.) Hale, **b** *Flavopunctelia soledica* (Nyl.) Hale, **c** *Fuscopannaria coeruleus* P. M. Jørg., **d** *F. saltuensis* P. M. Jørg., **e** *Heppia lutosa* (Ach.) Nyl., **f** *Heterodermia angustiloba* (Müll. Arg.) D. D. Awasthi, **g** *H. boryi* (Fée) Kr. P. Singh and S. R. Singh, **h** *H. diademata* (Taylor) D. D. Awasthi, **i** *H. formula* (Nyl.) Trevis. Scale in **e**=1 mm; in **c**, **d**=2 mm; in **h**, **i**=5 mm; in **a**, **b**, **f**, **g**=10 mm

**Thallus:** foliose, closely to loosely adnate to the substratum, up to 20 cm across, thick; **lobes:** elongate, ascending, imbricate to confluent, up to 10 mm wide, margins entire to crenate, eciliate, apices subrotund; **upper surface:** greenish yellow to yellow-grey, smooth at peripheral parts, marginally faintly maculate, plicate, pustules on ridges developing into discrete or confluent soralia; **soralia:** laminal to submarginal, capitate; **soredia:** granular; **medulla:** white; **lower surface:** black, narrow marginal zone brownish and shiny, with white or pale yellow rhizinal papillae along margins, leaving a narrow erhizinate area; **rhizines:** short, simple to furcate. **Apothecia:** rare, to 3 mm in diam.; **spores:** 16–20 × 7–10 μm.

**Chemistry:** Upper cortex K<sup>-</sup>; medulla K<sup>-</sup>, C<sup>-</sup>, KC<sup>-</sup>, P<sup>+</sup> orange-red. Usnic acid in cortex; caperatic and protocetraric acids in medulla.

**Ecology and distribution:** *Microhabitat occupied:* Terricolous; terricolous-rupicolous; detriticolous-terricolous. In India, the species is reported from Andhra Pradesh, Assam, Himachal Pradesh, Jammu and Kashmir, Manipur, Meghalaya, Nagaland, Sikkim, Tamil Nadu, Uttarakhand and West Bengal, while species growing on soil is known from different localities of Assam and Uttarakhand. The species is also distributed in Bhutan, China, Japan and Nepal; Taiwan, lower temperate regions of the world.

**SPECIMENS EXAMINED:** **INDIA:** ASSAM, over soil, Bhatt 3386 (LWG-AWAS); **UTTARAKHAND, ALMORA DISTRICT,** Almora taluka below Dinapani, alt. 1,676 m, over stone on soil, D. D. Awasthi and A. M. Awasthi 560 (LWG-AWAS); **CHAMOLI DISTRICT,** Badrinath, Mana to Vasudhara, alt. 3,340 m, on soil over rocks, D. K. Upreti and S. Nayaka 07-010219 (LWG); **UTTARKASHI DISTRICT,** Gangotri, alt. 3,118 m, on ground (over degrading *Pinus* needles), Himanshu Rai and Pramod Nag 10-0014502 (LWG); Govind Wildlife sanctuary, way from Taluka to Osla, alt. 2,174 m, on rock over soil, D. K. Upreti, S. Nayaka, R. Bajpai 11-015817 (LWG).

### **FLAVOPUNCTELIA** (Krog) Hale (*Parmeliaceae*)

Hale, Mycotaxon 20: 682. 1984.

**Thallus:** foliose, adnate to adglutinated, lacking marginal cilia; **upper surface:** yellow-green usually with punctiform pseudocyphellae, and sorediate; **lower surface:** brown-black with simple, sparse rhizines; a narrow marginal zone erhizinate, brown and shiny; **medulla:** white. **Apothecia:** laminal, imperforate; **asci:** 8-spored; **spores:** colourless, simple. **Pycnoconidia:** bifusiform. Usnic acid present in upper cortex.

Out of 5 species known from the world; 1 terricolous species is known from the India.

#### *Flavopunctelia soledica* (Nyl.) Hale (Fig. 2.17b; Fig. 2.45)

Hale, Mycotaxon 20: 682. 1984.

Basionym: *Parmelia soledica* Nyl., Flora 68: 605. 1885.

Synonyms: *Punctelia soledica* (Nyl.) Krog, Nord. J. Bot. 2: 291. 1982. *Parmelia ulophyllodes* (Vain.) Savicz in L.I. Savicz, Bull. Jard. Imp. Bot. Pierree le Grand 15: 316. 1915. *Parmelia manshurica* Asahina, J. Jap. Bot. 17: 75. 1941.

**Thallus:** foliose, coriaceous, closely adnate to agglutinated to the substratum, up to 8 cm across; **lobes:** subirregular, close to compact, imbricate to confluent, margins entire to crenate, eciliate, up to 5 mm wide; **upper surface:** yellow-green to grey, smooth to lacunose-rugulose or wrinkled longitudinally, pruinose near periphery, lacking pseudocyphellae, sorediate; **soralia:** marginal, globose, crescent-shaped to sinuous; **medulla:** white; **lower surface:** black, with narrow, erhizinate, dark tan and shining marginal zone, rhizinate; **rhizines:** sparse, distributed in central part, black, simple, short. **Apothecia:** rare, up to 3 mm in diam.; **spores:** 13–17 × 7–8.5 μm.

**Chemistry:** Medulla K<sup>-</sup>, C<sup>+</sup> red, KC<sup>+</sup> red, P<sup>-</sup>. Usnic and lecanoric acid present.

**Ecology and distribution:** Detriticolous-terricolous. In India, the species is distributed only in Himachal Pradesh, Jammu and Kashmir and Uttarakhand, while

species growing on soil is known from different localities of Uttarakhand. The species is also reported from Bhutan, China, Japan, Pakistan, South Africa and Russia; North America.

**SPECIMEN EXAMINED: INDIA: UTTARAKHAND, UTTARKASHI DISTRICT, Gangotri, alt. 3,104 m, on ground on *Pinus* litter, Himanshu Rai and Pramod Nag, 10-0014528 (LWG).**

**FRUTIDELLA** Kalb (*Ramalinaceae*)

Hoppea 55: 582. 1994.

**Thallus:** developing in spreading patches, crowded, clustered, pale greyish white, nodular, isidioid or papillate. **Apothecia:** scattered, convex to tuberculate-conglomerate, bluish black to greyish, with a fine, grey-blue bloom; **asci:** *Bacidia*-type; **spores:** simple, nonhalonate. Sphaerophorin and thiophanic acid as secondary compounds. The genus is monotypic, widespread.

*Frutidella caesioatra* (Schaer.) Kalb (Fig. 2.45)

Kalb, Hoppea, Denkschr. Regensb. Bot. Ges. 55: 582.1994.

Basionym: *Lecidea caesioatra* Schaer., Naturw. Anzeiger Allgem. Schweizer Ges. Naturw. 2: 10. 1818.

Synonym: *Lecidella caesioatra* (Schaer.) Kalb, Denkschr. Regensb. Bot. Ges. 34: 305. 1975.

**Thallus:** rather thick, of densely crowded, subglobose, isidioid, nodular or papillate granules, 0.1–0.2 mm diam., grey to dark grey or blackish, eroding whitish or with a violet tinge. **Apothecia:** sessile or subimmersed in granules, (0.3–)0.5–1(–1.2) mm diam., convex; **proper exciple:** reflexed; **hymenium:** 60–90 µm high, colourless below, blue-green above; **hypothecium:** hyaline to reddish brown to almost violet, K+ reddish orange; **paraphyses:** strongly conglutinated, 1.5–2 µm thick, simple or sparsely branched, apices not swollen; **asci:** *Bacidia* type, 50–60 × 15–20 µm; **spores:** simple, colourless, ellipsoid (12–)15–20(–25) × 5–8(–9) µm. **Pycnidia:** immersed or semi-immersed, globose to subpyriform, apically pigmented; **conidia:** filiform, 15–25 × 0.7–1 µm.

**Chemistry:** Thallus K+ weakly yellow, C–, KC+ orange, P–; containing sphaerophorin (major), thiophanic acid (minor) and atranorin (minor).

**Ecology and distribution:** *Microhabitat occupied:* Terricolous. In India, the species is exclusively terricolous and reported from Jammu and Kashmir (Sheikh et al. 2006). The species is also reported from Australia, Great Britain and New Zealand; Scandinavia, European Alps; Antarctica. Bipolar in distribution.

**FUSCOPANNARIA** P. M. Jørg. (*Pannariaceae*)

J. Hattori Bot. Lab. 76: 202. 1994.

**Thallus:** squamulose, with or without hypothallus; **photobiont:** a blue-green alga or a green alga, very rare. **Apothecia:** sessile, exciple nature in variation; **hymenium:** I+ blue-green turning reddish brown; **asci:** with ring-shaped or tubular amyloid thallus, 8-spored; **spores:** colourless, simple with epispore.

Out of 40 species known from the world, 7 species are known from India, of which 2 are terricolous.

**Key to the terricolous species of *Fuscopannaria*:**

- 
1. Squamules to 3 mm wide, thick, incised, imbricate ..... *F. saltuensis*  
 1a. Squamules beset with ecorticate blue-grey lobules, apothecia with  
 woolly margin ..... *F. coeruleascens*
- 

***Fuscopannaria coeruleascens*** P. M. Jørg (Fig. 2.17c; Fig. 2.45).

Jørgensen, Bryologist 103: 104. 2000.

**Thallus:** squamulose; **squamules:** forming cushions up to 3 cm across, and with blue-grey lobules; **photobiont:** *Nostoc*. **Apothecia:** to 2 mm in diam., with woolly exciple; **spores:** 13–15 × 8–10 µm.

**Chemistry:** Thallus K–, C–, KC–, P–. Two unidentified fatty acids and terpenoids are reported.

**Ecology and distribution:** *Microhabitat occupied:* Terricolous. In India, the species is distributed in Kerala and Tamil Nadu, while species growing on soil is known from single locality of Tamil Nadu. Outside India, the species is also reported from Bhutan, Borneo, Indonesia, Nepal, Papua New Guinea and Philippines.

**SPECIMEN EXAMINED: INDIA: TAMIL NADU, NILGIRI HILLS, Avalanche, near forest rest house, alt. 2,134 m, over soil, K. P. Singh 71.568 (LWG-LWU).**

***Fuscopannaria saltuensis*** P. M. Jørg. (Fig. 2.17d; Fig. 2.45)

Jørgensen, J. Hattori Bot. Lab. 89: 255. 2000.

**Thallus:** squamulose, forming cushions up to 3 cm diam., squamules 0.5–2.0 mm wide, rounded, incised, imbricate, and dense; **upper surface:** uniformly brown, marginal area light brown, with lobes; **lobes:** up to 0.5 mm wide; **photobiont:** *Nostoc*. **Apothecia:** 0.5–2.0 mm diam.; **disc:** brown-dark brown, with or without margin; **hymenium:** 90–110 µm high, I+ blue; **asci:** clavate, 40–50 × 10–15 µm; **spores:** colourless, ovoid, 10–18 × 5–7 µm.

**Chemistry:** Thallus K–, C–, KC–, P–; no secondary metabolites in TLC.

**Ecology and distribution:** *Microhabitat occupied:* Terricolous; terricolous-rupicolous; muscicolous-rupicolous. In India, the species is commonly distributed in Himachal Pradesh and Uttarakhand, while species growing on soil is known from different localities of Uttarakhand. Outside India, the species is also reported from China.

**SPECIMENS EXAMINED: INDIA: UTTARAKHAND, BAGESHWAR DISTRICT, 5 km from Loharkhet-Dhakuri, alt. 2,591 m, on soil over stone, D. D. Awasthi 7578 C (LWG-AWAS); en route to Phurkiya to Mirtoli, alt. 3,414 m, on mossy soil in crevices of stones, D. D. Awasthi 7736 (LWG-AWAS); from Khati to Dwali en route to Pindari glacier, alt. 2,472 m, on soil, S. Joshi and Y. Joshi 07-008933 (LWG); RUDRAPRAYAG DISTRICT, Kedarnath, Hill surface on east and north of the temple, alt. 3,648 m, on boulder over soil, K. Dange 76.276 (LWG-LWU).**

**GYMNODERMA** Nyl. (*Cladoniaceae*)

Nylander, Syn. Lich. 2: 26. 1885.

**Thallus:** dimorphic; **squamules:** of primary thallus broadly fan-shaped, lacking rhizines, heteromerous, corticated on upper side only; **photobiont:** a green alga;

**secondary thallus:** podetial, podetia shortly stipitate, lacking photobiont. **Apothecia:** terminal, aggregated, biatorine; paraphyses branched; **asci:** similar to *Cladonia* in tip structure, 8-spored; **spores:** colourless, simple.

Out of the 3 species known from the world, 1 terricolous species is known from India.

*Gymnoderma coccocarpum* Nyl. (Fig. 2.45)

Nylander, Syn. Lich. 2: 27. 1885.

**Primary thallus:** orbicular; lobes fan-shaped, 4 cm long, 8 mm wide; **upper surface:** greenish grey; **podetia:** arising from margins of primary thallus. **Apothecia:** terminal, aggregated, brown to dark brown; **spore:** oblong-fusiform, 9–12 × 2.5–3.5 μm.

**Chemistry:** Thallus K<sup>-</sup>, C<sup>-</sup>, KC<sup>+</sup> rosy, Fe<sup>+</sup> purple, UV<sup>+</sup>, P<sup>-</sup>. An unknown substance present.

**Ecology and distribution:** *Microhabitat occupied:* Terricolous. In India, the species is distributed in Arunachal Pradesh, Sikkim and West Bengal hills. The species is also reported from China, Japan, Malaysia, the Philippines and Taiwan and restricted to Southeast Asia. Awasthi (2007) considered it to be extinct from its type locality because of lack of subsequent collections. However, Singh and Sinha (2010) reported specimens pertaining to this species were collected recently from Mehao Wildlife Sanctuary (Arunachal Pradesh) and Neora Valley National Park (West Bengal hills) by touring parties of Botanical Survey of India and thus confirming its occurrence in India.

**HEPPIA** Nägeli ex A. Massal. (*Lichinaceae*)

Geneac. Lich.: 6, 8. 1854.

**Thallus:** crustose to squamulose-foliose or fruticose with small tuberculate lobes, umbilicate or rhizinate; **photobiont:** a cyanobacterium *Scytonema*, either enclosed with in paraplectenchymatous tissue of mycobiont or in a layer. **Apothecia:** initially immersed, then sessile with distinct disc; **paraphyses:** simple; **asci:** 4–many-spored; **spores:** colourless, simple. **Pycnoconidia:** ellipsoid, straight.

Out of 40 species known from the world, 2 species are known from India, of which 1 is terricolous.

*Heppia lutosa* (Ach.)Nyl. (Fig. 2.17e; Fig. 2.45)

Nylander, Syn. Lich. 2: 45. 1885.

Basionym: *Collema lutosum* Ach., Syn. Lich.: 309. 1814.

**Thallus:** squamulose, up to 7 mm across; **squamules:** lobed, grey to olive-grey, closely adnate to the substratum, orbicular, rhizinate, lacking isidia and soredia; **photobiont:** blue-green alga, in a layer below cortex or dispersed throughout the thallus. **Apothecia:** 1 mm in diam. at maturity, circular, depressed to emergent; **disc:** orange-red to reddish brown; **hymenium:** hyaline to yellowish; **asci:** 8-spored, clavate; **spores:** hyaline, broadly ellipsoid, 10–15 × 6–10 μm.

**Chemistry:** K<sup>+</sup> yellow, C<sup>-</sup>, KC<sup>-</sup>, P<sup>-</sup>; no secondary metabolites in TLC.

**Ecology and distribution:** *Microhabitat occupied:* Terricolous. In India, the species is rarely distributed in Uttar Pradesh. It is the oldest lichen specimen collected during 1926 from Allahabad area of Uttar Pradesh by W. Dudgeon. Thereafter, it

has not been collected anywhere from India. The specimen preserved in herbarium is very fragile. The species is also reported from Europe.

**SPECIMEN EXAMINED:** **INDIA: UTTAR PRADESH, ALLAHABAD**, on soil, W. Dudgeon 729, 729 B (LWG).

**HETERODERMIA** Trevis. (*Physciaceae*)

Atti Soc. Ital. Sci. Nat. 11: 613. 1868 em. Poelt, Nova Hedwigia 9: 31. 1965.

**Thallus:** foliose, adnate, suberect, rosulate to pendulous, dichotomously or irregularly branched, heteromerous, corticated on both the surfaces or only on upper surface; **photobiont:** a green alga; **upper cortex:** uniformly or unevenly (flexuose on inner surface) thick; **lower surface:** corticated and rhizinate or ecorticated and then rhizines arising from usually corticated margins. **Apothecia:** laminal, sessile to pedicellate, lecanorine; **asci:** 8-spored; **spores:** 2-celled (loculed), thick-walled, *Pachysporaria*-type, with or without sporoblastidia. Atranorin always present in upper cortex.

Out of 93 species known from the world, 43 species are known from India, of which 11 are terricolous.

**Key to the terricolous species of *Heterodermia*:**

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1.	Thallus corticated on both upper and lower surfaces.....	2
1a.	Thallus corticated only on upper surface.....	6
2.	Thallus sorediate, soralia capitate and/or labriform on main or lateral lobes.....	<i>H. pseudospeciosa</i>
2a.	Thallus lacking soredia.....	3
3.	Medulla yellow-ochraceous, K+ purple, lobes up to 1 mm wide....	<i>H. firma</i>
3a.	Medulla white.....	4
4.	Medulla K+ red, P+ yellow.....	5
4a.	Medulla K+ yellow, P+ yellow or P-.....	<i>H. diademata</i>
5.	Lobes ca. 2 mm wide, not flexuose, medulla P+ yellow.....	<i>H. rubescens</i>
5a.	Lobes 0.5–1.5 mm wide, flexuose, medulla P+ deep yellow.....	<i>H. angustiloba</i>
6.	Thallus dichotomously branched, lobes uniformly narrow ribbon-like, medulla K+ red (salazinic acid), lobes rarely sorediate at apices.....	7
6a.	Thallus usually suborbicular, adnate to rosulate, apices often suberect.....	8
7.	Lobes circinate-revolute at apices, rarely sorediate along margins or on lower side.....	<i>H. boryi</i>
7a.	Lobes not circinate-revolute at apices.....	<i>H. leucomelos</i>
8.	Thallus esorediate, lobes with numerous small lobules along the margins.....	<i>H. microphylla</i>
8a.	Thallus sorediate.....	9
9.	Medulla K+ red, lateral lobules apically sorediate.....	<i>H. hypoaesia</i>
9a.	Medulla K+ yellow or purple.....	10
10.	Lower surface deep yellow to brownish yellow, soralia apical on lateral lobules or labriform on recurved apices.....	<i>H. obscurata</i>
10a.	Lower surface white at apices and purple in central part, soralia capitate on lateral lobules.....	<i>H. japonica</i>

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***Heterodermia angustiloba*** (Müll. Arg.) D. D. Awasthi (Fig. 2.17f; Fig. 2.45)

D. D. Awasthi, *Geophytology* 3: 113. 1973.

Basionym: *Anaptychia speciosa* var. *angustiloba* Müll. Arg., *Flora* 66: 78. 1883.

Synonym: *Anaptychia angustiloba* (Müll. Arg.) Kurok., *Beih. Nova Hedwigia* 6: 39. 1962.

**Thallus:** foliose, lobate; **lobes:** flexuose, up to 1.2 mm wide, corticated on both surfaces; **upper surface:** greyish, lacking soredia and isidia; **lower surface:** brownish, rhizinate; **medulla:** white. **Apothecia:** sessile, up to 2.5 mm in diam.; receptacle I+ violet; **spores:** 25–30 × 13–15 µm, lacking sporoblastidia.

**Chemistry:** Medulla K+ red, C–, P+ deep yellow. Zeorin, norstictic and salazinic acids, and an unknown substance present.

**Ecology and distribution:** *Microhabitat occupied:* Terricolous-rupicolous. In India, the species is widely distributed in Arunachal Pradesh, Himachal Pradesh, Karnataka, Maharashtra, Sikkim and Uttarakhand, while species growing on soil is reported from different localities of Uttarakhand. The species is also reported from Australia, China, Japan, Nepal and Taiwan.

**SPECIMENS EXAMINED: INDIA: UTTARAKHAND, CHAMOLI DISTRICT,** between Debal and Bagrigad, alt. 1,500 m, on soil over rock surface, Ajay Singh 91538 (LWG); **RUDRAPRAYAG DISTRICT,** between Madmaheshwar and Gondar, alt. 3,005 m, on soil over rock surface, A. Singh and M. Ranjan 107059 (LWG).

***Heterodermia boryi*** (Fée) Kr. P. Singh and S. R. Singh (Fig. 2.17g; Fig. 2.45)

Kr. P. Singh and S. R. Singh, *Geophytology* 6: 33. 1976.

Basionym: *Borrera boryi* Fée, *Essai Crypt. Ecorc.*: 92, tab. II, Figure 23. 1824.

Synonyms: *Heterodermia leucomela* subsp. *boryi* (Fée) Swinscow and Krog, *Lichenologist* 8: 124. 1976. *Anaptychia neoleucomelaena* Kurok., *J. Jap. Bot.* 36: 51. 1961.

**Thallus:** loosely attached, erect or pendulous, up to 15 cm or more long, dichotomously branched; **lobes:** linear, uniformly to 1.5 mm wide, greyish to partly blackish; **apices:** circinately revolute; corticated only on upper surface; **lower surface:** ± canaliculate, with long, black rhizines along margins, rarely sorediate. **Apothecia:** subpedicellate, to 5 mm in diam.; **margin:** lacinulate, black ciliate; cortex of receptacle I–; **spores:** (36–)40–50 × (16–)20–24 µm, with several sporoblastidia in each locule.

**Chemistry:** Medulla K+ yellow, C–, P+ yellowish. Zeorin present.

**Ecology and distribution:** *Microhabitat occupied:* Terricolous-rupicolous. In India, the species is widely distributed in Jammu and Kashmir, Kerala, Maharashtra, Nagaland, Sikkim, Tamil Nadu and Uttarakhand, while species growing on soil is reported from single locality of Uttarakhand. The species is widely distributed in tropical and temperate regions of the world.

**SPECIMEN EXAMINED: INDIA: UTTARAKHAND, UTTARKASHI DISTRICT,** on way to Gangotri below Baisaran ghati, near Nilong river bridge, alt. 8,500 ft., on soil over boulders, D. D. Awasthi and S. R. Singh 8122 (LWG-AWAS).

***Heterodermia diademata*** (Taylor) D. D. Awasthi (Fig. 2.17h; Fig. 2.45)

D. D. Awasthi, *Geophytology* 3: 133. 1973.

Basionym: *Parnelia diademata* Taylor, *London J. Bot.* 6: 165. 1847.

Synonyms: *Anaptychia diademata* (Taylor) Kurok., *Beih. Nova Hedwigia* 6: 28. 1962. *Physcia speciosa* var. *cinerascens* f. *brachyloba* Müll. Arg., *Flora* 73: 340. 1890.

**Thallus:** foliose, up to 15 cm across, branched; **lobes:** linear, up to 2.5 mm wide, rarely secondary lobules in central part, corticated on both surfaces; **upper surface:** grey to grey-white, lacking isidia and soredia; **lower surface:** pale brown with concolorous, sparse rhizines. **Apothecia:** usually numerous, to 7 mm in diam., cortex of receptacle I-; **spores:** (16-)22-32(-40) × 10-18 µm, lacking sporoblastidia.

**Chemistry:** Medulla K+ yellow, C-, P+ pale yellow or P-. Zeorin present.

**Ecology and distribution:** *Microhabitat occupied:* Terricolous; terricolous-rupicolous; muscicolous-terricolous. In India, the species is widely distributed in Arunachal Pradesh, Assam, Himachal Pradesh, Jammu and Kashmir, Karnataka, Kerala, Madhya Pradesh, Maharashtra, Manipur, Meghalaya, Nagaland, Rajasthan, Sikkim, Tamil Nadu, Uttarakhand and West Bengal hills, while species growing on soil is reported from different localities of Himachal Pradesh, Sikkim, Uttarakhand and West Bengal hills. The species is also reported from Bhutan, China, Japan, Nepal, Sri Lanka and Taiwan; Africa, Central and South America.

**SPECIMENS EXAMINED: INDIA: HIMACHAL PRADESH, KANGRA DISTRICT,** Palampur, Bagh Nala, alt. 2,000 m, on soil over rocks, D. K. Upreti 213642 (LWG); **SIKKIM, NORTH SIKKIM,** Tingrong, alt. 1,800 m, on soil over rocks, Arvind Saklani s.n. (LWG); **UTTARAKHAND, BAGESHWAR DISTRICT,** Almora Taluka (en route to Pindari glacier), alt. 1,829 m, on soil, D. D. Awasthi and A. M Awasthi 552 (LWG-AWAS); **CHAMOLI DISTRICT,** Govind Ghat, alt. 1,800 m, on rock surface over soil, Ajay Singh, 86965 (LWG); between Gondar and Lank, alt. 1,550 m, on rock over soil, A. Singh and M. Ranjan, 107065 (LWG); **PITHORAGARH DISTRICT,** Sandev Botanical Hotspot, Deochula, Pamtori, alt. 1,400 m, on soil, Vikas Pant 02000919 (LWG); Dharchula, Sobhla, opposite mountain of the village Vatan, alt. 2,000 m, on soil over rocks, Upreti and Hariharan 202032 (LWG); **UTTARKASHI DISTRICT,** on way to Gangotri between Bhatwari and Gangnani, alt. 1,703 m, on soil over rock, Ajay Singh, 97095 (LWG); Phool Chetti and Narad Chetti, alt. 1,280 m, on rock over soil, A. Singh and Ram Pher, 77551 (LWG); **WEST BENGAL, DARJEELING,** Sandakhpoo, alt. 3,658 m, on ground with mosses and grasses, D. D. Awasthi and A. M. Awasthi 67.405 (LWG-LWU); Kalimpong, on soil over rock surface, Ajay Singh 54502 (LWG); Tonglu, alt. 3,225 m, on soil-covered rocks, P. D. Dogra 54563 (LWG).

***Heterodermia firmula*** (Nyl.) Trevis. (Fig. 2.17i; Fig. 2.45)

Trevisan, *Atti Soc. Ital. Nat.* 11: 615. 1868.

Basionym: *Physcia firmula* Nylander, *Syn. Lich.* 1(2): 418. 1860.

Synonym: *Anaptychia firmula* (Nyl.) C. W. Dodge and D. D. Awasthi, *J. Indian Bot. Soc.* 39: 423. 1960.

**Thallus:** foliose, closely adnate, to 5 cm across, branched; **lobes:** 1(-2) mm wide, corticated on both surfaces; **upper surface:** grey to sordid grey, lacking isidia and soredia; **medulla:** yellow to croceous; **lower surface:** with rhizines. **Apothecia:** 2(-4) mm in diam.; cortex of receptacle I+ violet; **spores:** (20-)24-28(-30) × 11-14 µm.

**Chemistry:** Medulla K<sup>+</sup> purple, C<sup>-</sup>, P<sup>+</sup> deeper yellow. Zeorin and unknown substance present.

**Ecology and distribution:** *Microhabitat occupied:* Terricolous-rupicolous. In India, the species is widely distributed in Arunachal Pradesh, Himachal Pradesh, Madhya Pradesh, Manipur, Meghalaya, Nagaland, Sikkim, Uttarakhand and West Bengal hills, while species growing on soil is reported from different localities of Uttarakhand. The species is also reported from China and Nepal.

**SPECIMENS EXAMINED: INDIA: UTTARAKHAND, RUDRAPRAYAG DISTRICT,** Guptakashi, alt. 1,300 m, on rock surface over soil, A. Singh and M. Ranjan 106819 (LWG); between Kalimath and Laink, alt. 1,360 m, on rock surface over soil, A. Singh and M. Ranjan 106896 (LWG).

***Heterodermia hypocaesia*** (Yasuda) D. D. Awasthi (Fig. 2.18a; Fig. 2.45)

D. Awasthi, *Geophytology* 3: 113. 1973.

Basionym: *Anaptychia hypocaesia* Yasuda in Räsänen, *J. Jap. Bot.* 16: 139. 1940.

**Thallus:** foliose, up to 7 cm across, branched; **lobes:** up to 3 mm wide, corticated on upper surface only; **upper surface:** greyish white with lateral lobes apically sorediate; **lower surface:** white to ochraceous towards apices; **margin:** with black rhizines. **Apothecia:** not observed.

**Chemistry:** Medulla K<sup>+</sup> yellow turning red, C<sup>-</sup>, P<sup>+</sup> yellow. Zeorin and salazinic acid present.

**Ecology and distribution:** *Microhabitat occupied:* Terricolous; terricolous-rupicolous; muscicolous-terricolous; detriticolous-terricolous. In India, the species is widely distributed in Himachal Pradesh, Kerala, Madhya Pradesh, Manipur, Nagaland, Sikkim, Tamil Nadu, Uttarakhand and West Bengal hills while species growing on soil is reported from different localities of Uttarakhand. The species is also reported from Australia, China, Hawaii, Japan, Indonesia and the Philippines; Africa.

**SPECIMENS EXAMINED: INDIA: UTTARAKHAND, BAGESHWAR DISTRICT,** en route to Pindari glacier from Dwali to Phurkiya, alt. 2,972 m, on soil, S. Joshi and Y. Joshi 07-008843 (LWG); **RUDRAPRAYAG DISTRICT,** Chopta, alt. 3,000 m, on soil over rocks with decaying mosses, Himanshu Rai and Pramod Nag 08-0012223, 08-0012232 (LWG); Chopta, alt. 3,000 m, on soil over rock, Himanshu Rai and Pramod Nag 08-0012226 (LWG).

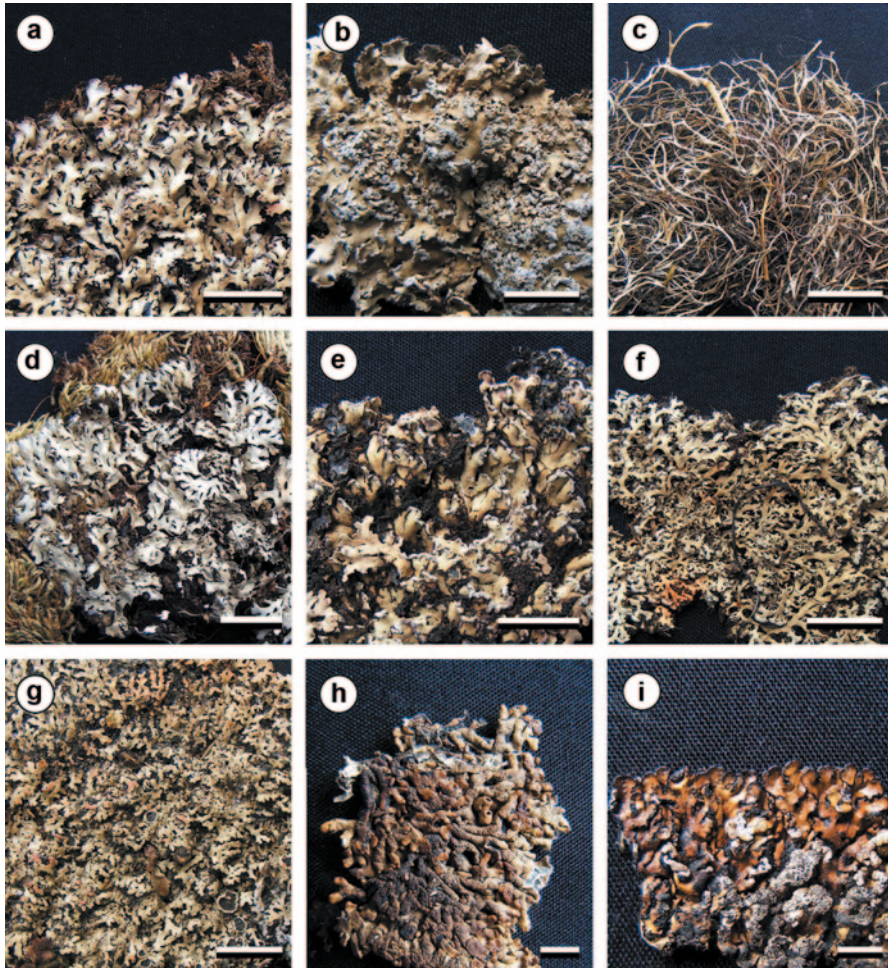
***Heterodermia japonica*** (M. Satô) Swinscow and Krog (Fig. 2.18b; Fig. 2.45)

Swinscow and Krog, *Lichenologist* 8: 122. 1976.

Basionym: *Anaptychia dendritica* var. *japonica* M. Satô, *J. Jap. Bot.* 12: 427. 1936.

Synonym: *Anaptychia japonica* (M. Satô) Kurok., *J. Jap. Bot.* 35: 353. 1960; and Kurokawa 1962: 58. *Heterodermia japonica* var. *reagens* (Kurok.) Swinscow and Krog, *Lichenologist* 8: 122. 1976.

**Thallus:** foliose, up to 15 cm across, branched; **lobes:** to 2 mm wide, corticated on upper surface only; **upper surface:** greyish white, sorediate on ends of short lateral lobules; **lower surface:** white with marginal rhizines. **Apothecia:** rare, substipitate, to 8 mm in diam., margin with lacinules; **spores:** 30–46 × 15–20 μm, with 2–3 sporoblastidia in each locule at maturity.



**Fig. 2.18** **a** *Heterodermia hypocaustia* (Yasuda) D. D. Awasthi, **b** *H. japonica* (M. Satô) Swinscow and Krog, **c** *H. leucomelos* (L.) Poelt, **d** *H. microphylla* (Kurok.) Skorepa, **e** *H. obscurata* (Nyl.) Trevis., **f** *H. pseudospeciosa* (Kurok.) W. L. Culb., **g** *H. rubescens* (Räsänen) D. D. Awasthi, **h** *Hypogymnia alpina* D. D. Awasthi, **i** *H. bitteri* (Lynge) Ahti. Scale in **h**, **i**=5 mm; in **a**, **b**, **c**, **d**, **e**, **f**, **g**=10 mm

**Chemistry:** Medulla K+ yellow, C-, P+ pale yellow or P-. Zeorin present.

**Ecology and distribution:** *Microhabitat occupied:* Terricolous-rupicolous; muscicolous-terricolous; muscicolous-rupicolous. In India, the species is widely distributed in Karnataka, Madhya Pradesh, Manipur, Sikkim, Tamil Nadu, Uttarakhand and West Bengal hills, while species growing on soil is reported from different localities of Uttarakhand. The species is cosmopolitan in distribution and reported from Bhutan, Canary Islands, China, Great Britain, Indonesia, Japan, New Zealand, Panama, Taiwan and Thailand.

**SPECIMENS EXAMINED: INDIA: HIMACHAL PRADESH, KULLU DISTRICT**, en route to Jalori lake, alt. 3,165 m, on soil among mosses, D. K. Upreti and Y. Joshi s.n. (LWG); **UTTARAKHAND, CHAMOLI DISTRICT**, Ali Bugyal to Wan, alt. 2,850 m, on moss-covered soil over rock, Ajay Singh, 90398 (LWG); **UTTARKASHI DISTRICT**, Gangotri towards Kedartal, alt. 3,100 m, on rocks over soil, S. Chatterjee and P. K. Diwakar, 02-000403 B (LWG).

***Heterodermia leucomelos* (L.) Poelt** (Fig. 2.18c; Fig. 2.45)

Poelt, *Nova Hedwigia* 9: 31. 1965.

Basionym: *Lichen leucomelos* L. Sp. Pl. ed. 2, 2: 1613. 1763.

Synonyms: *Anaptychia leucomelos* (L.) A. Massal., Mem. Lichenogr.: 35. 1853.

*Anaptychia leucomelos* (L.) Kurokawa, Beih. *Nova Hedwigia* 6: 74. 1962.

**Thallus:** foliose, loosely attached, dichotomously branched, ascending or pendulous, often covering large areas; **lobes:** 1.5 mm wide, tapering at apices, corticated on upper surface only; **upper surface:** greyish to darker, occasionally soreidiate at apices; **lower surface:** somewhat canaliculate, white to brownish; rhizines marginal, long, branched, black. **Apothecia:** rare, up to 5 mm in diam.; **disc:** pruinose; margin lacinulate; **spores:** 31–45(–52) × 17–25 μm with several sporoblastidia in each locule.

**Chemistry:** Medulla K<sup>+</sup> yellow turning red, C<sup>-</sup>, P<sup>+</sup> yellow. Zeorin, norstictic, salazinic acids, unknown pigments and triterpenoids present.

**Ecology and distribution:** *Microhabitat occupied:* Terricolous; terricolous-rupicolous; muscicolous-terricolous. In India, the species is widely distributed in Arunachal Pradesh, Himachal Pradesh, Karnataka, Kerala, Nagaland, Sikkim, Tamil Nadu and West Bengal hills, while species growing on soil is reported from different localities of Himachal Pradesh, Karnataka, Sikkim, Tamil Nadu, Uttarakhand and West Bengal hills. The species is cosmopolitan in distribution and also reported from Bhutan, Nepal and Sri Lanka; Africa, Europe, Central and South America.

**SPECIMENS EXAMINED: INDIA: HIMACHAL PRADESH, KULLU DISTRICT**, en route to Jalori lake, alt. 3,145 m, on soil, D. K. Upreti and Y. Joshi 08-006981 (LWG); **KARNATAKA**, Agumbe, Mysore, alt. 1,500 m, on soil, P. Chandra 54634 (LWG); **SIKKIM, NORTH SIKKIM**, Gangtok, Hanumantok, alt. 1,700 m, on soil over rock, Chatterjee and Divakara 20-67214 (LWG); 2 km before Shingbo Rhododendron Sanctuary, alt. 3,300 m, on soil, D. K. Upreti, S. Chatterjee, P. K. Divakar 04-004070 (LWG); **EAST SIKKIM**, Tumin area, alt. 2,000 m, on soil along roadside, Upreti and Chatterjee 01-67252 (LWG); **TAMIL NADU, NILGIRI HILLS**, Karagudy 40 miles from Ootakamund, on soil along with moss, A. Singh and party 40189 (LWG); **DINDIGUL, PALNI HILLS**, Berijam, alt. 2,438 m, on ground, D. D. Awasthi and K. P. Singh 70.334 (LWG-AWAS); **UTTARAKHAND, BAGESHWAR DISTRICT**, near Dhakuri ridge, alt. 2,591 m, on ground and shrub, D. D. Awasthi 7604 (LWG-AWAS); **CHAMOLI DISTRICT**, on way to Vasudhara, Badrinath area, alt. 3,340 m, on soil over rocks, D. K. Upreti and S. Nayaka, 07-010150 (LWG); **PITHORAGARH DISTRICT**, Lilam to Bogudiyar (Rargariudiyar) en route to Milam glacier, alt. 2,400 m, on soil over rock, S. Joshi 07-010374 (LWG); **UTTARKASHI DISTRICT**, between Phool chetti and Narad chetti, on rock over soil, A. Singh and Ram Pher, 77528 (LWG); **WEST BENGAL, DARJEELING**, Senchal, alt. 2,438 m, pendulous on ground by roadside, D. D. Awasthi 3897(LWG-AWAS).

***Heterodermia microphylla* (Kurok.) Skorepa** (Fig. 2.18d; Fig. 2.45)

Skorepa, *Bryologist* 75: 490. 1972.

Basionym: *Anaptychia hypoleuca* var. *microphylla* Kurok., J. Jap. Bot. 34: 123. 1959.

Synonym: *Anaptychia microphylla* (Kurok.) Kurok., Beih. Nova Hedwigia 6: 44. 1962.

**Thallus:** foliose, lobes to 1.5 mm wide, densely lobulate along margins, corticated on upper surface only; **upper surface:** greyish brown, lacking isidia and soredia. **Apothecia:** not observed.

**Chemistry:** Medulla K+ yellow, C-, P-. Zeorin present.

**Ecology and distribution:** *Microhabitat occupied:* Terricolous-rupicolous. In India, the species is widely distributed in Sikkim and Uttarakhand, while species growing on soil is reported from single locality of Uttarakhand. The species is also reported from Australia, Bhutan, China, Japan, New Zealand, Papua New Guinea, Taiwan, Thailand and Zimbabwe; North America.

**SPECIMEN EXAMINED: INDIA: UTTARAKHAND, UTTARKASHI DISTRICT,** Gangotri towards Kedartal, alt. 3,100 m, on rocks over soil, S. Chatterjee and P. K. Diwakar, 02-000405 A (LWG).

***Heterodermia obscurata*** (Nyl.) Trevis. (Fig. 2.18e; Fig. 2.45)

Trevisan, Nuovo Giorn. Bot. Ital. 1: 114. 1869.

Basionym: *Physcia obscurata* Nyl., Ann. Sci. Nat. Bot., ser. 4, 19: 310. 1863.

Synonyms: *Anaptychia obscurata* (Nyl.) Vain., Acta Soc. Fauna Fl. Fenn. 7:137. 1890. -*Anaptychia speciosa* var. *hypoleuca* f. *sorediifera* (Müll. Arg.) Zahlbr., Cat. Lich. Univ. 7: 741. 1931. -*Pseudophyscia speciosa* var. *hypoleuca* f. *sorediifera* (Müll. Arg.) Müll. Arg., Bull. Soc. Bot. Belgique 32: 129. 1893.

**Thallus:** foliose, up to 15 cm across, branched; lobes up to 2 mm wide, with short lateral lobules; corticated on upper surface only; **upper surface:** greyish to darker; lobules sorediate at apices or apices recurved, labriform soraliolate; **lower surface:** deep yellow to ochraceous brown with marginal rhizines. **Apothecia:** rare, substipitate, up to 5 mm in diam.; **spores:** 25–35 × 15–19 µm, with 1–3 sporoblastidia in each locule.

**Chemistry:** Medulla K+ yellow or purple, C-, P+ pale yellow or P-. Zeorin and unknown pigment present.

**Ecology and distribution:** *Microhabitat occupied:* Terricolous-rupicolous. In India, the species is widely distributed in Arunachal Pradesh, Himachal Pradesh, Jammu and Kashmir, Kerala, Maharashtra, Manipur, Nagaland, Sikkim, Tamil Nadu, Uttarakhand and West Bengal hills, while species growing on soil is known from single locality of Uttarakhand. The species is cosmopolitan in distribution and reported from Bhutan, China, Japan, Nepal, New Zealand, the Philippines and Thailand; Africa, North, Central and South America.

**SPECIMEN EXAMINED: INDIA: UTTARAKHAND, RUDRAPRAYAG DISTRICT,** Tungnath Bugyal, alt. 3,400 m, on soil over rock in open grassland, Himanshu Rai and Pramod Nag 08-0012244 (LWG).

***Heterodermia pseudospeciosa*** (Kurok.) W. L. Culb. (Fig. 2.18f; Fig. 2.45)

W. Culberson, Bryologist 69: 484. 1966.

Basionym: *Anaptychia pseudospeciosa* Kurok., J. Jap. Bot. 34: 176. 1959.

Synonym: *Heterodermia speciosa* sensu auct. Ind. -*Anaptychia speciosa* sensu D. D. Awasthi, Beih. Nova Hedwigia 17: 21. 1965.

**Thallus:** foliose, rosettiform, up to 5 cm across, branched; **lobes:** short, flexuose, up to 1.5 mm wide, corticated on both surfaces; **upper surface:** greyish white; **sorediate:** on apices of lobules; **lower surface:** white to dark, with sparse rhizines. **Apothecia:** not seen.

**Chemistry:** Medulla K+ yellow turning red, C-, P+ yellow. Zeorin, norstictic and salazinic acids present.

**Ecology and distribution:** *Microhabitat occupied:* Terricolous-rupicolous; muscicolous-rupicolous. In India, the species is widely distributed in Arunachal Pradesh, Himachal Pradesh, Kerala, Madhya Pradesh, Maharashtra, Manipur, Nagaland, Sikkim, Tamil Nadu, Uttarakhand and West Bengal hills while species growing on soil is known from different localities of Uttarakhand. The species is also reported from China, Japan, Nepal, Taiwan; Africa, Central and South America.

**SPECIMENS EXAMINED: INDIA: UTTARAKHAND, PAURI-GARHWAL DISTRICT,** Pauri, alt. 1,800 m, on soil over rock surface, s.n. (LWG); Khirsu, Khirsu reserve forest, alt. 1,871 m, on soil over rock with mosses, Himanshu Rai 11-0014559 (LWG); **UTTARKASHI DISTRICT,** Phool Chetti and Narad Chetti, alt. 1,280 m, on rock over soil, A. Singh and Ram Pher 77531 (LWG); Sayana Chetti, alt. 2,200 m, on rock over soil, Ram Pher 76016 (LWG).

***Heterodermia rubescens*** (Räsänen) D. D. Awasthi (Fig. 2.18g; Fig. 2.46)

D. D. Awasthi, *Geophytology* 3: 114. 1973.

Basionym: *Anaptychia hypoleuca* f. *rubescens* Räsänen, *Arch. Soc. Zool. Bot. Fenn.* 'Vanamo' 39: 423.1950.

Synonyms: *Anaptychia esorediata* f. *rubescens* (Räsänen) D. D. Awasthi, *J. Indian Bot. Soc.* 39: 423. 1960. *Anaptychia rubescens* (Räsänen) Kurok., *Beih. Nova Hedwigia* 6: 31. 1962.

**Thallus:** foliose, up to 15 cm across, branched, lobes up to 2 mm wide, corticated on both surfaces; **upper surface:** greyish white to sometimes red coloured, lacking isidia and soredia; **lower surface:** white to brown with concolorous rhizines. **Apothecia:** substipitate, to 5 mm in diam., with crenate lacinate margin; cortex of receptacle I+ violet; **spores:** 23–30 × 11–14 μm, lacking sporoblastidia.

**Chemistry:** Medulla K+ yellow turning red, C-, P+ yellow. Zeorin, norstictic and salazinic acids present.

**Ecology and distribution:** *Microhabitat occupied:* Terricolous; muscicolous-terricolous. In India, the species is widely distributed in Arunachal Pradesh, Himachal Pradesh, Manipur, Meghalaya, Nagaland, Rajasthan, Sikkim, Uttarakhand and West Bengal hills, while species growing on soil is known from different localities of Uttarakhand. The species is also reported from China, Nepal and Taiwan.

**SPECIMENS EXAMINED: INDIA: UTTARAKHAND, BAGESHWAR DISTRICT,** Taluka (en route to Pindari glacier), alt. 1,829 m, on soil, D. D. Awasthi and A. M. Awasthi 552 A (LWG-AWAS); **DEHRADUN DISTRICT,** Mussoorie, alt. 2,134 m, on ground over mosses, Hiralal 462 (LWG-AWAS).

**HYPOGYMNIA** (Nyl.) Nyl. (*Parmeliaceae*)

Nylander, *Lich. Env. Paris*: 39. 1896.

**Thallus:** foliose, lobate or lacinate, dichotomously or irregularly branched; **upper surface:** yellow, yellow-grey to brownish; **lower surface:** blackish, erhizinate,

usually perforated at apices and axils, rarely perforations absent. Thallus heteromorous, corticated on both surfaces; **photobiont**: a green alga; **medulla**: generally hollow, rarely solid. **Apothecia**: lecanorine; **hypothecium**: colourless; **asci**: 8-spored; **spores**: colourless, simple. **Pycnoconidia**: bifusiform, 5–8 µm long.

Out of 15 species known from the world, 17 are from India, of which 4 are terricolous.

#### Key to the terricolous species of *Hypogymnia*:

1.	Thallus sorediate .....	2
1a.	Thallus not sorediate .....	3
2.	Soralia apical, medulla P <sup>-</sup> , laciniae with distinct black margin and with adventitive branchlets .....	<i>H. vittata</i>
2a.	Soralia partly or wholly terminal, often on small upturned surface lobes .....	<i>H. bitteri</i>
3.	Thallus yellow or dark yellow, lobes 4–6 mm wide, apices round, physodalic and usnic acids present.....	<i>H. hypotrypa</i>
3a.	Thallus grey-brown, or of various colours, lobes broad or narrow, upper cortex readily solarized to dark brown or blackish.....	<i>H. alpina</i>

#### *Hypogymnia alpina* D. D. Awasthi (Fig. 2.18h; Fig. 2.46)

D. Awasthi, Kavaka 12(2): 91. 1984..

**Thallus**: loose appressed, adnate, branched; **lobes**: up to 1.5 mm wide, separate, apically somewhat swollen; **upper surface**: grey-brown to blackish, lacking isidia and soredia; **lower surface**: perforated; outline of lobes ellipsoid in cross section; **medulla**: hollow. **Apothecia**: goblet-shaped, 2 mm in diam.; **spores**: 5–10 × 4–6 µm.

**Chemistry**: Upper cortex K<sup>+</sup> yellowish; medulla K<sup>-</sup>, C<sup>-</sup>, KC<sup>-</sup>, P<sup>+</sup> orange. Atranorin and chloroatranorin in cortex; physodalic, physodic, protocetraric, oxyphysodic and traces of virensic acids and unknown substances in medulla.

**Ecology and distribution**: *Microhabitat occupied*: Muscicolous-terricolous. In India, the species is widely distributed from Western to Eastern Himalayas (McCune et al. 2012), while species growing on soil is reported from single locality of Arunachal Pradesh. The species is also reported from Nepal, Sichuan, Tibet and Yunan.

**SPECIMEN EXAMINED**: INDIA: ARUNACHAL PRADESH, WEST KAMENG DISTRICT, Sela pass, alt. 4,176 m, on soil over mosses, Upreti, Dubey, Khare and Mishra 08-009395 (LWG).

#### *Hypogymnia bitteri* (Lynge) Ahti (Fig. 2.18i; Fig. 2.46)

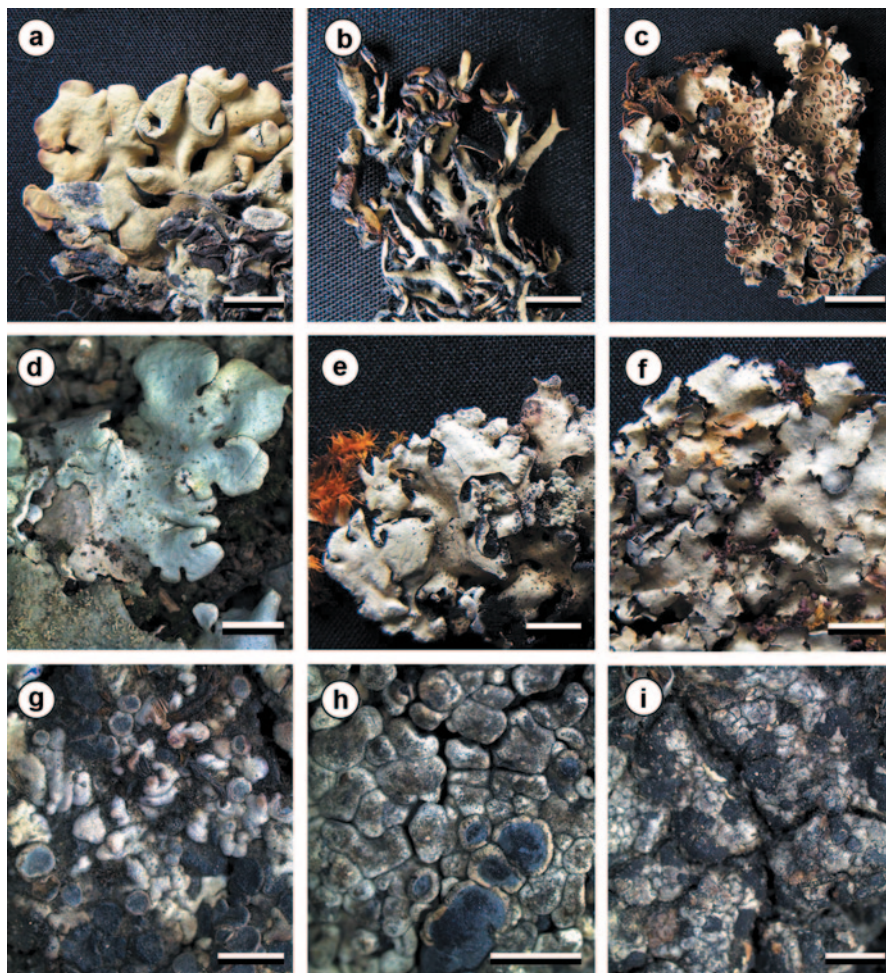
Ahti, Ann. Bot.Fenn. 1: 20. 1964.

Basionym: *Parmelia bitteri* Lynge, Stud. Lich. Flora Norway, p. 138. 1921.

**Thallus**: forming rosettes; **lobes**: contiguous, appressed solarizing to brown; **upper surface**: dark brown, shiny, sorediate; **soralia**: partly or wholly terminal, on short narrow upturned lateral lobes and often with small hole in the lobe tips; **lower surface**: black and perforated. **Apothecia**: absent.

**Chemistry**: Cortex: K<sup>-</sup>; medulla: K<sup>+</sup> slow red-brown or K<sup>-</sup>, C<sup>-</sup>, KC<sup>+</sup> orange red, P<sup>-</sup>. Atranorin, physodic acid and accessory 3-hydroxyphysodic, 2'-O- methylphysodic and vittatolic acids (McCune et al. 2012).





**Fig. 2.19** **a** *Hypogymnia hypotrypa* (Nyl.) Rassad., **b** *H. vittata* (Ach.) Gasilien., **c** *Hypotrachyna adducta* (Nyl.) Hale, **d** *H. crenata* (Kurok.) Hale, **e** *H. exsecta* (Taylor) Hale, **f** *H. scytophylla* (Kurok.) Hale, **g** *Lecanora chondroderma* Zahlbr., **h** *L. himalayae* Poelt, **i** *Lecidoma demissum* (Rutström) G. Schneider and Hertel. Scale in **d, g, h, i**=2 mm; in **a, b, e, f**=5 mm; in **c**=10 mm

**Ecology and distribution:** *Microhabitat occupied:* Terricolous. In India, the species growing on soil exhibits restricted distribution to Eastern Himalaya and is known only from single locality of Sikkim. Widespread in distribution but rare in high mountains of Southern Asia, more common northward in Asia, Europe and North America (McCune et al. 2012).

**SPECIMEN EXAMINED:** **INDIA:** **SIKKIM, NORTH SIKKIM,** Kalep before Thangu, alt. 3,900 m, on soil, D. K. Upreti, S. Chatterjee and P. K. Divakar 04-003849 (LWG).

***Hypogymnia hypotrypa*** (Nyl.) Rassad. (Fig. 2.19; Fig. 2.46)

Rassadina, Notul. Syst. Sect. Crypt. Inst. Bot. Komarovii Acad. Sci. URSS 4: 297. 1967.

Basionym: *Parmelia hypotrypa* Nyl., Syn. Lich. 1:403. 1860.

**Thallus:** distinctly dichotomously branched; **lobes:** (3–)4–6 mm wide, lacking adventitive branchlets, lobe outline ellipsoid in cross section; **upper surface:** yellow, yellow-grey to yellowish brown, lacking isidia and soredia; **lower surface:** perforated, perforations 3–4 mm in diam. **Apothecia:** absent.

**Chemistry:** Upper cortex K–; medulla K–, C–, KC–, P+ orange. Usnic acid in cortex; physodalic and protocetraric acids in medulla.

**Ecology and distribution:** *Microhabitat occupied:* Terricolous. In India, the species is widely distributed in Sikkim and Uttarakhand while species growing on soil is known from single locality of Sikkim. The species is also reported from Bhutan, China, Japan, Korea, Nepal, Russia and Taiwan.

**SPECIMEN EXAMINED:** INDIA: SIKKIM, NORTH SIKKIM, Yangdi, above Thangu, alt. 4,250 m, on soil, D. K. Upreti, S. Chatterjee and P. K. Divakar 04-003982 (LWG).

***Hypogymnia vittata*** (Ach.) Parrique. (Fig. 2.19b; Fig. 2.46)

Gasilien, Acta Soc. Linn. Bordeaux 53: 66. 1898.

Basionym: *Parmelia physodes* var. *vittata* Ach., Methodus: 251. 1803.

Synonym: *Parmelia vittata* (Ach.) Nyl., Meddel. Sällsk. Fauna Fl. Fenn. 1: 17. 1876.

**Thallus:** lax, branched; **lobes:** up to 4 cm long and 2 mm wide, attenuated at apices; adventitive branchlets usually present; **upper surface:** yellowish brown to pale brown; lateral margins black due to extension of lower surface, usually apically labrose-sorediate, rarely esorediate; **lower surface:** perforated; lobe outline pouch-shaped in cross section. **Apothecia:** absent.

**Chemistry:** Upper cortex K+ yellow; medulla K–, C–, KC+ faint reddish, P–. Atranorin in cortex; physodic acid and an unknown substance in medulla.

**Ecology and distribution:** *Microhabitat occupied:* Terricolous. In India, the species is widely distributed in Himachal Pradesh, Jammu and Kashmir, Nagaland, Sikkim and West Bengal hills, while species growing on soil is known from different localities of Sikkim. The species is also reported from Bhutan, China, Japan, Nepal; Europe, North America.

**SPECIMENS EXAMINED:** INDIA: SIKKIM, NORTH SIKKIM, Kalep before Thangu, alt. 3,900 m, on soil, D. K. Upreti, S. Chatterjee and P. K. Divakar 04-003881 (LWG); Near Yumthang, alt. 3,800 m, on soil D. K. Upreti, S. Chatterjee and P. K. Divakar 04-004148 (LWG).

**HYPOTRACHYNA** (Vain.) Hale (*Parmeliaceae*)

Hale, Phytologia 28: 340. 1974.

**Thallus:** foliose, adnate, subdichotomously or irregularly sinuate-lobate; lobes linear to sublinear; margin usually eciliate, rarely ciliate; **upper surface:** grey to yellow-green, with or without isidia, soredia and pustules; **lower surface:** black, rhizinate throughout; **rhizines:** dichotomously branched, rarely furcate. **Apothecia:** laminal, imperforate; **asci:** 8-spored; **spores:** colourless, simple. Atranorin is present in the upper cortex.

Out of 198 species known from the world, 38 species are known from India, of which 4 are terricolous.

**Key to the terricolous species of *Hypotrachyna*:**

1.	Thallus isidiate or sorediate .....	2
1a.	Thallus lacking isidia or soredia .....	3
2.	Thallus isidiate, isidia simple or branched, lobes margin crenate, medulla P+ orange or red .....	<i>H. crenata</i>
2a.	Thallus sorediate, soredia postulate-sorediate at apices, medulla P-, C-, KC+ red.....	<i>H. exsecta</i>
3.	Medulla P+ orange, lobes soft, protocetraric acid present.....	<i>H. adducta</i>
3a.	Medulla P-, C+ rose-red, lobes black-rimmed.....	<i>H. scytophylla</i>

***Hypotrachyna adducta* (Nyl.) Hale (Fig. 2.19; Fig. 2.46)**

Hale, Phytologia 28: 340. 1974.

Basionym: *Parmelia adducta* Nyl., Flora 68: 610. 1885.

**Thallus:** coriaceous, foliose, loosely adnate to the substratum, irregularly sinuate lobes, up to 4 cm across; **lobes:** short, 3(-4) mm wide, margins eciliate, apices rounded to notched; **upper surface:** ashy grey, smooth, emaculate; **medulla:** white; **lower surface:** black, densely rhizinate; **rhizines:** simple, dichotomously branched rhizines. **Apothecia:** numerous, often crowded, sessile, cupuliform, to 2 mm in diam., constricted at base; **disc:** brown, concave; **asci:** clavate, 8-spored; **spores:** colourless, simple, oval-ellipsoid, 18-25 × 11-13 μm with an epispore.

**Chemistry:** Medulla K-, C-, KC-, P+ red. Atranorin, protocetraric acid and an unknown substance present.

**Ecology and distribution:** *Microhabitat occupied:* Terricolous. In India, the species is widely distributed in Arunachal Pradesh, Assam, Manipur, Nagaland, Sikkim and West Bengal hills while species growing on soil is known from single locality of Uttarakhand. Outside India, the species is also reported from Japan, the Philippines, Nepal, Papua New Guinea, Taiwan, Thailand and China.

**SPECIMEN EXAMINED: INDIA: UTTARAKHAND, UTTARKASHI DISTRICT,** Gangotri, alt. 3,137 m, on soil, Himanshu Rai and Pramod Nag 10-0014522 (LWG).

***Hypotrachyna crenata* (Kurok.) Hale (Fig. 2.19d; Fig. 2.46)**

Hale, Phytologia 28: 34. 1974.

Basionym: *Parmelia crenata* Kurok. in Hale and Kurok., Contr. U.S. Natl. Herb. 36: 168. 1964.

**Thallus:** foliose, loosely adnate, to 5 cm across; **lobes:** subirregular, to 4 mm wide, subrotund with crenate margins; **upper surface:** pale grey, smooth, emaculate, isidiate; **isidia:** moderately present on lobes, short, filiform, simple to branched; **medulla:** white; **lower surface:** blackish with sparse, pale brown, papillate peripheral zone, rhizinate; **rhizines:** dichotomously branched, black. **Apothecia:** rare, up to 4 mm in diam.; **spores:** 9-11 × 6-9 μm.

**Chemistry:** Cortex K+ yellow; medulla K+ yellow or yellow turning red, C-, KC-, P+ pale orange. Atranorin, stictic acid with or without constictic and norstictic acid present.

**Ecology and distribution:** *Microhabitat occupied:* Terricolous. In India, the species is widely distributed in Himachal Pradesh, Karnataka, Kerala, Maharashtra, Meghalaya, Sikkim, Tamil Nadu, Uttarakhand and West Bengal hills, while species growing on soil is distributed in different localities of Uttarakhand and West Bengal hills. Outside India, the species is also reported from Japan, Nepal, Taiwan and Thailand.

**SPECIMENS EXAMINED:** **INDIA:** UTTARAKHAND, PAURI–GARHWAL DISTRICT, Khirsu reserve forest, alt. 1,911 m, on soil at base of tree trunk, Himanshu Rai, 11-0014550 (LWG); **WEST BENGAL,** DARJEELING, Kurseong, near Mahanadi towards North surface, along Tea garden, alt. 1,400 m, over soil and stones, Awasthi and Agarwal 67.54 (LWG-LWU).

*Hypotrachyna exsecta* (Taylor) Hale (Fig. 2.19e; Fig. 2.46)

Hale, Phytologia 28: 341. 1974.

Basionym: *Parmelia exsecta* Taylor, London J. Bot. 6: 166. 1847.

Synonym: *Parmelia laevigata* var. *exsecta* Zahlbr., Cat. Lich. Univ. 6: 172. 1929.

**Thallus:** adnate, up to 8 cm across, subdichotomously to irregularly sinuate lobate, branched; **lobes:** discrete to imbricate, apices dentate, brown tipped, 2–5 mm wide, margin often black rimmed, eciliate; **upper surface:** yellowish grey to dark grey, subapically postulate; pustules becoming crateriform-soresiate and darker in central part; **soresia:** granular; **medulla:** white; **lower surface:** black, densely rhizinate; **rhizines:** dichotomously branched, usually project beyond margins. **Apothecia:** not seen in the specimen.

**Chemistry:** Cortex K<sup>+</sup> yellow; medulla K<sup>-</sup>, C<sup>-</sup>, KC<sup>+</sup> red, P<sup>-</sup>. Atranorin, barbatic and below barbatic acid, barbatic-like unknown compound at R<sub>f</sub> class between 3–4, value 0.23 and 0.30, respectively.

**Ecology and distribution:** *Microhabitat occupied:* Terricolous-rupicolous. In India, the species is widely distributed in Arunachal Pradesh, Kerala, Manipur, Nagaland, Sikkim, Tamil Nadu, Uttarakhand and West Bengal hills while species growing on soil is reported from single locality of Tamil Nadu. Outside India, the species is also reported from Australia, Taiwan and Thailand.

**SPECIMEN EXAMINED:** **INDIA:** TAMIL NADU, NILGIRI HILLS, Emerald Road near Muthorai, on rocks over soil, K. P. Singh 73.459 A (LWG).

*Hypotrachyna scytophylla* (Kurok.) Hale (Fig. 2.19f; Fig. 2.46)

Hale, Phytologia 28: 342. 1974.

Basionym: *Parmelia scytophylla* Kurok. in Hale and Kurok. Contr. U. S. Natl. Herb. 36: 186. 1964.

**Thallus:** closely to loosely adnate to the substratum, coriaceous, to 8 cm across, irregularly sinuate lobed; **lobes:** sublinear, 2–6 mm wide, crenate; margins black-rimmed; **upper surface:** grey to olive-grey, dull, shining at periphery, lacking isidia and soresia; **medulla:** white; **lower surface:** black, dark tan, naked or marginal zone, with densely rhizinate; **rhizines:** simple and dichotomously branched. **Apothecia:** common, to 10(–20) mm in diam., often radially split; **disc:** brown to blackish brown, margins split into lobules; **asci:** clavate, 8-spored; **spores:** colourless, simple, oval-ellipsoid, 6–9(–15) × 4–6(–11) μm.

**Chemistry:** Cortex K<sup>+</sup> yellow; K<sup>-</sup>, C<sup>+</sup> rose-red, KC<sup>+</sup> red, P<sup>-</sup>. Atranorin and gyrophoric acid present.

**Ecology and distribution:** *Microhabitat occupied:* Terricolous-rupicolous. In India, the species is widely distributed in Arunachal Pradesh, Himachal Pradesh, Nagaland, Sikkim, Uttarakhand and West Bengal hills while species growing on soil is reported from single locality of Sikkim. The species is also reported from Nepal and Bhutan.

**SPECIMEN EXAMINED:** INDIA: SIKKIM, NORTH SIKKIM, Thangu area, alt. 4,000 m, on soil over rocks, Upreti, Chatterjee and Divakar 04-003885 (LWG).

### ICMADOPHILA Trevis. (*Icmadophilaceae*)

Trevisan, *Revista Period. Lav. Regia Acad. Sci.*, Padova, 1: 267. 1853.

**Thallus:** crustose, squamulose or foliose, grey to greenish grey, corticated or not; **photobiont:** a green alga (*Coccomyxa*). **Apothecia:** solitary or in groups, sessile or stipitate, lecanorine; disc pale to pink; **thalline exciple:** soon excluded; proper exciple cream to buff coloured; **hymenium:** I<sup>+</sup> blue; **asci:** lacking ocular chamber, (6–)8-spored; **spores:** colourless, 1–3-septate.

Out of 4 species growing on soil, on rotting wood or humus in the temperate regions of the world, 1 terricolous species is known from India.

#### *Icmadophila ericetorum* (L.) Zahlbr. (Fig. 2.46)

Zahlbruckner. *Wiss. Mitteil. Bosn. Herceg*, 8: 605. 1895.

Basionym: *Lichen ericetorum* L. *Sp. Pl.*: 1141. 1753.

Synonym: *Baeomyces icmadophilus* (L. f.) Nyl., *Acta Soc. Linn. Bordeaux* 21: 281. 1856.

**Thallus:** terricolous or on decaying plant material, crustose to warty granulose, whitish to greenish grey. **Apothecia:** sessile to shortly stipitate, to 3 mm in diam.; **disc:** pinkish, wrinkled when mature; **hymenium:** up to 140  $\mu\text{m}$  high; **spores:** ellipsoid-fusiform, 13–28  $\times$  4–6  $\mu\text{m}$ . The description of species is based on Awasthi 2007.

**Chemistry:** Thallus K<sup>+</sup> yellow; KC<sup>+</sup> orange, P<sup>+</sup> orange. Thamnic and perlatolic acids present.

**Ecology and distribution:** *Microhabitat occupied:* Terricolous. In India, the species is distributed in West Bengal hills (Awasthi 2007). The species is also reported from Bhutan, Nepal, New Zealand and South Africa. The specimen pertaining to the species was untraceable during study.

### LECANORA Ach. (*Lecanoraceae*)

In Luyken, *Kongl. Vetensk. Acad. Nya Handl.* 31: 66. 1809.

**Thallus:** crustose, granular, areolate or placodioid; **photobiont:** *Trebouxia* or other chlorococcoid algae. **Apothecia:** sessile or shortly stipitate; **margin:** thin to thick, concolours with the thallus; **true exciple:** poorly developed; **thalline exciple:** prominent; **epihymenium:** greenish brown to dark brown; **hymenium:** hyaline, I<sup>+</sup> blue; **hypothecium:** hyaline; **paraphyses:** simple to septate, apices slightly swollen; **asci:** elongate-clavate, *Lecanora* type; **spores:** ellipsoid to subglobose, hyaline, simple, smooth-walled.

Out of 552 species known from the world, 84 species are from India, of which 2 are terricolous.

**Key to the terricolous species of *Lecanora*:**

- 
1. Thallus sulphur-yellow to yellow-green, granular pruinose, lobes short, radiating, concave, lower side black; apothecia sunken ..... *L. himalayae*
- 1a. Thallus yellowish green to bluish, marginal lobes elongate, convex, subsascending, pruinose, later nude, apothecia sessile..... *L. chondroderma*
- 

***Lecanora chondroderma*** Zahlbr. (Fig. 2.19g; Fig. 2.46)

Zahlbruckner in Handel-Mazzetti, Symb. Sin. 3: 174. 1930.

Type: India, Eastern Himalayas, Sikkim, Changu, 13,000 ft. (=3,900 m), on soil with mosses, 1947, D. D. Awasthi 353 (Holotype: H; Isotype: LWG-Awasthi).

Synonym: *Placolecnora sikkimensis* Räsänen, Arch. Soc. Zool. Bot. Fenn, 'Vanamo' 5: 26. 1950.

**Thallus:** on decaying plant material or on very thin soil layer over acidic rocks, in distinct rosettes, to 5 cm across; **lobes:** elongate, imbricate, thick, convex, 2–3 × 1–3 mm in size; **upper surface:** greenish to yellowish grey, yellowish pruinose; **lower surface:** pale to dark brown; **cortex:** prosoplectenchymatous; **medulla:** white. **Apothecia:** up to 3 mm in diam., sessile; **disc:** yellowish red-brown to brown-black, pruinose; **spores:** 8–13 × 5.5–7 μm. **Pycnoconidia:** 7.5–9 × 1.5–2 μm, rod-shaped.

**Chemistry:** Thallus K–, C–, KC+ yellowish, P–. Usnic acid and zeorin present.

**Ecology and distribution:** *Microhabitat occupied:* Terricolous; muscicolous-terricolous. In India, the species is exclusively terricolous and distributed in Arunachal Pradesh, Sikkim and West Bengal hills. The species is also reported from Bhutan, Nepal and China.

**SPECIMEN EXAMINED: INDIA: ARUNACHAL PRADESH, WEST KAMENG DISTRICT,** Sela to Senge Dzong, alt. 3,978, on dry soil slope, Rolla Seshagiri Rao 7751 (BSI).

***Lecanora himalayae*** Poelt (Fig. 2.19h; Fig. 2.46)

Poelt. Ergebn. Forsch. Nepal Himalaya, Lief 3: 194. 1966.

**Thallus:** placodioid, ± radiating, up to 3 cm, sulphur yellow to yellow-green, granular, pruinose; **lobes:** 0.5–1.0 mm wide to 3.0 mm long, rough; isidia and soredia absent; **lower surface:** black, prothallus absent. **Apothecia:** sessile constricted at base, rounded; **disc:** brown black to blackish green, epruinose; **margin:** thick, verrucose; **amphithecium:** with small and large crystals; **hymenium:** hyaline to paler upwards; **asci:** cylindrical; **spores:** 8 per ascus, ellipsoidal, 10–32 × 6–17 μm.

**Chemistry:** Thallus and apothecial margin K–, C–, KC+ yellow, P–. Usnic acid, zeorine and unknown red brown at R<sub>f</sub> class 4 and between 6–7, and blue at 5.

**Ecology and distribution:** *Microhabitat occupied:* Terricolous; terricolous-rupicolous. In India, the species is exclusively terricolous and distributed in Jammu and Kashmir and Sikkim. The species is endemic in Himalayas and also reported from Nepal.

**SPECIMENS EXAMINED: INDIA: JAMMU AND KASHMIR, LADAKH,** Hemis national park, Rumbak valley, Tiblis, alt. 4,300 m, on soil, H. R. negi, L18/B (LWG); **SIKKIM,** Lachung, on soil-covered rock, V. S. Sharma and M. Ranjan 76767 (LWG).

**LECIDOMA** G. Schneider and Hertel (*Lecideaceae*)

In Hertel, *Herzogia* 5: 460. 1981.

**Thallus:** continuous to marginal lobate, sometimes imbricate-lobate rather than squamulose as in *Psora*; **hypothallus:** black, sometimes present; **upper cortex:** plectenchymatous; **medulla:** I–; **lower cortex:** not differentiated; attach directly to the substratum. **Apothecia:** to 1 mm in diam., flat to convex; **exciple:** radiate; **hypothecium:** hyaline; **epihymenium:** brown; **hymenium:** 60–70  $\mu\text{m}$  high, I+ blue; **paraphyses:** straight, thin walled, strongly conglutinated; **asci:** clavate, with well-developed tholus and ring pore; **spores:** 8 per ascus, simple, hyaline, ellipsoid or ovoid. The genus is monotypic worldwide.

***Lecidoma demissum*** (Rutström) G. Schneider and Hertel (Fig. 2.19i; Fig. 2.46)

*Herzogia* 5(3–4): 460. 1981.

Basionym: *Lichen demissus* Rutstr., *Spicil. Pl. Cryptog. Suecicae* (Aboae): 8.1794.

Synonyms: *Psora demissa* (Rutstr.) Stein, in Cohn, *Krypt.-Fl. Schlesien* (Breslau) 2(2): 171. 1879. *Lecidea demissa* (Rutstr.) Ach., *Method. Lich.*: 81. 1803.

**Thallus:** coarsely areolate to subsquamulose, 3 to 7 cm in diam., dark brown, rarely grey to grey brown,  $\pm$  shiny; **areoles:** 1–2(–4) mm across, flat to convex, tightly packed,  $\pm$  turgid, often contiguous; **lower surface:** deep brown-black. **Apothecia:** 0.5–1(–1.5) mm diam., discrete or becoming confluent, flat or convex; **disc:** round, dull brown-black, red-brown when moist; **hymenium:** 60–70  $\mu\text{m}$  high, hyaline; **paraphyses:** straight, thin-walled, strongly conglutinated; **asci:** *Porpidia*-type, 8-spored, spores hyaline, simple, ellipsoid or ovoid, 12–16  $\times$  5.5–7  $\mu\text{m}$ . *Pycnidia* not seen.

**Chemistry:** Thallus K–, C–, KC–, P–; no secondary metabolites in TLC.

**Ecology and distribution:** *Microhabitat occupied:* Terricolous. In India, the species is exclusively terricolous and exhibits restricted distribution to Western Himalaya and known only from Himachal Pradesh. It is also reported from Scotland, northwest England, north Wales, Ireland, Central Europe, Fennoscandia and North America.

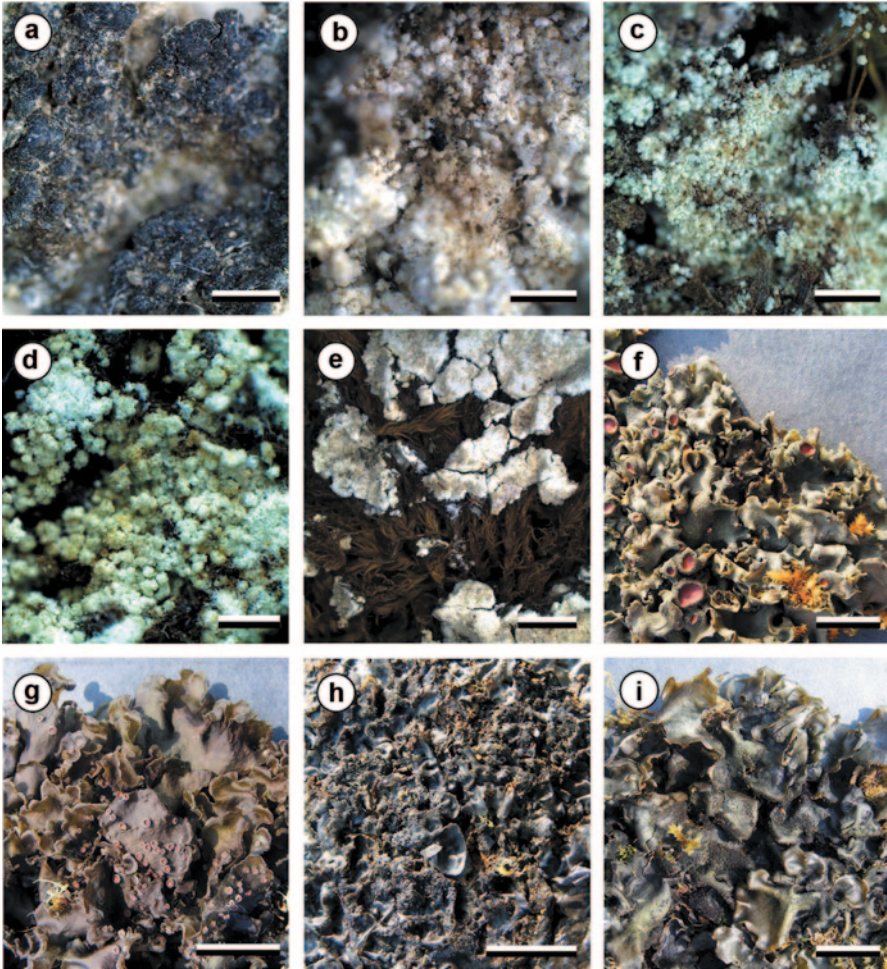
**SPECIMENS EXAMINED: INDIA: HIMACHAL PRADESH, LAHAUL AND SPITI DISTRICT,** Lahaul valley, Rohtang Pass, alt. 3,600 m, on soil, D. K. Upreti 01-26571 (LWG); alt. 3,750 m, on soil, D. K. Upreti and P. K. Divakar 02-0000 18, 02-0000 19/A (LWG).

**LEMPHOLEMMA** Körb. (*Lichinaceae*)

Körber, *Syst. Lich. Germ.*: 400. 1855.

**Thallus:** crustose, warted, squamulose, blackish or blue green to olivaceous when wet, gelatinous, without a well-defined cortex; **photobiont:** *Nostoc*. **Apothecia:** mainly laminal,  $\pm$  immersed to sessile; **asci:** 8-spored, clavate to cylindrical, without a distinct apical apparatus; **spores:** ellipsoid to globose, simple, colourless, gelatinous perispore present that disperses in K.

Out of 33 species known from the world; a single terricolous species is known from India.



**Fig. 2.20** **a** *Lempholemma chalazanum* (Ach.) de Lesd., **b** *Lepraria caesioalba* var. *groenlandica* L. Saag, **c** *L. lobifigans* Nyl., **d** *L. neglecta* (Nyl.) Erichsen, **e** *L. vouauxii* (Hue) R. C. Harris, **f** *Leptogium arisanense* Asahina, **g** *L. askotense* D. D. Awasthi, **h** *L. austroamericanum* (Malme) C. W. Dodge, **i** *L. burnetiae* var. *burnetiae* C. W. Dodge. Scale in **b**, **d**=0.2 mm; in **c**=0.5 mm; **a**=1 mm; **e**=2 mm; in **g**=5 mm; in **f**, **h**=10 mm; in **i**=20 mm

***Lempholemma chalazanum* (Ach.) de Lesd.** (Fig. 2.20a; Fig. 2.46)

de Lesdain, Recherch. Lich. Dunkerque: 261. 1910.

Basionym: *Collema chalazanum* Ach., Lichenogr. Universalis: 630. 1810.

**Thallus:** dark olivaceous to blackish, much swollen when wet, verrucose to minutely foliose thallus, not corticated on either surface; **upper surface:** verruculose; **photobiont:** *Nostoc*. **Apothecia:** up to 0.5 mm diam.; **spores:** hyaline, simple, 21–27 × 9–13 μm.

**Chemistry:** Thallus K–, C–, KC–, P–; no secondary metabolites in TLC.



**Ecology and distribution:** *Microhabitat occupied:* Terricolous-rupicolous. In India, the species exhibits restricted distribution to Western Himalaya and known only from single locality of Uttarakhand. The species is also reported from Europe.

**SPECIMEN EXAMINED:** **INDIA:** UTTARAKHAND, UTTARKASHI DISTRICT, Dharasu, alt. 2,850 m, on rock over soil, A. Singh 75302 (LWG).

**LEPRARIA** Ach. (*Stereocaulaceae*)

Methodus: 3. 1803.

**Thallus:** with a powdery, granular, cottony, membranous or subsquamulose to subfoliose appearance; variously coloured, greyish, greenish and creamy hues prevalent; thin to thick, soft or hard; firmly or loosely attached to the substratum; **lobes:** absent or present, obscure to well-developed; **soredia:** usually abundant, rarely absent, sometimes scarce on some parts of thallus: or sparsely and evenly distributed throughout, often aggregated; **photobiont:** trebouxiod green alga, most often *Asterochloris*. **Apothecia:** absent.

Out of 54 species known from the world, 7 species are from India, of which 5 are terricolous.

**Key to the terricolous species of *Lepraria*:**

1.	Stictic acid complex present .....	2
1a.	Stictic acid complex absent.....	3
2.	Soredia with long projecting hyphae, loosely packed and soft, mostly fine to medium-sized thallus greenish, zeorin .....	<i>L. lobificans</i>
2a.	Soredia are coarse, consoredia abundant, thallus margin usually delimited, thallus grey or bluish grey, not greenish .....	<i>L. caesioalba</i> var. <i>groenlandica</i>
3.	Alectorialic acid present, thallus hard, granular .....	<i>L. neglecta</i>
3a.	Alectorialic acid absent.....	4
4.	Pannaric acid present, lobes absent or poorly-developed, without marginal rim.....	<i>L. vouaxii</i>
4a.	Pannaric acid absent, usnic acid present together with zeorin, thallus margin distinctly lobed, lobes with raised rim .....	<i>L. coriensis</i>

***Lepraria caesioalba* var. *groenlandica*** L. Saag (Fig. 2.20b; Fig. 2.46)

Saag et al. Mycotaxon 102: 73. 2007.

**Thallus:** leprose, granular; **margin:** usually delimited, sometimes diffuse, obscure minute; **lobes:** sometimes present, without raised rims; **medulla:** present, inconspicuous, white; **hypothallus:** usually absent; rarely small patches with exposed medulla present; **soredia:** abundant, coarse or variably sized, typically 100–150(–200) µm diam., projecting hyphae sometimes present, usually short; **consoredia:** frequent, typically 200–300 µm.

**Chemistry:** Thallus K–, C–, P–. Atranorin, stictic acid complex, zeorin (in variable amounts), roccellic/angardianic acid.

**Ecology and distribution:** *Microhabitat occupied:* Muscicolous-rupicolous. Earlier, the species is reported from Greenland. In the present study, the species

extends its distribution to India and known only from Uttarakhand, found to be growing on soil at an altitude of 2,850 m (Rai et al. 2012).

**SPECIMEN EXAMINED: INDIA: UTTARAKHAND, RUDRAPRAYAG DISTRICT, Chopta, alt. 2,850 m, on soil over rock on moss tuft, Himanshu Rai and Pramod Nag 08-0012255 (LWG).**

*Lepraria coriensis* (Hue) Sipman (Fig. 2.46)

Herzogia 17: 28. 2004.

Basionym: *Crocynia coriensis* Hue, Bull. Soc. Bot. France 71: 386. 1924.

**Thallus:** leprose, powdery to membranous; margin delimited, **lobes:** present, obscure or more often well-developed (0.5–2 mm wide) and with raised marginal rim; **medulla:** usually present, thin to medium, white; **hypothallus:** sometimes present, thin, brown to black; sometimes soredia sparse in places, exposing smooth ecorticate surface especially near margins; **soredia:** fine to coarse, up to 300 µm diam., projecting hyphae usually absent.

**Chemistry:** K–, C–, KC–, P–. Three chemotypes were distinguished by Elix (2006), with Usnic acid, Zeorin (major) and a number of minor and trace lichen substance reported.

**Ecology and distribution:** *Microhabitat occupied:* Terricolous. In India, the species is recorded from Karnataka. The terricolous specimen pertaining to the species is untraceable in Herbarium but reported by Singh and Sinha (2010).

*Lepraria lobificans* Nyl. (Fig. 2.20c; Fig. 2.46)

Flora 56: 196. 1873.

**Thallus:** leprose, cottony to rarely powdery; **margin:** usually diffuse; **lobes:** rarely present, weakly developed; **medulla:** present, usually thick, white; **hypothallus:** rarely present, scarce, pale brown; thallus surfaces without soredia sometimes present, then medulla exposed; **soredia:** abundant, fine, up to 60 µm diam., projecting hyphae present, long; **consoredia:** abundant, up to 100(–200) µm.

**Chemistry:** Atranorin, stictic acid, constictic acid, cryptostictic acid ± (variable amounts, often major), norstictic acid ± (trace) and zeorin. K– or + yellow, C–, KC–, P+ orange.

**Ecology and distribution:** *Microhabitat occupied:* Terricolous. In India, the species is widely distributed in Himachal Pradesh, Madhya Pradesh, Karnataka, Tamil Nadu and Uttarakhand, while species growing on soil is known from single locality of Uttarakhand. The species is cosmopolitan in distribution and reported from Australia and New Zealand; Africa, Europe, North America.

**SPECIMEN EXAMINED: INDIA: UTTARAKHAND, PAURI–GARHWAL DISTRICT, Khirsu, Khirsu reserve forest, alt. 1,835 m, on soil at vertical face along bridle path, Himanshu Rai 11-0014549 (LWG).**

*Lepraria neglecta* (Nyl.) Erichsen (Fig. 2.20d; Fig. 2.46)

In Lettau, Feddes Repert. Spec. Nov. Veg. 61: 127. 1958.

Basionym: *Lecidea neglecta* Nyl., Not. Sällsk. Fauna Fl. Fenn. Förh. 4: 233. 1859.

**Thallus:** leprose, granular; **margin:** usually delimited, obscure minute; **lobes:** sometimes present; **medulla:** sometimes present, inconspicuous, white; **hypothallus:** sometimes present, poorly developed, grey to brown; rarely small patches with exposed medulla present; **soredia:** abundant, mostly coarse; **consoredia:** frequent.

**Chemistry:** Alectorialic acid and roccellic/angardianic acid; rarely rangiformic acid replaces roccellic/angardianic acid or very rarely both fatty acids are present.

**Ecology and distribution:** *Microhabitat occupied:* Muscicolous-rupicolous. In India, the species exhibits restricted distribution to Western Himalaya and known from single locality of Uttarakhand. The species is bipolar in distribution and reported from Australia, Brazil, Great Britain, Greenland and New Zealand; Scandinavia; Antarctica, North America.

**SPECIMENS EXAMINED:** **INDIA:** UTTARAKHAND, RUDRAPRAYAG DISTRICT, Tungnath Bugyal, alt. 3,400 m, on soil over rock on tuft of mosses and grass root and stem, Himanshu Rai and Pramod Nag 08-0012238, 08-0012239 (LWG).

*Lepraria vouauxii* (Hue) R. C. Harris (Fig. 2.20e; Fig. 2.46)

In Egan, *Bryologist* 90(1): 163. 1987.

Basionym: *Crocynia vouauxii* Hue, *Bull. Soc. Bot. France* 71: 392. 1924.

Synonym: *Leproloma vouauxii* (Hue) J. R. Laundon, *Lichenologist* 21(1): 13. 1989.

**Thallus:** leprose, cottony to powdery; margin diffuse to delimited, sometimes obscure; **lobes:** present, without raised rims; **medulla:** usually present and thick, white; **hypothallus:** sometimes present, brownish, often poorly developed; often medulla exposed between soredia; **soredia:** abundant, mostly coarse, up to 100 µm diam., projecting hyphae often present, short; **consoredia:** often present, up to 300 µm.

**Chemistry:** Pannaric, methyl pannaric and elatinic acids and unknown dibenzofurans.

**Ecology and distribution:** *Microhabitat occupied:* Terricolous; muscicolous-terricolous. In India, the species is distributed in Himachal Pradesh, Tamil Nadu and Uttarakhand, while species growing on soil is known from different localities of Uttarakhand. The species is bipolar in distribution and reported from Colombia, Dominican Republic, Ecuador, Great Britain, Greenland, Hawaii, Japan, Nepal, Papua New Guinea, Peru, South Georgia and Turkey; Scandinavia; Antarctic Peninsula.

**SPECIMENS EXAMINED:** **INDIA:** UTTARAKHAND, BAGESHWAR DISTRICT, Phurkia bungalow, alt. 3,353 m, over moss on soil, D. D. Awasthi 7663 B (LWG-AWAS); PITHORAGARH DISTRICT, Sandev Botanical Hot Spot, alt. 1,700–2,050 m, on soil, Vikas Pant 02-000962 (LWG); Gori Ganga Catchment, Thakala forest, alt. 1,500 m, on soil, Vikas Pant 02-000655 (LWG).

**LEPROCAULON** Nyl. (Imperfect Lichenized Fungi)

Nylander in Lamy, *Bull. Soc. Bot. France* 25: 352. 1878.

**Thallus:** dimorphic; **primary thallus:** present (verrucose to squamulose) or absent; **secondary thallus:** pseudopodetium with simple or branched cartilaginous structure with verrucose to leprose, phyllocladial granules composed of central mass of photobiont cells enveloped by loose hyphae; **cephalodia:** absent. Apothecia and pycnidia not known.

Out of 7 species known from the world, 2 terricolous species are known from India.

**Key to the terricolous species of *Leprocaulon*:**

- 
- |     |   |                           |
|-----|---|---------------------------|
| 1.  | Thallus K <sup>-</sup> or K <sup>+</sup> brownish, P <sup>+</sup> orange-red to miniate red, atranorin, physodalic, didymic and grayanic acids present .....                            | <i>L. arbuscula</i>       |
| 1a. | Thallus K <sup>+</sup> intense yellow or K <sup>-</sup> , P <sup>+</sup> yellow then orange-red, or P <sup>-</sup> , thamnolic, squamatic, baeomycesic and barbatic acids present ..... | <i>L. pseudoarbuscula</i> |
- 

***Leprocaulon arbuscula* (Nyl.) Nyl. (Fig. 2.47)**

Nylander, Lich. Ins. Guin.: 8.1889

Basionym: *Stereocaulon nanum* subsp. *arbuscula* Nyl., Syn. Lich. 1(2): 253. 1860.

Synonym: *Stereocaulon arbuscula* var. *aberrans* Asahina, J. Jap. Bot. 19: 282. 1943.

**Primary thallus:** not seen; **pseudopodetia:** attached by rooting base, upwards dendroid branched; **branches:** flattened or dorsiventral, in one plane, soft, fragile, greyish white to yellow-brown; phyllocladial granules on ultimate branchlets, often dissolute into powdery particles; **pseudopodetia:** anatomically differentiated into central axis of longitudinally compact hyphae; and an outer mantle composed of loose intricate hyphae; **photobiont:** on surface of pseudopodetium or in powdery granules enveloped by hyphae.

**Chemistry:** Thallus K<sup>+</sup> brownish, P<sup>+</sup> red. Morphologically similar but chemically two different strains: (1) Atranorin, protocetraric, grayanic, didymic acids and two unknown substances; (2) Atranorin, protocetraric, physodalic acids.

**Ecology and distribution:** *Microhabitat occupied:* Terricolous-rupicolous. In India, the species is reported from Sikkim (Sinha and Singh 2005; Awasthi 2007). The species is also reported from Australia, Bhutan, Brazil, China, Colombia, Cuba, Korea, Nepal and Venezuela. No terricolous specimen pertaining to this species was found during study.

***Leprocaulon pseudoarbuscula* (Asahina) I. M. Lamb and Ward (Fig. 2.47)**

Lamb and Ward, J. Hattori Bot. Lab. 38: 533. 1974.

Basionym: *Stereocaulon pseudoarbuscula* Asahina, J. Jap. Bot. 19: 282. 1943.

Synonym: *Stereocaulon novo-arbuscula* Asahina, J. Jap. Bot. 19: 283. 1943.

The species is morphologically and anatomically indistinguishable from *Leprocaulon arbuscula*, but chemically different.

**Chemistry:** Thallus K<sup>+</sup> yellow, P<sup>+</sup> yellow then red or K<sup>-</sup>, P<sup>-</sup> (lacking thamnolic acid). The full spectrum consists of thamnolic, squamatic, baeomycesic and barbatic acids. Atranorin always absent.

**Ecology and distribution:** *Microhabitat occupied:* Terricolous. In India, the species is distributed in Kerala, Sikkim, Tamil Nadu and West Bengal (Sinha and Singh 2005; Awasthi 2007). The species is also reported from Australia, Japan, Papua New Guinea, Sri Lanka, Western Samoa and Taiwan. No terricolous specimen pertaining to this species was found during study.

**LEPTOGIUM** (Ach.) Gray (*Collema*taceae)

Nat. Arr. Brit. Pl. 1: 400. 1821.

**Thallus:** foliose, squamulose or subfruticose, homoiomerous, gelatinous, lead-grey to bluish or suffuse brown; **lobes:** flattened, orbicular to elongate, crowded or congested and subsascent; **margin:** entire to lacerate, crenate or isidiate; **upper surface:** smooth, wrinkled-plicate, undulate or lobulate or isidiate; **photobiont:** *Nostoc*; **medulla:** compact or loose; **lower surface:** smooth or glabrous or tomentose, composed of cylindrical cells or rarely with spherical cells. **Apothecia:** emergent, adnate, sessile or pedicellate, substipitate or distinctly pedicellate, lecanorine; **disc:** orange-red, red-brown to black; **hymenium:** I+ blue; **epithecium:** yellow-brown; **hypothecium:** colourless; **asci:** (4-)8-spored; **spores:** colourless, acicular, transversely septate or muriform, ellipsoid fusiform; **paraphyses:** simple. **Pycnoconidia:** short, straight.

Out of 189 species known from world, 36 species are reported from India, out of which 20 are terricolous.

**Key to the terricolous species of *Leptogium*:**

1.	Thallus small, lobes usually less than 2(-3) mm wide, dwarf fruticose.....	<i>L. teretiusculum</i>
1a.	Thallus large, lobes 3 mm or more wide, foliose.....	2
2.	Thallus tomentose on lower surface (rarely upper surface), tomentum composed of spherical or elongate, cylindrical hyphal cells.....	3
2a.	Thallus lacking hyphal tomentum on either surface, hyphal projections as tufts, may sometimes be present.....	11
3.	Thallus isidiate.....	4
3a.	Thallus lacking isidia.....	7
4.	Thallus distinctly wrinkled.....	5
4a.	Thallus smooth, lacking wrinkles.....	6
5.	Thallus bluish grey, isidia coralloid branched, apothecia with inflated pedicel.....	<i>L. pseudopapillosum</i>
5a.	Thallus brown to dark brown, densely wrinkled, isidia globular to clavate, apically collapsed.....	<i>L. furfuraceum</i>
6.	Thallus bluish grey to brown, isidia globular to cylindrical, and coralloid branched.....	<i>L. burnetiae</i>
6a.	Thallus dark olivaceous green to black, isidia granular to coralloid branched.....	<i>L. saturninum</i>
7.	Apothecia on a long inflated tubular stalk, as wide as disc, thalline exciple smooth.....	<i>L. delavayi</i>
7a.	Apothecia lacking long inflated tubular stalks.....	8
8.	Thallus bluish grey.....	9
8a.	Thallus grey-brown to brown-black.....	10
9.	Apothecia sessile, exciple with few hyphal hairs or trichomes.....	<i>L. arisanense</i>
9a.	Apothecia stipitate, stalk short, not tubular.....	<i>L. pedicellatum</i>
10.	Apothecia sessile.....	<i>L. trichophorum</i>
10a.	Apothecia shortly stalked, stalk tubular.....	<i>L. askotense</i>
11.	Thallus and or apothecia isidiate.....	12
11a.	Thallus and apothecia lacking isidia.....	14
12.	Thallus wrinkled, bluish leaden grey.....	<i>L. austroamericanum</i>

12a.	Thallus smooth, not wrinkled .....	13
13.	Isidia squamiform, never cylindrical .....	<i>L. denticulatum</i>
13a.	Isidia granular to cylindrical, isidia of same colour as thallus.....	<i>L. cyanescens</i>
14.	Thallus lobes anastomosing .....	15
14a.	Thallus lobes not anastomosing.....	16
15.	Apothecial margin lobulate, thallus leaden grey.....	<i>L. phyllocarpum</i>
15a.	Apothecial margin not lobulate, thallus greenish grey to brownish	<i>L. chloromelum</i>
16.	Thallus surface wrinkled, lobes 4–6 mm wide at apices, wrinkles acute .....	<i>L. platynum</i>
16a.	Thallus surface smooth, not wrinkled.....	17
17.	Proper exciple euparaplectenchymatous throughout from margin to the base of hypothecium .....	18
17a.	Proper exciple euparaplectenchymatous only at margin, indistinct or not cellular below hypothecium .....	19
18.	Thallus lobes erect to suberect forming cushion-like growth, thalline exciple periclinally wrinkled.....	<i>L. gelatinosum</i>
18a.	Thallus lobes horizontal, not forming cushion-like growth thalline exciple smooth, lacking wrinkles.....	<i>L. ulvaceum</i>
19.	Apothecia pedicellate, stalk short, hollow, thalline exciple periclinally wrinkled .....	<i>L. indicum</i>
19a.	Apothecia sessile to basally constricted, cortex of thalline exciple 5–10 cell layered at base, thallus 30–60 µm thick.....	<i>L. moluccanum</i>

***Leptogium arisanense*** Asahina (Fig. 2.20f; Fig. 2.47)

Asahina, J. Jap. Bot. 12: 252. 1936.

**Thallus:** foliose, adnate loosely, up to 4 cm across, bluish grey in dry condition, swollen when wet; **lobes:** orbicular 8–14 mm wide, discrete margins entire, regular to wavy; **upper surface:** rough, irregularly minutely wrinkled; **lower surface:** paler than the upper surface, tomentose; **tomentum:** pale brown. **Apothecia:** submarginal to laminal, sessile; **disc:** orange-red to reddish brown, concave to plane or slightly convex, 0.5–2 mm in diam.; **thalline exciple:** irregular to periclinally wrinkled, hairs (trichomes) present; **spores:** muriform, 4–6-septate transversely and 1–2 longitudinal septa, ends acuminate, 27–43 × 9–13 µm.

**Chemistry:** Thallus K–, C–, KC–, P–; no secondary metabolites in TLC.

**Ecology and distribution:** *Microhabitat occupied:* Terricolous; terricolous-rupicolous; muscicolous-terricolous; muscicolous-rupicolous. In India, the species is widely distributed in Arunachal Pradesh, Manipur, Sikkim and West Bengal hills, while species growing on soil is known from different localities of Sikkim and West Bengal hills. The species is also reported from Taiwan. The specimens examined had less distinctly wrinkled surface and smaller cortical cells than the type specimen.

**SPECIMENS EXAMINED: INDIA: SIKKIM, NORTH SIKKIM,** Singhbo Rhododendron Sanctuary, near Yumthang, alt. 3,500 m, on rocks over soil among mosses D. K. Upreti, S. Chatterjee and P. K. Divakar 04-004119 (LWG); above Lachen, alt. 3,000 m, on soil, D. K. Upreti, S. Chatterjee and P. K. Divakar 04-003818 (LWG); 15 km before Lachen Sat Gumati, alt. 2,400 m, on soil, D. K. Upreti, S. Chatterjee and P. K. Divakar 04-003761 (LWG); **WEST BENGAL, DARJEELING DISTRICT,** Sandakhpoo to Tongloo, alt. 2,590 m, on ground among mosses, D. D. Awasthi 195 (LWG-AWAS).

***Leptogium askotense*** D. D. Awasthi (Fig. 2.20g; Fig. 2.47)

In D. D. Awasthi and Akhtar, *Norweg. J. Bot.* 24: 63. 1977.

**Thallus:** foliose, 3–4 cm in size, loosely attached to substratum, blackish grey to dark brown when dry dark olivaceous green, regularly or irregularly lobed; **lobes:** 3–20 mm wide, orbicular, margins entire to wavy; **upper surface:** dull wrinkled; **lower surface:** tomentose; **tomentum:** pale brown, composed of cylindrical cells,  $6\text{--}15 \times 3\text{--}6 \mu\text{m}$ . **Apothecia:** common, submarginal, sub-pedicellate to pedicellate, tubular, 0.5–2 mm tall; **disc:** concave to plane; **thalline exciple:** well-developed, thick, wrinkled, with hyphal hairs; **proper exciple:** eu-paraplectenchymatous; **hy-menium:** hyaline, 90–160  $\mu\text{m}$  high, I+ deep blue, oil globules present; **asci:** cylindrical-clavate, unitunicate, 8-spored; **spores:** colourless, submuriform to muriform, transversely 3–7-septate, longitudinally 1(–2)-septate, ellipsoid with acute ends,  $25\text{--}53 \times 9\text{--}15 \mu\text{m}$ .

**Chemistry:** Thallus K–, C–, KC–, P–; no secondary metabolites in TLC.

**Ecology and distribution:** *Microhabitat occupied:* Terricolous; terricolous-rupicolous; muscicolous-terricolous; muscicolous-rupicolous. In India, the species is widely distributed in Arunachal Pradesh, Himachal Pradesh, Manipur, Sikkim, Uttarakhand and West Bengal hills, while species growing on soil is known from different localities of Himachal Pradesh and Uttarakhand. The species is endemic in Himalayas. In colour of thallus, it resembles *L. trichophorum*, but apothecia in the latter species are sessile, spores smaller and the thalline exciple has hyphae as trichomes.

**SPECIMENS EXAMINED:** **INDIA:** **HIMACHAL PRADESH, SHIMLA,** Summer Hills, alt. 2,100 m, on stones over soil, A. Singh and Ram Pher L 18201 (LWG); **UTTARAKHAND, PITHORAGARH DISTRICT,** Askot Sandev Botanical Hotspot, Adichaura, alt. 2,150 m, on soil, Vikas Pant 02-103915 (LWG); Dharchula, Sobhla, on the way to Sundung and Humchya village, alt. 2,200 m, on soil along mosses, Upreti and Hariharan 202068 (LWG); Birthi falls, 19 km from Tejran on the Mumsiyari vehicle road, alt. 1,225 m, on rocks over soil, D. K. Upreti, S. Joshi, H. Rai, R. Khare, G. K. Mishra and A. Dwivedi 09-012435 (LWG); en route to Sunderdhunga glacier, between Jatoli and Dhuniyadon, alt. 3,353 m, on soil, D. K. Upreti and Jyoti Tandon 213855 (LWG); **CHAMOLI DISTRICT,** between Bagrigad and Wan, alt. 2,100 m, on moss covered rock over soil, A. Singh and party, 91577 (LWG); Mandal, alt. 1,000 m, on rock over soil, S. Rawat, 07-011121 (LWG); **RUDRARAYAG DISTRICT,** Chopta, alt. 2,700 m, on soil with mosses, D. K. Upreti and Balwant Kumar, 06-005976 (LWG); on the way from Chopta to Tungnath, alt. 3,200 m, on rocks over soil, D. K. Upreti and Sanjeeva Nayaka, 07-010178 (LWG).

***Leptogium austroamericanum*** (Malme) C. W. Dodge (Fig. 2.20h; Fig. 2.47)

Dodge, *Ann. Missouri Bot. Garden* 20: 419. 1933.

Basionym: *Leptogium cyanescens* var. *austroamericanum* Malme, *Ark. Bot.* 19(8): 21. 1924.

**Thallus:** foliose, adnate to 7 cm across, loosely to closely attached to the substratum; **lobes:** 2–7 mm wide, not much swollen when wet; spreading to suberect, orbicular; margin: entire, plane to wavy; **upper surface:** dark grey, rough, wrinkled, wrinkles usually running parallel to the thallus, isidiate; **isidia:** laminal to marginal, globular to rarely branched, squamiform; **lower surface:** paler, wrinkled with tufts of hyphal hair but not tomentose. **Apothecia:** absent.

**Chemistry:** Thallus K–, C–, KC–, P–; no secondary metabolites in TLC.

**Ecology and distribution:** *Microhabitat occupied:* Terricolous; terricolous-rupicolous. In India, the species is widely distributed in Andaman and Nicobar Islands, Arunachal Pradesh, Goa, Himachal Pradesh, Karnataka, Kerala, Madhya Pradesh, Maharashtra, Manipur and Uttarakhand, while species growing on soil is known from different localities of Himachal Pradesh and Uttarakhand. The species is pantropical in distribution and reported from Australia, Bhutan, Taiwan and Thailand; Europe, Central, North and South America. The species closely resembles to *L. cyanescens* in colour of thallus and nature of isidia, but the latter has a smooth thallus.

**SPECIMENS EXAMINED:** **INDIA:** **HIMACHAL PRADESH, KULLU DISTRICT,** Great Himalayan National Park, Manjhan village area, alt. 2,600 m, on rocks in open area over soil, D. K. Upreti 217366 (LWG); **UTTARAKHAND, PITHORAGARH DISTRICT,** Gori Ganga catchment area, alt. 1,450 m, on soil, V. Pant 02-000897 (LWG); **CHAMPAWAT DISTRICT,** Baleshwar Temple, alt. 1,650 m, on soil, Ajay Singh 102628 (LWG).

***Leptogium burnetiae*** C. W. Dodge (Fig. 2.20i; Fig. 2.47)

Dodge, Beih. Nova Hedwigia 12: 120. 1964.

Synonym: *Leptogium menziesii* f. *fuliginosum* Müll. Arg., Flora 72: 60. 1889.  
var. *burnetiae*

**Thallus:** 2–4 cm in size, loosely to firmly attached to substratum, bluish to grey-blue when dry, dark olive green, translucent, generally non-glossy and slightly swollen when wet, deeply to shallowly lobate; **lobes:** orbicular to sublinear; **margins:** entire to dentate, isidiate, flat to ascending and revolute; **upper surface:** dull, smooth to slightly rough, densely isidiate; **isidia:** solid, simple, globular or cylindrical when young, later coralloid branched, 0.1–0.7 mm long, concolorous with thallus or darker; **lower surface:** paler than upper surface, densely tomentose; **tomentum:** usually white, hyphae of tomentum free to anastomosing. **Apothecia:** not seen.

**Chemistry:** Thallus K–, C–, KC–, P–; no secondary metabolites in TLC.

**Ecology and distribution:** *Microhabitat occupied:* Terricolous; terricolous-rupicolous; muscicolous-terricolous; muscicolous-rupicolous. In India, the species is widely distributed in Arunachal Pradesh, Himachal Pradesh, Jammu and Kashmir, Kerala, Madhya Pradesh, Maharashtra, Manipur, Nagaland, Sikkim, Tamil Nadu, Uttarakhand and West Bengal hills, while species growing on soil is known from different localities of Arunachal Pradesh, Himachal Pradesh, Jammu and Kashmir, Maharashtra, Tamil Nadu and Uttarakhand. The species is also reported from Bhutan, Sri Lanka, Taiwan; Africa, America and Europe.

**SPECIMENS EXAMINED:** **INDIA:** **ARUNACHAL PRADESH, WEST KAMENG DISTRICT,** Salari area, alt. 1,500 m, on rock over soil with mosses, Ashish Kar 04-009755 (LWG); **HIMACHAL PRADESH, KULLU DISTRICT,** Parbati river valley, on the way to Pulga from Bhandag Thaj, alt. 2,400 m, on shady vertical side of rock over soil, D. D. Awasthi and K. Dange 76.290 (LWG-LWU); Beas river valley, Manali, alt. 1,800 m, on boulders over soil, D. D. Awasthi and K. Dange 75.15 (LWG-LWU); Great Himalayan National Park, Dhela, alt. 3,737 m, on rock over soil, R. Srivastava 04-003669 (LWG); **CHAMBA DISTRICT,** from Brahmaur Hadsar, Mani Mahesh, Doonch, alt. 2,150 m, on rock over soil, D. K. Upreti and S. Nayaka 01-75500 (LWG); **SHIMLA,** Rampur, Gaura up to 4 km towards Rampur, alt. 1,800 m, on



rock over soil with mosses, S. Nayaka and R. Srivastava 02-81629 (LWG); **JAMMU AND KASHMIR, ANANTNAG DISTRICT**, Pahalgam, on the way to Chandanwari, alt. 2,700 m, on rock over soil in shady places with mosses, K. Dange 77.321 (LWG-LWU); **MAHARASHTRA, SATARA DISTRICT**, Panchgani, near Awakali village, alt. 1,233 m, on soil with mosses, R. Bajpai 11-015063 (LWG); Mahabaleshwar, near Lingmala forest rest house, alt. 1,339 m, on soil, R. Bajpai 10-013883 (LWG); **TAMIL NADU, NILGIRI HILLS**, Avalanche, near forest rest house, alt. 2,134 m, on rocks over soil, K. P. Singh 71.762 (LWG-LWU); **PALNI HILLS**, Perumalai area, on the way to Perumal peak, alt. 1,905 m, over stones on soil nera shola forest patch, K. P. Singh 70.1089 (LWG-LWU); Dindigul, Kodaikanal, Croaker's walk, near travellers bungalow, alt. 2,134 m, on stones over rock, D. D. Awasthi and K. P. Singh 69.27 (LWG-LWU); **UTTARAKHAND, BAGESHWAR DISTRICT**, en route to Pindari Glacier, Dwali to Phurkiya, alt. 2,972 m, on soil, S. Joshi and Y. Joshi 07-008846 (LWG); **CHAMOLI DISTRICT**, Valley of Flowers, alt. 3,000 m, on rock over soil with mosses, S. Rawat 06-007146 (LWG); Lata, alt. 2,800 m, on rock over soil with mosses, S. Rawat 06-007221 (LWG); **PITHORAGARH DISTRICT**, Askot, alt. 2,134 m, on rock over soil, D. D. Awasthi 2684 B (LWG-AWAS); Askot near Naret, alt. 1,448 m, on stones over hard soil, D. D. Awasthi 6410 (LWG-AWAS); Askot, alt. 3,048 m, on rock over soil, Ajay Singh 90373 (LWG); Dwaj-Temple, alt. 2,743 m, on moss covered soil, D. K. Upreti L/18446 (LWG); Munsyari to Lilam en route to Milam Glacier, alt. 2,025 m, on rock over soil with mosses, S. Joshi 07-010409 (LWG); **RUDRAPRAYAG DISTRICT**, Mandakini river valley, on the way from Gaurikund to Rambara, alt. 2,390 m, on rock surface over soil, K. Dange 76.116, 76.136 (LWG-LWU); Kedarnath valley Rambara, alt. 1,900 m, on rock over soil with mosses, D. K. Upreti, P. K. Divakar, B. Kumar 06-006000 (LWG).

***Leptogium chloromelum*** (Sw.) Nyl. (Fig. 2.21a; Fig. 47)

Nylander. Syn. Lich. 1(2): 128. 1860.

Basionym: *Lichen chloromelos* Sw. Fl. Ind. Occid. 3: 1892. 1806.

**Thallus:** foliose, 2–7 cm in diam., loosely adnate to the substratum; **lobes:** irregular, elongate, 1–4 mm wide; **upper surface:** greenish gray to medium gray, usually dull, wrinkled longitudinally; **lower surface:** pale to greenish gray, wrinkled, with scattered tufts of white hairs. **Apothecia:** common, laminal, often marginal, sessile, 0.5–3 mm wide; **disc:** brown to red-brown, concave to plane; **thalline exciple:** periclinally wrinkled, with single-cell-layered cortex at base and margin of apothecia; **proper exciple:** euparaplectenchymatous throughout; **asci:** cylindrico-clavate, 8-spored; **spores:** hyaline, muriform, transversely 3–5-septate, longitudinally 0–1-septate ellipsoid to subfusiform, 20–30 × 9–12 μm in size.

**Chemistry:** Thallus K–, C–, KC–, P–; no secondary metabolites in TLC.

**Ecology and distribution:** *Microhabitat occupied:* Muscicolous-terricolous. In India, the species is widely distributed in Himachal Pradesh, Kerala, Madhya Pradesh, Maharashtra, Tamil Nadu and Uttarakhand, while species growing on soil is known from single locality of Maharashtra. The species is also reported from tropical America. *L. chloromelum* resembles *L. platynum* but can be differentiated by smaller spores and larger apothecia.

**SPECIMEN EXAMINED:** **INDIA: MAHARASHTRA, SATARA DISTRICT**, Mahabaleshwar, on the way to Wilson point, alt. 1,350 m, on mosses over soil, R. Bajpai 10-013893(LWG).

***Leptogium cyanescens*** (Rabenh.) Körb. (Fig. 2.21b; Fig. 47)

Körber. Syst. Lich. Germ.: 420. 1855.

Basionym: *Collema cyanescens* Rabenh. Deutschl. Krypt. -Fl. 2: 50. 1845.



**Fig. 2.21** a *Leptogium chloromelum* (Sw.) Nyl., b *L. cyanescens* (Rabenh.) Körb., c *L. delavayi* Hue, d *L. denticulatum* Nyl., e *L. furfuraceum* (Harm.) Sierk, f *L. gelatinosum* (With.) J. R. Laundon, g *L. indicum* D. D. Awasthi and Akhtar, h *L. moluccanum* (Pers.) Vain., i *L. pedicellatum* P. M. Jørg. Scale in a, b, c, d, e, f, g, h, i = 10 mm

Synonyms: *Collema tremelloides* var. *caesium* Ach. Lichenogr. Universalis: 656. 1810.

*Leptogium caesium* (Ach.) Vain., Acta Soc. Fauna Fl. Fenn. 7: 225. 1890.

**Thallus:** loosely to closely attached to substratum, 1–6 cm in size, foliose, usually lead-grey when dry, olivaceous ashy green; **lobes:** orbicular, 2–13 mm; **margin:** entire, isidiate or rarely lobulate; **upper surface:** smooth, sparsely to densely isidiate; **isidia:** cylindrical up to 1 mm long, rarely squamiform; **lower surface:** smooth. **Apothecia:** uncommon, laminal, sessile, up to 1.5 mm in diam.; **disc:** concave, reddish brown, smooth; **thalline exciple:** entire, isidiate, 6–9 layered cor-

tex at base and 2–3 cell layered at margin; **proper exciple**: euparaplectenchymatous at margin, indistinct at the centre; **spores**: ellipsoid, muriform, transversely 2–4(5)-septate, longitudinally 1-septate,  $10\text{--}18 \times 5\text{--}8 \mu\text{m}$ .

**Chemistry**: Thallus K–, C–, KC–, P–; no secondary metabolites in TLC.

**Ecology and distribution**: *Microhabitat occupied*: Terricolous; terricolous-rupicolous; muscicolous-terricolous; muscicolous-rupicolous. In India, the species is widely distributed in Arunachal Pradesh, Himachal Pradesh, Jammu and Kashmir, Kerala, Madhya Pradesh, Maharashtra, Manipur, Nagaland, Tamil Nadu, Uttarakhand and West Bengal hills, while species growing on soil is known from different localities of Himachal Pradesh, Jammu and Kashmir, Tamil Nadu, Uttarakhand and West Bengal hills. The species is Cosmopolitan in distribution and reported from Australia and Bhutan; Africa, Central, North and South America. It is closely related to *L. denticulatum* but in latter, isidia are always squamiform.

**SPECIMEN EXAMINED**: **INDIA**: **HIMACHAL PRADESH**, **KINNAUR DISTRICT**, Chitkul forest area, alt. 3,950 m, on humus, Upreti, Srivasata and Prakash 03-002714 B (LWG); **KULLU DISTRICT**, Parbati river valley, above kheer Ganga, alt. 3,150 m, on stones over soil with mosses, D. D. Awasthi, K. Dange 75.317 (LWG-LWU); **MANDI DISTRICT**, en route from Barot to Winch camp, alt. 2,200 m, on rock over soil, D. K. Upreti 213550 (LWG); **JAMMU AND KASHMIR**, **ANANTNAG DISTRICT**, Pahalgam, on the way to Chandanwari, alt. 2,700 m, on rock surfaces with mosses, K. Dange 77.356 (LWG-LWU); Gulmarg, on the way from Gulmarg to Khilanmarg, alt. 2,655 m, on soil over rock surface along with mosses, K. Dange 70.504 (LWG-LWU); **TAMIL NADU**, **PALNI HILLS**, Kodaikanal, Shenbaganur, below Silver cascade to Tiger Shola, alt. 1,676 m, on ground, by roadside, D. D. Awasthi, K. P. Singh 70.82 (LWG-LWU); **UTTARAKHAND**, **BAGESHWAR DISTRICT**, Dwali alt. 9,000 ft. on rock among mosses over soil, 24. 5. 1972, A. Singh 9191 (LWU-LWG); **CHAMOLI DISTRICT**, between Ghanghariya and Valley of flowers, alt. 3,100 m, on soil-covered rocks along with mosses, A. Singh 85897, 85881 (LWG); **WEST BENGAL**, **DARJEELING**, Kurseong, near Mahanadi, towards north side, along tea garden, alt. 1,219 m, on soil with mosses, D. D. Awasthi and M. R. Agarwal 66.283 (LWG-LWU).

*Leptogium delavayi* Hue (Fig. 2.21c; Fig. 2.47)

Hue, Bull. Soc. Bot. France. 36: 25. 1889.

**Thallus**: foliose, 1.5–4 cm in size, loosely or closely attached to substratum, dark grey to pale green in dry condition, olivaceous grey, translucent, non-glossy when wet; **lobes**: orbicular, 3–6 mm wide, discrete; **margins**: entire to rarely crenate, regular to wavy or ascending or revolute; **upper surface**: dull, smooth, sometimes slightly wrinkled; **lower surface**: paler than the upper surface, densely tomentose; **tomentum**: colourless to pale brown, tomentum hyphae composed of cylindrical cells, free. **Apothecia**: common, submarginal to laminal, 2–6 mm in diam., distinctly pedicellate, tubular, smooth not constricted, 2–5 mm long, with minute white hyphal hairs on the surface; **thalline exciple**: entire, thin, smooth, running continuous with the pedicel; **spores**: transversely 4–5-septate, longitudinally 1–2-septate, ellipsoid with acute ends,  $25\text{--}34 \times 8\text{--}12 \mu\text{m}$ .

**Chemistry**: Thallus K–, C–, KC–, P–; no secondary metabolites in TLC.

**Ecology and distribution**: *Microhabitat occupied*: Terricolous; terricolous-rupicolous; muscicolous-rupicolous. In India, the species is widely distributed in Arunachal Pradesh, Himachal Pradesh, Nagaland, Sikkim, Uttarakhand and West

Bengal hills, while species growing on soil is known from different localities of Himachal Pradesh and Uttarakhand. The species is also reported from China, Japan and Nepal. It is closely related to *L. denticulatum* but in latter, isidia is always squamiform.

**SPECIMENS EXAMINED: INDIA: HIMACHAL PRADESH, KULLU DISTRICT**, Great Himalayan National Park, Ecodevelopment zone, Khanoti, alt. 2,800 m, over soil on mosses over rock, R. Srivasatava 04-003141 (LWG); **SHIMLA**, Shimla, Summer hills, alt. 2,100 m, on rock over soil, A. Singh and Ram Pher L 18220 (LWG); **SOLAN DISTRICT**, Kandaghat, alt. 1,615 m, on rock over soil, S. Nayaka 20-85733 (LWG); **UTTARAKHAND, BAGESHWAR DISTRICT**, en route Dhakuri to Khati, on soil, S. Joshi and Y. Joshi 07-008852 (LWG); Khati to Dwali en route to Pindari, alt. 2,000 m, on rock over soil, Upreti, Chatterjee and Tandon L69037 (LWG); **PITHORAGARH DISTRICT**, Munsyari, Khaliya top, alt. 2,850 m, on rock over soil, D. K. Upreti, S. Joshi, H. Rai, R. Khare, G. K. Mishra and A. Dwivedi 09-013557 (LWG); Munsyari to Lilam en route to Milam glacier, alt. 2,050 m, on rock over soil, S. Joshi 07-010404 (LWG).

***Leptogium denticulatum*** Nyl. (Fig. 2.21d; Fig. 2.47)

Nylander, Ann. Sci. Nat. Bot. ser. 5, 7: 302. 1867.

**Thallus:** foliose, adnate, to 3.5 cm across; **lobes:** orbicular, 2–10 mm wide; **margins:** isidiate, lobulate; **upper surface:** lead grey to darker, slightly wrinkled; **isidia:** 2 mm wide, squamiform; **lower surface:** paler, etomentose. **Apothecia:** rare, to 1 mm in diam.; **thalline exciple:** cortex multi cell layered at base, few cells layered at margin; **proper exciple:** euparaplectenchymatous throughout; **spores:** muriform with 3–5 transverse and 0–1 longitudinal septa, ellipsoid, acute at ends 15–28 × 6–12 μm.

**Chemistry:** Thallus K–, C–, KC–, P–; no secondary metabolites in TLC.

**Ecology and distribution:** *Microhabitat occupied:* Terricolous; terricolous-rupicolous; muscicolous-terricolous; muscicolous-rupicolous. In India, the species is widely distributed in Andaman and Nicobar Islands, Arunachal Pradesh, Goa, Jammu and Kashmir, Karnataka, Kerala, Madhya Pradesh, Maharashtra, Manipur, Meghalaya, Nagaland, Sikkim, Tamil Nadu and West Bengal hills, while species growing on soil is known from different localities of Arunachal Pradesh, Jammu and Kashmir and Uttarakhand. The species is also reported from Bhutan, Colombia, Mexico, New Zealand, Taiwan and the USA. Pantropical in distribution. It shows smilarily to *L. cyanescens* in thallus colour but differs in the nature of isidia.

**SPECIMENS EXAMINED: INDIA: ARUNACHAL PRADESH, UPPER SIANG DISTRICT**, Jengging, alt. 795 m, on soil, Urvashi Dubey 07-013699 (LWG); **JAMMU AND KASHMIR, BARAMULLA DISTRICT**, Gulmarg, alt. 2,580 m, on soil over rocks among mosses, M. Sheikh 05-006025 (LWG); **TAMIL NADU, MADURAI**, Shenbaganur-Kodaikanal, along heving's path, alt. 1,905 m, on ground with mosses, G. Foreau and D. D. Awasthi 4299 (LWG-AWAS); **UTTARAKHAND, CHAMOLI DISTRICT**, Laink, alt. 1,300 m, on rock over soil, A. Singh and M. Ranjan 106879 (LWG).

***Leptogium furfuraceum*** (Harm.) Sierk (Fig. 2.21d; Fig. 2.47)

Sierk, Bryologist 67: 266. 1964.

**Basionym:** *Leptogium hildenbrandii* f. *furfuraceum* Harm., Lich. France 1: 118. 1905.

**Thallus:** foliose, small, up to 2.5 cm in size, loosely attached to substratum, brownish black in dry condition, dark-olivaceous green, translucent, swollen and glossy when wet; **lobes:** orbicular, 5–12 mm wide, discrete, margins entire to isidiate, flat to ascending and undulate; **upper surface:** distinctly wrinkled, wrinkles prominent in dry condition, periclinal to irregular, isidiate; **isidia:** simple, globular to clavate, solid; **lower surface:** concolorous with or paler than the upper surface, tomentose; **tomentum:** pale brown 0.3–0.7 mm long, hyphae of tomentum free to anastomosing, confluent. **Apothecia:** not seen.

**Chemistry:** Thallus K–, C–, KC–, P–; no secondary metabolites in TLC.

**Ecology and distribution:** *Microhabitat occupied:* Terricolous; terricolous-rupicolous. In India, the species is widely distributed in Himachal Pradesh, Madhya Pradesh, Sikkim, Tamil Nadu and Uttarakhand, while species growing on soil is known from different localities of Sikkim and Uttarakhand. The species is also reported from East Africa, S. W. Europe and North America.

**SPECIMENS EXAMINED:** **INDIA:** **SIKKIM, NORTH SIKKIM,** Shingbo Rhododendron Sanctuary, near Yumthang, alt. 3,500 m, on soil, D. K. Upreti, S. Chatterjee and P. K. Divakar 04-004122 (LWG); **UTTARAKHAND, BAGESHWAR DISTRICT,** en route to Sunderdhunga glacier, before 5 km to Dhakuri, alt. 2,125 m, on rock over soil, D. K. Upreti and Jyoti Tandon 213416 (LWG); **PITHORAGARH DISTRICT,** Lilam to Bogudiyar, alt. 2,125 m, on rock over soil, S. Joshi 07-010399 (LWG).

*Leptogium gelatinosum* (With.) J. R. Laundon (Fig. 2.21f; Fig. 2.47)

Laundon, *Lichenologist* 16: 219. 1984.

Basionym: *Lichen gelatinosus* With., *Bot. Arr. Veg. Gr. Br.*: 710. 1776.

Synonyms: *Lichen sinuatus* Huds. *Fl. Angl.* 2 ed., 2: 535. 1778. *-Leptogium sinuatum* (Huds.) Massal. *Mem. Lichenogr.*: 88. 1853.

**Thallus:** foliose, forms cushion, 2–5(–8) cm in diam., adnate; **lobes:** elongate, ± plane, separate or more usually imbricate, 1–3(–5) mm wide; **upper surface:** dark brown or reddish brown or in sheltered situations greyish brown, dull centrally and shiny marginally; **lower surface:** paler, wrinkled, etomentose. **Apothecia:** common, laminal, sessile, 0.2–0.5(–2) mm wide; **disc:** light to dark brown, concave to plane; **margin:** thalline, concolorous with the thallus, entire to wrinkled periclinally; **exciple:** euparaplectenchymatous, 10–35 µm thick; **hymenium:** 115–170 µm high; **paraphyses:** unbranched, 1–2 µm wide, slightly inflated apically; **asci:** cylindrical-clavate, 8-spored; **spores:** hyaline, muriform, 5–7(–9)-septate transversely, 1–2-septate longitudinally, ellipsoid to subfusiform, 25–35 × 16–18 µm in size.

**Chemistry:** Thallus K–, C–, KC–, P–; no secondary metabolites in TLC.

**Ecology and distribution:** *Microhabitat occupied:* Terricolous. In India, the species is widely distributed in Kerala, Sikkim, Tamil Nadu and West Bengal, while species growing on soil is reported from single locality of Tamil Nadu. The species is also reported from America and Europe. *Leptogium gelatinosum* resembles *L. platynum*, but the latter has a thicker (270–450 µm) thallus.

**SPECIMEN EXAMINED:** **INDIA:** **TAMIL NADU, PALNI HILLS,** Berijam, alt. 2,438 m, on ground and bark of tree, D. D. Awasthi and K. P. Singh 70.326 C (LWG-LWU).

***Leptogium indicum*** D. D. Awasthi and Akhtar (Fig. 2.21g; Fig. 2.47)

Awasthi and Akhtar, *Geophytology* 8: 197. 1979.

**Thallus:** adnate, to 6 cm across; **lobes:** orbicular, 4–9 mm wide; **upper surface:** light to dark lead-grey, lacking isidia; **lower surface:** wrinkled, etomentose. **Apothecia:** shortly pedicellate, to 2.5 mm in diam., pedicel tubular; **thalline exciple:** periclinally wrinkled; cortex of thalline exciple multicell layered at base, 1–4 cell layered at margin; **proper exciple:** euparaplectenchymatous at margin, indistinct at centre; **spores:** muriform, with 3–5 transverse and 0–1 longitudinal septa, ellipsoid-fusiform, acute at ends, 19–27 × 9–13 μm.

**Chemistry:** Thallus K–, C–, KC–, P–; no secondary metabolites in TLC.

**Ecology and distribution:** *Microhabitat occupied:* Terricolous-rupicolous; muscicolous-terricolous. In India, the species is widely distributed in Kerala, Maharashtra, Madhya Pradesh, Rajasthan and Sikkim, while species growing on soil is known from localities of Madhya Pradesh and Rajasthan. The species is endemic to India.

**SPECIMENS EXAMINED: INDIA: MADHYA PRADESH, DINDORI DISTRICT,** near Kabie, alt. 1,400 m, on rock over soil, Upreti, Nayaka, Satya 05-005791 (LWG); **RAJASTHAN, SIROHI DISTRICT,** Mt. Abu, near Machgaon, alt. 1,219 m, on mossy soil, S. R. Singh 78.30 (LWG-LWU).

***Leptogium moluccanum*** (Pers.) Vain. (Fig. 2.21h; Fig. 2.47)

Vainio, *Acta Soc. Fauna Fl. Fenn.* 7: 233. 1890.

Basionym: *Collema moluccanum* Pers. in Gaudich., *Voy. Urane.*: 20.3. 1826.

**Thallus:** loosely to closely adnate to the substratum, foliose, up to 4 cm across; **lobes:** orbicular, 4–10 mm wide, 40–60 μm thick, discrete; **margins:** entire; **upper surface:** grey to lead-grey, smooth, lacking isidia; **lower surface:** paler, etomentose. Thallus 40–60 μm thick. **Apothecia:** common, submarginal, sessile to sub-stipitate, constricted at base, 1.2 mm in diam.; **thalline exciple:** creamish; cortex of thalline exciple multicell layered at base; **proper exciple:** euparaplectenchymatous only at margin, indistinct at centre; **spores:** muriform with 3–5 transverse and 0–1 longitudinal septa, 16–30 × 6–11 μm.

**Chemistry:** Thallus K–, C–, KC–, P–; no secondary metabolites in TLC.

**Ecology and distribution:** *Microhabitat occupied:* Muscicolous-terricolous. In India, the species is widely distributed in Andaman and Nicobar Islands, Arunachal Pradesh, Maharashtra, Manipur, Nagaland, Tamil Nadu and West Bengal hills, while species growing on soil is reported from single locality of West Bengal hills. The species is also reported from Australia and Bhutan; South America. It resembles *L. cochleatum* but latter has broader lobes and cellular proper exciple throughout.

**SPECIMEN EXAMINED: INDIA: WEST BENGAL, DARJEELING DISTRICT,** Kurseong, at Dow hill, alt. 5,500 m, on soil with mosses, D. D. Awasthi and M. R. Agarwal 66: 211 (LWU-LWG).

***Leptogium pedicellatum*** P. M. Jørg. (Fig. 2.21i; Fig. 2.47)

Jørgensen, *Herzogia* 3: 448. 1975.

Synonym: *Leptogium menziesii* sensu auct. Ind.

**Thallus:** foliose, up to 10 cm in size, spreading, bluish to greyish blue when dry, dark olivaceous green, translucent, slightly glossy and not much swollen when wet;

**lobes:** broadly orbicular, 5–10 mm wide, in older parts and 10–20 mm wide in peripheral region; **upper surface:** not wrinkled; **lower surface:** paler than the upper surface, densely tomentose, tomentum white to pale brown, hyphae of tomentum free composed of cylindrical cells. **Apothecia:** submarginal to laminal, 0.5–2.5 mm in diam., mostly pedicellate, smooth to wrinkled, rarely tomentose; **disc:** concave to plane, smooth, reddish brown; **thalline exciple:** entire, smooth; **spores:** transversely 3–7-septate, longitudinally 1–2-septate, ellipsoid, usually with beak-like ends,  $28\text{--}37 \times 12\text{--}17 \mu\text{m}$ .

**Chemistry:** Thallus K–, C–, KC–, P–; no secondary metabolites in TLC.

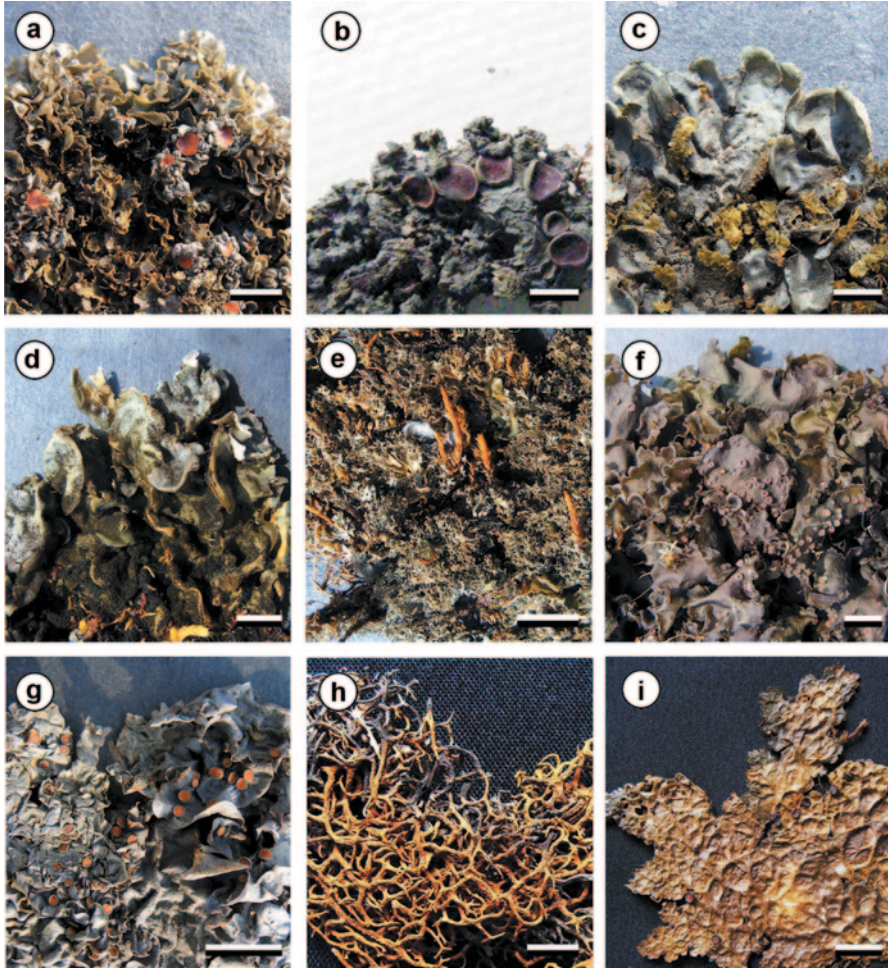
**Ecology and distribution:** *Microhabitat occupied:* Terricolous; terricolous-rupicolous; muscicolous-terricolous; muscicolous-rupicolous. In India, the species is widely distributed in Arunachal Pradesh, Himachal Pradesh, Jammu and Kashmir, Manipur, Sikkim, Uttarakhand and West Bengal hills, while species growing on soil is reported from different localities of Himachal Pradesh, Sikkim, Uttarakhand and West Bengal hills. The species is also reported from Bhutan, China, Japan and Thailand. The species closely resembles to *L. menzeisii*, which has sessile apothecia and small spores.

**SPECIMENS EXAMINED:** **INDIA: HIMACHAL PRADESH, KULLU DISTRICT,** Greater Himalayan National Park, Shilt, alt. 2,800 m, on rock over soil, S. Nayak and R. Srivastava 02-000587 (LWG); **MANDI DISTRICT,** en route from Barot to Winch camp, alt. 2,100 m, on soil among mosses, D. K. Upreti 213541 (LWG); **SHIMLA, Rampur,** Gaura up to 4 km towards Rampur, alt. 1,800 m, on rock over soil, S. Nayaka and R. Srivastava 02-81632 (LWG); Narkanda, 3–4 km towards Hatu peak, alt. 2,800 m, on rock over soil, S. Nayaka and R. Srivastava 02-67188 Dup (LWG); **SIKKIM, NORTH SIKKIM,** Lachen, alt. 3,000 m, on soil, D. K. Upreti, S. Chatterjee and P. K. Divakar 04-003821 (LWG); near Karponang, alt. 2,438, on ground among mosses, D. D. Awasthi 196 (LWG-AWAS); **UTTARAKHAND, BAGESHWAR DISTRICT,** Loharkhet to Dhakuri en route to Pindari, alt. 2,438 m, on mossy soil, D. D. Awasthi and A. M. Awasthi 615 (LWG-AWAS); above Phurkiya towards Pindari glacier, alt. 3,200 m, on ground among mosses, D. D. Awasthi and A. M. Joshi 741 (LWG-AWAS); **CHAMOLI DISTRICT,** between Gondar and Laink, alt. 1,550 m, on rock over soil, A. Singh and M. Ranjan 107086 (LWG); **DEHRADUN DISTRICT,** Mussoorie, Landour, along the road between Kellogg church and GB Hospital alt. 2,108 m, on rock and ground, O. A. Höeg 1449 (LWG-AWAS); Chakrata hills, on stones over soil with mosses, alt. 2,438 m, on rock surface along mosses over soil, D. D. Awasthi and M. Joshi 75.195 (LWG-LWU); **NAINITAL DISTRICT,** Naina peak, alt. 2,377 m, on rock over soil, A. Singh 90260 (LWG); **PITHORAGARH DISTRICT,** Narain Swami Ashram, alt. 2,748 m, on rock over soil, D. K. Upreti and party 2748 (LWG); **RUDRAPRAYAG DISTRICT,** on the way to Kedarnath from Sonprayag to Gaurikund, alt. 1,890 m, on rock surface over soil, 17 Sep 1976, K. Dange 76.29 (LWG-LWU); Mandakini river valley, on the way to Rambara from Kedarnath, alt. 3,165 m, on rock surface over soil, 21 Sep 1976, K. Dange 76.351 (LWG-LWU); on the way from Chopta to Tungnath peak, alt. 3,900 m, on rock surface along mosses over soil, 24 Sep 1976, K. Dange 75.628 (LWG-LWU); **WEST BENGAL, DARJEELING,** Batasi to Pahnajna, alt. 2,134 m, on ground among mosses, D. D. Awasthi 193 (LWG-AWAS).

***Leptogium phyllocarpum* (Pers.) Mont. (Fig. 2.22a; Fig. 2.47)**

Montagne, Ann. Sci. Nat. Bot. ser.3, 10: 134. 1848; Sierk 1964: 295, p. 313, Fig. 46.

Basionym: *Collema phyllocarpum* Persoon in Gaudichaud, Voy. Uran. Bot.: 204. 1826.



**Fig. 2.22** **a** *Leptogium phyllocarpum* var. *phyllocarpum* (Pers.) Mont., **b** *L. platynum* (Tuck.) Herre, **c** *L. pseudopapillosum* P. M. Jørg., **d** *L. saturninum* (Dicks.) Nyl., **e** *L. teretiusculum* (Flörke in Wallr.) Arnold, **f** *L. trichophorum* Müll. Arg., **g** *L. ulvaceum* (Pers.) Vain., **h** *Lethariella cladonioides* (Nyl.) Krog, **i** *Lobaria isidioides* (Müll. Arg.) Vain. Scale in **b**=2 mm; in **a, c, h**=5 mm; in **d, e, f, g, i**=10 mm

var. *phyllocarpum*

**Thallus:** foliose, 2–7 cm in diam., irregularly lobate; **lobes:** elongate, strongly thickened, often anastomosing, 1–2 mm wide; apices rotund, thickened, entire or lobulate; **upper surface:** medium gray to dark gray to black, usually dull, heavily lamellate longitudinal; **lower surface:** pale to medium gray, wrinkled with scattered tufts of white hairs. **Apothecia:** common, submarginal towards lobe tips, sessile, 1–5 mm wide; **disc:** brown to red-brown, concave to plane; **margin:** thal-line, concolorous with the thallus, entire or lobulate, heavily wrinkled; **hymenium:**



120–180 µm high; **paraphyses**: unbranched, 1–2 µm wide, **asci**: cylindrico clavate, 8-spored; **spores**: hyaline, muriform, transversely 3–5-septate, 1 longitudinally septate, ellipsoid to subfusiform, 25–30 × 9–13 µm.

**Chemistry**: Thallus K–, C–, KC–, P–; no secondary metabolites in TLC.

**Ecology and distribution**: *Microhabitat occupied*: Terricolous-rupicolous. In India, the species is widely distributed in Kerala, Madhya Pradesh, Tamil Nadu and Uttarakhand, while species growing on soil is known from different localities of Uttarakhand. The species shows pantropical distribution and reported from Australia, Bhutan, Taiwan and Thailand; tropical and subtropical regions of Africa, America.

**SPECIMENS EXAMINED**: **INDIA**: **UTTARAKHAND**, **CHAMOLI DISTRICT**, between Ransi and Gondar, alt. 1,820 m, on rock over soil, A. Singh and M. Ranjan 106917 (LWG); between Kalimath and Laink, alt. 1,350 m, on rock over soil, A. Singh and M. Ranjan 106883 (LWG); **PITHORAGARH DISTRICT**, Gori Ganga catchment, Thakala forest, alt. 1,400 m, on rock over soil, Vikas Pant 02-000643 (LWG).

***Leptogium platynum*** (Tuck.) Herre (Fig. 2.22b; Fig. 2.47)

Herre, Proc. Washington Acad. Sci. 12: 144. 1910.

Basionym: *Leptogium californicum* var. *platynum* Tuck., Syn. N. Amer. Lich. 1: 159. 1882.

**Thallus**: loosely adnate, to 3 cm across; **lobes**: 4–6 mm wide; **upper surface**: dark grey to brown-black, wrinkled, lacking isidia; **lower surface**: paler, wrinkled, tomentose. **Apothecia**: to 1.8 mm in diam.; **thalline exciple**: wrinkled, cortex of thalline exciple 1–2 cell layered from base to margin; **proper exciple**: euparaplectenchymatous throughout; **spores**: muriform with 4–6 transverse and 1–2 longitudinal septa, ellipsoid to subfusiform, 28–53 × 9–16 µm.

**Chemistry**: Thallus K–, C–, KC–, P–; no secondary metabolites in TLC.

**Ecology and distribution**: *Microhabitat occupied*: Terricolous. In India, the species growing on soil exhibits restricted distribution to Eastern Ghats and Deccan Plateau and known only from Tamil Nadu. The species is also reported from North America.

**SPECIMEN EXAMINED**: **INDIA**: **TAMIL NADU**, **PALNI HILLS**, Berijam, alt. 2,438 m, on ground and bark of tree, D. D. Awasthi and K. P. Singh 70.326 B (LWG-LWU).

***Leptogium pseudopapillosum*** P. M. Jørg. (Fig. 2.22c; Fig. 2.47)

Jørgensen, Symb. Bot. Upsal. 32(1): 120. 1997.

Synonym: *Leptogium menziesii* var. *coralloideum* Jatta, Nuov. Giorn. Bot. Ital. 9: 481. 1902; *Leptogium papillosum* sensu D. Awasthi and Akhtar 1977.

**Thallus**: loosely attached to the substratum, irregularly spreading, 4–8 cm across; **lobes**: orbicular or elongate, 3–8 mm wide, 115–200 µm thick; **margin**: entire, rounded, revolute or involute, sometimes isidiate; **upper surface**: lead-grey when dark, sometimes brown, olivaceous green, slightly swollen when wet, rough, dull, wrinkled, wrinkles most prominent in wet condition, isidiate; **isidia**: usually dense, globular to clavate, solid, often squamiform; **lower surface**: paler, densely tomentose; **tomentum**: white to pale brown, 0.2–1.0 mm long. **Apothecia**: absent.

**Chemistry**: Thallus K–, C–, KC–, P–; no secondary metabolites in TLC.

**Ecology and distribution:** *Microhabitat occupied:* Terricolous-rupicolous. In India, the species is widely distributed in Himachal Pradesh, Kerala, Nagaland, Tamil Nadu and Uttarakhand, while species growing on soil is known from different localities of Himachal Pradesh. The species is also reported from China, Ethiopia and Taiwan.

**SPECIMENS EXAMINED: INDIA: HIMACHAL PRADESH, KULLU DISTRICT,** Great Himalayan National Park, Karoangcha, alt. 1,800–1,900 m, on rocks over soil, D. K. Upreti 99-52637 (LWG); Rolla, alt. 2,000–2,100 m, on rock over soil, S. Nayaka and R. Srivastava 02-001094 (LWG); Ordi, alt. 2,135 m, on rock over soil, S. Nayaka and R. Srivastava 02.001126 (LWG); **SHIMLA,** Rohru, Jubbal, along Sandali naala, alt. 1,650 m, on rock over soil, S. Nayaka and R. Srivastava 02-87174 (LWG).

*Leptogium saturninum* (Dicks.) Nyl. (Fig. 2.22d; Fig. 2.47)

Nylander, Acta Soc. Linn. Bordeaux 21: 272. 1856.

Basionym: *Lichen saturninus* Dicks., Fasc. Pl. Crypt. Brit. 2: 21. 1790.

**Thallus:** 4–10 cm across, adnate, subdichotomously to irregularly lobate; **lobes:** ± plane, separate, 3–10 mm wide, apices rotund, entire to irregularly cut and isidiate; **upper surface:** dark olivaceous gray to almost black, dull or smooth, wrinkled, isidiate; **isidia:** scattered to dense, usually laminal but sometimes marginal, usually granular, black, usually simple and darker than the thallus; **lower surface:** pale to brown, wrinkled, with dense white tomentum of cylindrical cells. **Apothecia:** rare, laminal, sessile, 1–2 mm in diam.; **disc:** brown to red brown, pale to convex; **margin:** thalline; **exciple:** 20–25 µm thick; **hymenium:** 100–120 µm high; **paraphyses:** unbranched, 1–2 µm wide, **asci:** cylindrico-clavate, 8-spored; **spores:** hyaline, muriform, transversely 3–4-septate, longitudinally 1-septate, ellipsoid to subfusiform, 20–25 × 7–10 µm.

**Chemistry:** Thallus K<sup>-</sup>, C<sup>-</sup>, KC<sup>-</sup>, P<sup>-</sup>; no secondary metabolites in TLC.

**Ecology and distribution:** *Microhabitat occupied:* Terricolous-rupicolous; muscicolous-rupicolous. In India, the species is widely distributed in Assam, Himachal Pradesh, Jammu and Kashmir, Madhya Pradesh, Sikkim, Tamil Nadu and Uttarakhand, while species growing on soil is known from different localities of Himachal Pradesh, Jammu and Kashmir and Uttarakhand. The species is also reported from Sri Lanka; Europe and North America.

**SPECIMENS EXAMINED: INDIA: HIMACHAL PRADESH, CHAMBA DISTRICT,** from Brahmaur Hadsar, Mani Mahesh, Doonch, alt. 2,150 m, on rock over soil, Upreti and Nayaka 01.75500 A (LWG); **KULLU DISTRICT,** Manali, alt. 1,829 m, over stones on soil, D. D. Awasthi, M. Agarwal and M. Sc. students s.n. (LWG-LWU); Parbati river valley, on the way to Pulga from Manikaran, alt. 1,800 m, on rock surface over soil, D. D. Awasthi and K. Dange 75054 B (LWG-LWU); **SHIMLA,** Rohru, Chirgona, Sandasu, alt. 1,700 m, on rock over soil, S. Nayaka and R. Srivastava 02-81670 (LWG); **JAMMU AND KASHMIR, ANANTNAG DISTRICT,** Pahalgam, on the way to Baisaran, alt. 2,241 m, on boulders over soil in shady places along with mosses, K. Dange 77.32 (LWG-LWU); **UTTARAKHAND, BAGESHWAR DISTRICT,** 4 km from Loharkhet to Dhakuri, alt. 2,134 m, over stones and ground, D. D. Awasthi 7543 (LWG-AWAS); **CHAMOLI DISTRICT,** Jumma area, alt. 2,800 m, on rock over soil, S. Rawat 06-006816 (LWG); Joshimath, alt. 1,700 m, on rock over soil, S. Rawat 08-010907 (LWG); **PITHORAGARH DISTRICT,** Munsiyari, alt. 2,250 m, on rock over soil, A. Singh 102709 (LWG).

***Leptogium teretiusculum*** (Flörke in Wallr.) Arnold (Fig. 2.22e; Fig. 2.48)

Lich. Fl. München 2: 26. 1892.

Basionym: *Collema teretiusculum* Flörke in Wallroth, Fl. Crypt. Germ. 3: 551. 1831.

**Thallus:** foliose-dwarf fruticose, forming minute crust like cushions, 1–2 cm wide; **lobes:** terete to fairly flattened, 0.1–0.2 mm wide, 0.3–0.9 mm long, apex developing long cylindrical to coralloid isidial-like appendages; **upper surface:** olivaceous brown to brown, smooth, thallus internally paraplectenchymatous and with loosely interwoven chains of *Nostoc*. **Apothecia:** absent.

**Chemistry:** Thallus K–, C–, KC–, P–; no secondary metabolites in TLC.

**Ecology and distribution:** *Microhabitat occupied:* Muscicolous-rupicolous. Earlier the species is widely scattered across the northern hemisphere in Western Europe and North America, now it extends its distribution to India. It is a new record for Indian lichen flora and known only from Uttarakhand, growing over rocks among mosses in temperate regions at an altitude of 2,600 m in Dehradun district.

**SPECIMEN EXAMINED:** **INDIA:** UTTARAKHAND, DEHRADUN DISTRICT, Chakrata Hills, Deoban, 2,760 m, on stones over mosses and soil, D. D. Awasthi and M. Joshi 76–147 (LWG-LWU).

***Leptogium trichophorum*** Müll. Arg. (Fig. 2.22f; Fig. 2.48)

Müller Argoviensis, Flora 72: 505. 1899.

**Thallus:** loosely adnate to the substratum, 5–10 cm across; **lobes:** orbicular, 6–12 mm wide, young lobes with 1 mm long, stiff, white trichomes; **margin:** entire, flat to ascending; white trichomes of hyphal bundles often found in young lobes; **upper surface:** bluish grey to brown black, wrinkled, wrinkles more prominent in older lobes, rarely smooth; **lower surface:** with pale brown tomentum composed of elongate, cylindrical hyphal cells. **Apothecia:** to 2.5 mm in diam.; **thalline exciple:** periclinally wrinkled with dense, white to pale brown trichomes persistent or abraded in mature apothecia; single cell layered at base, 1–2 cell layered at margin; **proper exciple:** euparaplectenchymatous throughout; **spores:** muriform with 3–5 transverse and 1–2 longitudinal septa, ellipsoid, acute at ends, 20–37 × 9–16 µm.

**Chemistry:** Thallus K–, C–, KC–, P–; no secondary metabolites in TLC.

**Ecology and distribution:** *Microhabitat occupied:* Terricolous; terricolous-rupicolous; muscicolous-rupicolous. In India, the species is widely distributed in Arunachal Pradesh, Himachal Pradesh, Manipur, Meghalaya, Nagaland, Sikkim, Uttarakhand and West Bengal hills, while species growing on soil is known from different localities of Sikkim, Uttarakhand and West Bengal hills. The species is also reported from Bhutan, China, Japan and the Philippines.

**SPECIMENS EXAMINED:** **INDIA:** SIKKIM, EAST SIKKIM, Bhusuk area, alt. 2,000 m, on rocks over soil, Upreti and Chatterjee 01-26621 (LWG); NORTH SIKKIM, Near Yumthang, alt. 3,800 m, on soil, Upreti, Chatterjee and Divakar 04-004206 (LWG); UTTARAKHAND, BAGESHWAR DISTRICT, 4 miles from Loharkhet to Dhakuri, alt. 2,134 m, over stones and ground, D. D. Awasthi 7544 (LWG-AWAS); en route to Pindari Glacier, Khati to Dwali, alt. 2,286 m, on soil, S. Joshi and Y. Joshi 07-008845 (LWG); CHAMOLI DISTRICT, between Bagrigad and Wan, alt. 2,250 m, on moss covered rock over soil, Ajay Singh 91581 (LWG); PITHORAGARH DISTRICT, Askot-Dharamghar, near School, alt. 1,981 m, on ground and bark of Quercus tree, D. D. Awasthi 2662 (LWG-AWAS); Munsyari, alt. 2,250 m, on rock over soil, A. Singh 102714 (LWG); Narain Swami Ashram, alt. 2,748 m, on rock over soil,

Upreti, Rai, Joshi, Khare, Dwivedi and Mishra 09-0016993 (LWG); Tikson and Lilam, alt. 1,676 m, on rocks over soil, A. Singh 102765 (LWG); Gori Ganga catchment area, Kauli, alt. 1,450 m, on rock over soil, Vikas Pant 02-000900 (LWG); **RUDRAPRAYAG DISTRICT**, Mandakini river valley, on the way from Gaurikund to Rambara, alt. 2,390 m, on rock surface over soil, K. Dange 76.115 (LWG-LWU); on the way from Chopta to Tungnath, alt. 3,900 m, on rock surface over soil in shady and moist places, K. Dange 76.573 (LWG-LWU); **WEST BENGAL, DARJEELING**, Kurseong, Dow Hill, alt. 1,829 m, on rock over soil, D. D. Awasthi and M. R. Agarwal 66.229 (LWG-LWU).

***Leptogium ulvaceum*** (Pers.) Vain. (Fig. 2.22g; Fig. 2.48)

Vainio, Ann. Acad. Sci. Fenn. ser. A, 15 (6): 38. 1921.

Basionym: *Collema ulvaceum* Pers. in Gaudich., Voy. Uraine. Bot.: 203. 1827.

**Thallus:** loosely adnate, to 4 cm across, loosely adnate to substratum; **lobes:** broad, orbicular, to 15 mm wide, discrete; **margin:** entire, plane to wavy; **upper surface:** dark grey, smooth to rough, rugulose, lacking isidia; **lower surface:** smooth, tomentose. Thallus 85–165 µm thick. **Apothecia:** common, laminal to submarginal, sessile to substipitate, to 2 mm in diam.; **thalline exciple:** creamish or thalline, cortex of thalline exciple multicell layered at base, 1(–3) cell layered at margin; **proper exciple:** euparaplectenchymatous up to centre; **spores:** muriform, with 4–8 transverse and 1–2 longitudinal septa, ellipsoid, 16–32 × 10–13 µm.

**Chemistry:** Thallus K–, C–, KC–, P–; no secondary metabolites in TLC.

**Ecology and distribution:** *Microhabitat occupied:* Terricolous; terricolous-rupicolous. In India, the species is widely distributed in Arunachal Pradesh, Karnataka, Kerala, Madhya Pradesh, Nagaland and Tamil Nadu, while species growing on soil is known from different localities of Kerala, Maharashtra and Tamil Nadu. The species is also reported from Southeast Asia.

**SPECIMENS EXAMINED: INDIA: KERALA, THIRUVANANTHAPURAM DISTRICT**, ABP Athirumala, Pathalamathy, alt. 1,250 m, on soil over rock, Biju Haridas 06-007936 (LWG); **MAHARASHTRA, SATARA DISTRICT**, Mahabaleshwar, alt. 1,375 m, on soil, R. Bajpai 10-013880 (LWG); **TAMIL NADU, PALNI HILLS**, Berijam, alt. 2,438 m, on ground and bark of tree, D. D. Awasthi and K. P. Singh 70.326 A (LWG-LWU); Kodaikanal, Shenbaganur, Tiger Shola, alt. 1,676 m, on ground, D. D. Awasthi and K. P. Singh 70.176 (LWG-LWU).

**LETHARIELLA** (Motyka) Krog (*Parmeliaceae*)

Krog, Norweg. J. Bot. 23: 88. 1976.

**Thallus:** fruticose, erect or pendulous, dichotomously or irregularly branched, heteromerous, corticated; **branches:** terete, round or angular, soft and spongy, ridged, wrinkled or with longitudinal grooves, lacking pseudocyphellae; central chondroid axis rigid or elastic, solid or hollow; photobiont a green alga. **Apothecia:** extremely rare, apical to subapical, lecanorine; disc brown-black, lacking fibrils at margin; **spores:** colourless, simple. Pycnidia not known.

Out of 10 species known from the world, 2 terricolous species are known from India

**Key to the terricolous species of *Lethariella*:**

- 
- |     |   |                        |
|-----|---|------------------------|
| 1.  | Thallus shrubby, ascending, branches rounded, usually uniform in diam., soresiate, gyrophoric acid present .....      | <i>L. cashmeriana</i>  |
| 1a. | Thallus ± decumbent, branches irregular in outline, tapering, esoresiate, psoromic and norstictic acids present ..... | <i>L. cladonioides</i> |
-

***Lethariella cashmeriana*** Krog (Fig. 2.48)

Krog, Norweg. J. Bot. 23: 91. 1976.

**Thallus:** to 5 cm tall, branched; **branches:** strongly ridged and wrinkled, uniformly to 1 mm in diam.; surface orange, pale grey towards base, chondroid axis usually about half the width of branches, with fissures towards centre sorediate; **soralia:** in upper part of branches and spreading; **soredia:** orange. **Apothecia:** not known.

**Chemistry:** Atranorin and canarionic acid in cortex; gyrophoric acid in medulla.

**Ecology and distribution:** *Microhabitat occupied:* Terricolous. In India, the species is exclusively terricolous and rarely distributed in Jammu and Kashmir and Sikkim. Outside India, the species is also reported from China; Karakorum.

**SPECIMEN EXAMINED:** **INDIA:** SIKKIM, NORTH SIKKIM, Yangdi, above Thangu, alt. 4,250 m, on soil, D. K. Upreti, S. Chatterjee and P. K. Divakar 04-003992 (LWG).

***Lethariella cladonioides*** (Nyl.) Krog (Fig. 2.22h; Fig. 2.48)

Krog, Norweg. J. Bot. 23: 93. 1976.

Basionym: *Chlorea cladonioides* Nyl., Syn. Lich. 1(2): 276. 1860.

Synonyms: *Chlorea flexuosa* Nyl., Syn. Lich. 1(2): 276. 1860. -*Usnea flexuosa* (Nyl.) Du Rietz. Svensk. Bot. Tidskr. 20: 91. 1926- *Usnea hookeri* Motyka, Lich. Gen. *Usnea* Stud. Monogr. Pars. Syst.: 45. 1936-38.

**Thallus:** ascending or decumbent, to 5(-10) cm long, branched; **branches:** terete, to 0.8 mm in diam., flexuose, tapering; surface longitudinally ridged and grooved, orange, deep orange or orange grey in upper parts, dark grey to blackish at base; cortex fragile; chondroid axis with strands of pseudoparenchymatous tissue. **Apothecia:** rare, 2-4 mm. in diam.; **thalline exciple:** orange or greyish brown; **spores:** 5-8 × 3-5 μm.

**Chemistry:** Orange part of thallus K+ deep purple-violet. Atranorin, canarionic acid in cortex; medulla with two chemical strains: (1) Psoromic and consporomic acids, (2) norstictic acid only.

**Ecology and distribution:** *Microhabitat occupied:* Terricolous. In India, the species exhibits restricted distribution to Sikkim. Outside India, the species is also reported from Nepal and China. In Sikkim, the thallus is mixed with chilly, salt and garlic, eaten as pickle and used for dyeing wool.

**SPECIMENS EXAMINED:** **INDIA:** SIKKIM, NORTH SIKKIM, Giagaon, above Thangu, alt. 4,600 m, on soil, D. K. Upreti, S. Chatterjee and P. K. Divakar 04-004019 (LWG); Thangu to Goichung, D. C. S. Raju 8845 (BSI-Sikkim).

**LOBARIA** (Schreb.) Hoffm. (*Lobariaceae*)

*Deutschl. Fl.: 138. 1796*

**Thallus:** foliose, dorsiventral, heteromerous, irregularly spreading; **lobes:** branched, the apices rounded or truncate, often incised; upper surface smooth, flat or scrobiculate, often with prominent depressions with a network of ridges; **isidia or lobules:** present or absent; **photobiont:** blue green (*Nostoc* or *Scytonema*) or green algae *Trebouxia*; **medulla:** white; **lower surface:** pale brown to blackish, tomentose, rhizinate, cyphellae or pseudocyphellae absent. **Apothecia:** lecanorine, laminal, subpedicellate, constricted at base; **disc:** reddish brown, eperforate; **hyme-**

**nium:** I+ blue; **asci:** 8-spored; **spores:** colourless to pale brown, acicular or fusiform, transversely 2–7-septate; **paraphyses:** simple. **Pycnidia:** immersed in thalli; conidia rod-shaped.

Out of 67 species known from world, 14 species known from India, out of which 4 are terricolous.

**Key to the terricolous species of *Lobaria*:**

1.	Thallus with isidia.....	2
1a.	Thallus lacking isidia.....	3
2.	Medulla K+ yellow to red, P+ yellow.....	<i>L. isidiosa</i>
2a.	Medulla K-, P-.....	<i>L. retigera</i>
3.	Medulla K+ yellow to red, P+ yellow.....	<i>L. pseudopulmonaria</i>
3a.	Medulla K-, P-.....	<i>L. kurokawae</i>

***Lobaria isidiosa*** (Müll Arg.) Vain. (Fig. 2.22i; Fig. 2.48)

Vainio, Philipp. J. Sci. C, 8: 129. 1913.

Basionym: *Sticta retigera* f. *isidiosa* Müll. Arg., Flora 65: 300. 1882.

Synonyms: *Lobaria retigera* f. *isidiosa* (Müll. Arg.) Müll. Arg., Hedwigia 37: 35. 1898. -*Lobarina awasthiana* Räsänen. Arch. Soc. Zool. Bot. 'Vanamo' 5(1): 28. 1950. -*Lobaria awasthiana* (Ras.) D. D. Awasthi, Beih. Nova Hedwigia, Heft 17: 72. 1965. -*Stictina retigera* f. *isidiosa* Müll Arg., Flora 65: 300. 1882.

**Thallus:** loosely attached, brown, 8–14 cm across; **lobes:** divaricately to irregularly branched, up to 10 mm wide; **upper surface:** yellowish brown to brown, scrobiculate, isidiate; **isidia:** submarginal to laminal, restricted on ridges, granular to cylindrical, simple to coralloid branched; **photobiont:** *Nostoc*; **medulla:** white; **lower surface:** brown to black in grooves, pale brown on convexities, densely tomentose and rhizinate; **tomenta:** veined type, bluish black; **rhizines:** simple to branched, up to 5 mm long. **Apothecia:** not seen.

**Chemistry:** Cortex K-; medulla K+ red, C-, KC-, P+ yellow; norstictic acid and triterpenoids present. Strain (1) Norstictic acid and triterpenoids; strain (2) Norstictic, stictic, constictic acids and triterpenoids of norstictic acid.

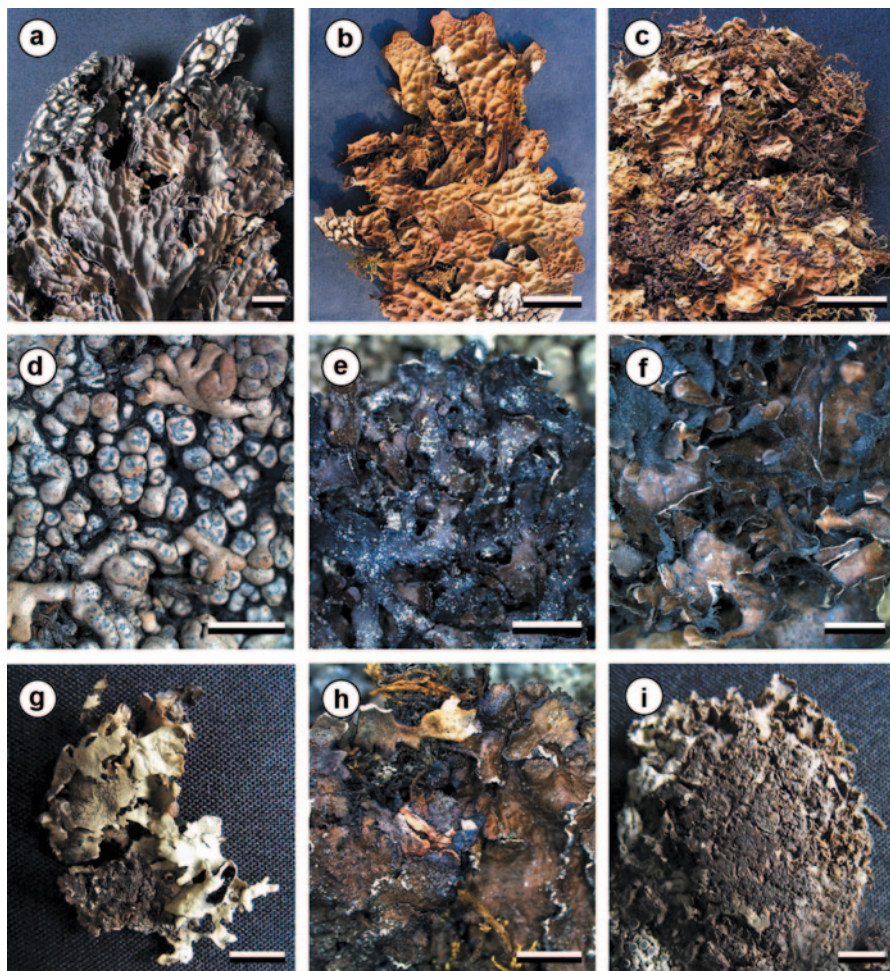
**Ecology and distribution:** *Microhabitat occupied:* Terricolous. In India, the species is widely distributed in Arunachal Pradesh, Nagaland, Sikkim, Uttarakhand and West Bengal hills, while species growing on soil is known from different localities of Sikkim and West Bengal hills. The species is also reported from Nepal; tropical America. The species is closely related to *L. pseudopulmonaria* but latter differs in absence of isidia. *L. isidiosa* resembles to *L. retigera* but the latter species is K-, P- in medulla and lacking norstictic acid.

**SPECIMENS EXAMINED:** **INDIA:** **SIKKIM, EAST SIKKIM,** on the way to Tashi view point, alt. 2,000 m, on soil along roadside, Upreti and Chatterjee 219580-DUP (LWG); **WEST BENGAL, DARJEELING DISTRICT,** Tanglu, alt. 10,075 ft., on soil, P. D. Dogra s.n. (LWG).

***Lobaria kurokawae*** Yoshim. (Fig. 2.23a; Fig. 2.48)

Yoshimura, J. Hattori Bot. Lab. 34: 297. 1971.

**Thallus:** large, loosely attached, brown to brownish black, up to 30 cm across; **lobes:** subdichotomously to irregularly branched, truncate, 8–25 mm wide; **mar-**



**Fig. 2.23** **a** *Lobaria kurokawae* Yoshim., **b** *L. pseudopulmonaria* Gyeln., **c** *L. retigera* (Bory) Trevis., **d** *Lobothallia praeradiosa* (Nyl.) Hafellner, **e** *Melanelia hepatizon* (Ach.) A. Thell, **f** *M. stygia* (L.) Essl., **g** *Melanelixia fuliginosa* (Fr. ex Duby) O. Blanco and al., **h** *M. villosella* (Essl.) O. Blanco and al., **i** *Melanohalea exasperatula* (Nyl.) O. Blanco and al. Scale in **d**, **e**, **f**, **h**=2 mm; in **g**, **i**=5 mm; in **a**, **c**=10 mm; **b**=20 mm

**gin:** ± rotund; upper surface scrobiculate, reticulately ridged; **photobiont:** *Nostoc*; **medulla:** white; **lower surface:** brown-black to black; tomenta and rhizines netted type; **rhizines:** black, branched, up to 3 mm long. **Apothecia:** on ridges, up to 3.5 mm in diam.; **thalline exciple:** verrucose, **spores:** 3-septate, fusiform, 21–28 µm.

**Chemistry:** Cortex K–; medulla K–, C–, KC–, P–; triterpenoids present.

**Ecology and distribution:** *Microhabitat occupied:* Terricolous; terricolous-rupicolous; muscicolous-terricolous; muscicolous-rupicolous. In India, the species

is widely distributed in Arunachal Pradesh, Himachal Pradesh, Manipur, Nagaland, Sikkim, Uttarakhand and West Bengal hills, while species growing on soil is known from different localities of Arunachal Pradesh, Himachal Pradesh, Sikkim and Uttarakhand. The species is also reported from Bhutan, China, Japan, Nepal and Taiwan.

**SPECIMENS EXAMINED:** **INDIA:** **ARUNACHAL PRADESH, WEST KAMENG DISTRICT,** Tawang, alt. 4,000 m, on soil with mosses, Jaishree Rout s.n. (LWG); **HIMACHAL PRADESH, KANGRA DISTRICT,** Tatwani, near hot water spring, alt. 2,200 m, on rocks among mosses over soil, R. Khare and S. Mohabe s.n. (LWG); **KULLU DISTRICT,** Great Himalayan National Park, Around Soupddhar, alt. 3,900 m, on soil along with *Cladonia* under *Rhododendron*, D. K. Upreti 99-53681 (LWG); **SIKKIM, NORTH SIKKIM DISTRICT,** Chubuk, Above Thangu, alt. 4,100 m, on soil, D. K. Upreti, S. Chatterjee and P. K. Divakar 04-003939 (LWG); **UTTARAKHAND, PITHORAGARH DISTRICT,** Johar, Munsiyari, alt. 7,000 ft., on ground among mosses, D. D. Awasthi 843A (LWG-AWAS); Dharchula, before Narayan Swami Ashram, alt. 2,400 m, on soil covered with mosses, D. K. Upreti, L/18409 (LWG); **RUDRAPRAYAG DISTRICT,** way to Tungnath from Chopta, alt. 3,250 m, on soil, D. K. Upreti and S. Nayaka 07-010183 (LWG).

***Lobaria pseudopulmonaria*** Gyeln. (Fig. 2.23b; Fig. 2.48)

Gyelnik. Acta Fauna Fl. Univ. ser. 2,1(5–6): 6. 1933.

**Thallus:** large, loosely attached, brown to dark brown, 10–40 cm across; **lobes:** divaricately to irregularly branched, apices truncate, 10–30 mm wide; **upper surface:** scrobiculate, reticulately ridged; **photobiont:** *Nostoc*; **medulla:** white; **lower surface:** brown to black in grooves, pale brown on convexities, densely tomentose, sparsely rhizinate; **rhizines:** black, simple to branched up to 2 mm long. **Apothecia:** constricted at base, present on ridges in marginal to submarginal region, 1.5–3.5 mm diam.; **margin:** entire; **thalline exciple:** verruculose, connate with parathecium; **disc:** flat to slightly convex; **spores:** transversely 1–3-septate, 24–35 × 7–9 μm.

**Chemistry:** Cortex K–; medulla K+ yellow-red, C–, KC–, P+ yellow-orange; constictic, norstictic, stictic acids and triterpenoids present.

**Ecology and distribution:** *Microhabitat occupied:* Terricolous; tericolous-rupicolous; muscicolous-terricolous. In India, the species is widely distributed in Arunachal Pradesh, Himachal Pradesh, Manipur, Nagaland, Sikkim, Uttarakhand and West Bengal hills, while species growing on soil is known from different localities of Arunachal Pradesh, Himachal Pradesh, Sikkim, Uttarakhand and West Bengal hills. The species is also reported from Alaska, Indonesia, Japan, Nepal, Papua New Guinea and Taiwan. *L. pseudopulmonaria* shows close resemblance to *L. kurokawae*, but in the latter species stictic acid complex absent. It also shows similarity to *L. isidiosa*, but the latter possess isidia.

**SPECIMENS EXAMINED:** **INDIA:** **ARUNACHAL PRADESH, WEST KAMENG DISTRICT,** Bomdila, alt. 2,400 m, on moist soil, B. Dutt and party s.n. (LWG); **HIMACHAL PRADESH, KULLU DISTRICT,** Greater Himalayan National Park, Soupddhar, alt. 3,900 m, on soil, D. K. Upreti 99-53680 (LWG); **SIKKIM, NORTH SIKKIM DISTRICT,** Near Yumthang, alt. 3,800 m, D. K. Upreti, S. Chatterjee and P. K. Divakar 04-004173 (LWG); Yangdi above Thangu, alt. 4,250 m, on soil, Upreti, Chatterjee and Divakar 04-003986 (LWG); **UTTARAKHAND, CHAMOLI DISTRICT,** Bagchu, Patar Nachauni, alt. 4,114 m, on rock over soil, A. Singh 91514 (LWG); **WEST BENGAL, DARJEELING DISTRICT,** Tiger Hill, north face of the hill, alt. 8,500 ft., on ground and twigs of shrubs along with mosses, D. D. Awasthi and M. R. Agrawal 67.30 (LWG).



***Lobaria retigera*** (Bory) Trevis. (Fig. 2.23c; Fig. 2.48)

Trevisan, Lichenotheca Veneta: 75. 1869.

Basionym: *Lichen retigera* Bory, Voya. Princip. Iles Mers-d' Afr. 1: 392. 1804.

Synonyms: *Sticta retigera* (Bory) Ach., Lichenogr. Universalis 455: 1810. -*Stictina retigera* (Bory) Müll. Arg., Flora 61: 484. 1878. -*Lobarina retigera* (Bory) Nyl., Lich. Insul. Guineens.: 10. 1889.

**Thallus:** loosely attached, foliose, pale brown to dark brown, 5–20 cm across; **lobes:** irregularly branched, imbricate, truncate, 10–25 mm wide, apices rotund; **upper surface:** scrobiculate, reticulately ridged, isidiate; **isidia:** dense, usually distributed on reticulate ridges or along the cracks, simple to globular, cylindrical to coralloid branched; **photobiont:** a *Nostoc*; **medulla:** white; **lower surface:** dark-brown to black in grooves, pale brown on convexities, tomentose, rhizinate; **tomenta:** netted type; **rhizines:** simple or squarrose, pale brown to bluish, 1–2 mm long. **Apothecia:** on ridges, up to 4 mm in diam.; **proper exciple:** 120–160 µm thick; **spores:** 3-septate, fusiform, 24–50 × 5–8 µm.

**Chemistry:** Cortex K–; medulla K–, C–, KC–, P–; triterpenes present.

**Ecology and distribution:** *Microhabitat occupied:* Terricolous; tericolous-rupicolous; muscicolous-terricolous. In India, the species is widely distributed in Arunachal Pradesh, Assam, Himachal Pradesh, Manipur, Meghalaya, Nagaland, Sikkim, Tamil Nadu, Uttarakhand and West Bengal hills, while species growing on soil is known from different localities of Uttarakhand. The species is also reported from Australia, Bhutan, Japan, Nepal, New Zealand and Thailand; Africa and North America. Indo-Malesian. *L. retigera* is distinguished from *L. isidiosa* by absence of norstictic, constictic and stictic acids. It shows close resemblance to *L. kurokawae*, but latter differs in absence of isidia.

**SPECIMENS EXAMINED: INDIA: UTTARAKHAND, PITHORAGARH DISTRICT,** Narayan Swami Ashram, alt. 2,748 m, on soil with mosses, D. K. Upreti, S. Joshi, H. Rai, R. Khare, G. K. Mishra and A. Dwivedi 09-013554 (LWG); **UTTARKASHI DISTRICT,** Govind Wildlife Sanctuary, on the way from Sankri to Taluka, 1 km before Taluka, alt. 1,970 m, on rocks over soil, D. K. Upreti, S. Nayaka and R. Bajpai 11-013270 (LWG).

**LOBOTHALLIA** (Clauzade and Cl. Roux) Hafellner (*Megasporaceae*)

Hafellner, Acta Bot. Malacitana 16 (1): 138. 1991.

**Thallus:** orbicular, adnate, effigurate, areolate-verrucose at centre, distinctly lobate at periphery; **upper surface:** corticated; **photobiont:** a green alga. **Apothecia:** cryptolecanorine; **thalline margin:** distinct; **epithecium:** yellowish brown, HNO<sub>3</sub>– or + yellow; **paraphyses:** simple; **asci:** 4–8-spored; **spores:** colourless, simple.

Out of 4 species known from world, 3 are from India; single terricolous.

***Lobothallia praeradiosa*** (Nyl.) Hafellner (Fig. 2.23d; Fig. 2.48)

Hafellner, Acta Bot. Malacitana 16(1): 138. 1991.

Basionym: *Lecanora praeradiosa* Nyl., Flora 67: 389. 1884.

Synonym: *Aspicilia praeradiosa* (Nyl.) Poelt and Leuck., Wildenowia 7(1): 25.1973- **Thallus:** on soil among mosses, adnate, crustose-effigurate, up to 4 cm across; centrally verrucose-areolate; **marginal lobes:** lacinate, flat, solid, 2–5 mm long, 1–3 mm wide; **upper surface:** brownish grey to reddish grey, often pruinose. **Apothecia:** up to 3 mm in diam.; **disc:** red to reddish brown, convex; **spores:**

9–11 × 7 μm (fide: Nylander, op. cit.) and 10–22 × 6–12 μm (fide: Upreti and Chatterjee 2002).

**Chemistry:** Medulla K<sup>+</sup> red to blood red, C<sup>-</sup>, P<sup>+</sup> red. Norstictic acid present.

**Ecology and distribution:** *Microhabitat occupied:* Terricolous-rupicolous; muscicolous-terricolous; muscicolous-rupicolous. In India, the species is widely distributed in Himachal Pradesh, Jammu and Kashmir and Uttarakhand while species growing on soil is known from different localities of Uttarakhand. Outside India, the species is also reported from Northern Asia and Europe.

**SPECIMENS EXAMINED: INDIA: UTTARAKHAND, BAGESHWAR DISTRICT,** near zero mile to Pindari glacier on ridge of moraine, alt. 3,657.6 m, on soil over stones with mosses, D. D. Awasthi 7715 (LWG); on way from Phurkiya to Mirtoli, alt. 3,474.72 m, on soil, over boulders and on stones, D. D. Awasthi 7748 (LWG).

### MELANELIA Essl. (*Parmeliaceae*)

Esslinger, Mycotaxon 7: 46. 1978.

**Thallus:** foliose, lobes narrow, eciliate; **upper surface:** olive-brown to brown-black, with or without effigurate pseudocyphellae, isidia and soredia; **lower surface:** black with simple or furcate rhizines; **photobiont:** a green alga (*Trebouxia*). Upper cortex HNO<sub>3</sub><sup>-</sup> or + pale red, medulla usually with perlatolic and stenosporic acids.

Out of 42 species known from world, 6 are known from India, of which 2 are terricolous.

#### Key to the terricolous species of *Melanelia*:

- 
- |     |   |                     |
|-----|---|---------------------|
| 1.  | Thallus isidiate, medulla P <sup>+</sup> orange-red (stictic and norstictic acids)..... | <i>M. hepatizon</i> |
| 1a. | Thallus lacking isidia, P <sup>+</sup> orange (fumarprotocetraric acid).....            | <i>M. stygia</i>    |
- 

### *Melanelia hepatizon* (Ach.) A. Thell (Fig. 2.23d; Fig. 2.48)

Thell, Nova Hedwigia 60: 419. 1995.

Basionym: *Lichen hepatizon* Ach., Lichenogr. Suec. Prodr.: 110. 1798.

Synonyms: *Cetraria hepatizon* (Ach.) Vain., Lich. Cauc. Taur.: 278. 1899. -*Tuckermannopsis hepatizon* (Ach.) Kurok., J. Jap. Bot. 66: 158. 1991.

**Thallus:** foliose, up to 1.5 cm across; **lobes:** up to 3 mm wide, ± convex; **upper surface:** dark brown to brown-black with short, black pycnidial papillae, lobe margins more or less distinctly rimmed; **pseudocyphellae:** restricted to vicinity of lobe margins (but not actually marginal); lacking isidia and soredia; **lower surface:** typically blackening, rhizinate. **Apothecia:** up to 1 mm in diam.; **spores:** 8–12 × 5–7.5 μm.

**Chemistry:** Medulla K<sup>-</sup>, C<sup>-</sup>, P<sup>+</sup> orange. Stictic and norstictic acids present.

**Ecology and distribution:** *Microhabitat occupied:* Terricolous; terricolous-rupicolous. In India, the terricolous species is widely distributed in Sikkim and Uttarakhand. Outside India, the species is also reported from Europe and North America.

**SPECIMENS EXAMINED: INDIA: SIKKIM, NORTH SIKKIM DISTRICT,** Yangdi, above Thangu, alt. 4,250 m, on soil, D. K. Upreti, S. Chatterjee, P. K. Divakar 04-003978 (LWG); Chubuk, above Thangu, alt. 4,100 m, on soil, D. K. Upreti, S. Chatterjee, P. K. Divakar 04-003918 (LWG); **UTTARAKHAND, UTTARKASHI DISTRICT,** on way to Gomukh, near Bhojwasa, alt.

3,658 m, on ground, D. D. Awasthi and S. R. Singh, 8379 (LWG-AWAS); Gomukh area, right bank, 5th moraine, alt. 3,840 m, on soil, D. D. Awasthi and S. R. Singh, 8540 C (LWG-AWAS); Gangotri-Gomukh trek, Chirwasa, alt. 3,500 m, on rock over soil, S. Chatterjee and P. K. Divakar, 02-000182 B (LWG).

***Melanelia stygia* (L.) Essl.** (Fig. 2.23f; Fig. 2.48)

Esslinger, Mycotaxon 7(1): 47.1978. 283

Basionym: *Lichen stygius* L., Sp. Pl.: 1143. 1753.

Synonym: *Parmelia stygia* (L.) Ach., Methodus: 203. 1803.

**Thallus:** foliose, loosely adnate to the substratum, rosetiform, orbicular to pulvinate, up to 5 cm across; **lobes:** concave to convex, linear elongate, up to 2 mm wide; **upper surface:** olive-brown to darker, without cortical hairs, dull to shining at periphery, lacking isidia and soredia, pseudocyphellate; **pseudocyphellae:** submarginal to laminal, irregular to effigurate, whitish to dark; **lower surface:** black, moderately rhizinate; **rhizines:** simple, black. **Apothecia:** rare, up to 5 mm in diam.; **spores:** 10–15 × 4.5–8 µm.

**Chemistry:** Upper cortex K<sup>-</sup>, HNO<sub>3</sub><sup>-</sup>; medulla K<sup>-</sup>, C<sup>-</sup>, KC<sup>-</sup>, P<sup>+</sup> orange or P<sup>-</sup>. Caperic acid always present, fumarprotocetraric acid present or rarely absent.

**Ecology and distribution:** *Microhabitat occupied:* Terricolous; terricolous-rupicolous; muscicolous-rupicolous. In India, the species is widely distributed in Himachal Pradesh, Sikkim, Tamil Nadu, Uttarakhand and West Bengal hills while species growing on soil is known from different localities of Himachal Pradesh and Uttarakhand. Outside India, the species is also reported from temperate Asia, Europe, North America, Siberia and Japan.

**SPECIMENS EXAMINED: INDIA: HIMACHAL PRADESH, KULLU DISTRICT,** Great Himalayan National Park, alt. 2,800 m, on soil among mosses over rocks, D. K. Upreti 99-53661 (LWG); **UTTARAKHAND, CHAMOLI DISTRICT,** Patar nachauni, alt. 3,318 m, on soil, A. Singh 91507 (LWG); **RUDRAPRAYAG DISTRICT,** Kedarnath valley, around Kedarnath Temple, alt. 3,500 m, on soil over rocks, D. K. Upreti, P. K. Divakar and B. Kumar 06-006222 (LWG); Tungnath Bugyal, alt. 3,400 m, on soil over rocky slope in open grassland, Himanshu Rai and Pramod Nag 08-0012246 (LWG).

**MELANELIXIA** O. Blanco et al. (*Parmeliaceae*)

Mycol. Res. 108(8): 881. 2004.

**Thallus:** foliose, adnate; **lobes:** up to 6 mm wide, eciliate, heteromerous, corticated on both surfaces; **photobiont:** a green alga; **upper surface:** usually dark brown, lacking pseudocyphellae; with or without isidia, soredia and cortical hairs; **epicortex:** fenestrate or pored; **lower surface:** brown-black with simple rhizines; **medulla:** white or pigmented. **Apothecia:** lecanorine; asci 8-spored; **spores:** colourless, simple. **Pycnoconidia:** fusiform to cylindrical. Upper cortex HNO<sub>3</sub><sup>-</sup> or + yellow, medulla with lecanoric acid.

Out of 8 species known from world, 6 are from India, of which 2 are terricolous.

**Key to the terricolous species of *Melanelixia*:**

- 
- |     |                                     |                      |
|-----|-------------------------------------|----------------------|
| 1.  | Thallus with cortical hairs.....    | <i>M. villosella</i> |
| 1a. | Thallus lacking cortical hairs..... | <i>M. fuliginosa</i> |
-

***Melanelixia fuliginosa*** (Fr. ex Duby) O. Blanco et al. (Fig. 2.23g; Fig. 2.48)

Blanco et al., Mycol. Res. 108(8): 382. 2004.

Basionym: *Parmelia olivacea var. fuliginosa* Fr. ex Duby, Bot. Gall. 2: 602. 1830.

Synonyms: *Melanelixia fuliginosa* (Fr. ex Duby) Essl. In Egan, Bryologist 90: 163. 1987. -*Parmelia fuliginosa* \* *P. glabratula* Lamy, Bull. Soc. Bot. France 34: 353. 1883. -*Parmelia glabratula* (Lamy) Nyl., Flora 66: 532. 1883. -*Melanelixia glabratula* (Lamy) Essl., Mycotaxon 7: 48. 1978.

**Thallus:** adnate, up to 5 cm across; **lobes:** up to 3 mm wide; upper **surface** olive-brown to darker; **upper surface:** olive-brown to blackish brown, lacking cortical hairs, dull but shining near the periphery, densely isidiate, pseudocyphellae and soredia absent; **isidia:** globular, cylindrical or knob shaped, solid, often with white spot at apices; **lower surface:** light brown, rhizinate; **rhizines:** concolorous with the lower surface. **Apothecia:** up to 2 mm in diam., isidiate; **spores:** subglobose, 9–13 × 6–9 μm.

**Chemistry:** Upper cortex K<sup>-</sup>, HNO<sub>3</sub><sup>-</sup>; medulla K<sup>-</sup>, C<sup>+</sup> red, KC<sup>+</sup> red, P<sup>-</sup>. Lecanoric acid and an unknown substance in medulla.

**Ecology and distribution:** *Microhabitat occupied:* Muscicolous-terricolous. In India, the species is widely distributed in Jammu and Kashmir and Uttarakhand, while species growing on soil is rarely known from single locality of Uttarakhand. The species is also reported from Southern Scandinavia, Europe, North America and Morocco.

**SPECIMEN EXAMINED: INDIA: UTTARAKHAND, UTTARKASHI DISTRICT,** Gomukh area, alt. 3,600 m, on soil with mosses, Awasthi and Singh 8540/A (LWG-AWAS).

***Melanelixia villosella*** (Essl.) O. Blanco et al. (Fig. 2.23h; Fig. 2.48)

Blanco et al. Mycol. Res. 108(8): 882. 2004.

Basionym: *Parmelia villosella* Essl., J. Hattori Bot. Lab. 42: 95. 1977.

Synonym: *Melanelixia villosella* (Essl.) Essl., Mycotaxon 7: 49. 1978.

**Thallus:** foliose, loosely attached to the substratum, up to 7 cm across; **lobes:** contiguous, marginally ascendant, 2–5 mm wide; **upper surface:** olive reddish brown, smooth to wrinkled-rugose, with dense hyaline cortical hairs, isidiate; **isidia:** dense, cylindrical, simple to branched; **medulla:** white; **lower surface:** brown, paler on lobe apices, sparsely rhizinate; **rhizines:** concolorous with the lower surface. **Apothecia:** up to 4(–8) mm in diam.; **spores:** ellipsoid 12–17 × 5–8(–10) μm.

**Chemistry:** Upper cortex K<sup>-</sup>, HNO<sub>3</sub><sup>-</sup>; medulla K<sup>-</sup>, C<sup>+</sup> red; Lecanoric acid and an unknown substance present.

**Ecology and distribution:** *Microhabitat occupied:* Terricolous; terricolous-rupicolous. In India, the species is widely distributed in Himachal Pradesh, Jammu and Kashmir and Uttarakhand while species growing on soil is known from different localities of Uttarakhand. The species is also reported China and Pakistan; North America.

**SPECIMENS EXAMINED: INDIA: UTTARAKHAND, CHAMOLI DISTRICT,** Badrinath, North of Temple, on way to Mana village, alt. 3,200 m, on soil, K. Dange 02-000408 A (LWG); near Badrinath, Mana to Vasudhara, alt. 3,340 m, on soil over rocks, D. K. Upreti and S. Nayaka 07-010142 (LWG); **UTTARKASHI DISTRICT,** Gangotri, alt. 3,200 m, on rocks over soil, S. Chatterjee and P. K. Divakar 02-000182 C (LWG); Gangotri, towards Kedartal, alt.

3,100 m, on rocks over soil, S. Chatterjee and P. K. Divakar 02-000426 B (LWG); Gangotri, alt. 3,133 m, on soil (ground), Himanshu Rai and Pramod Nag 10-0014507 (LWG).

**MELANOHALEA** O. Blanco et al. (*Parmeliaceae*)

Mycol. Res. 108(8): 882.2004

**Thallus:** foliose, adnate; **lobes:** eciliate, heteromerous, corticated on both surfaces; **upper surface:** olive-green to dark brown, with or without isidia and soredia; **pseudocyphellae:** on warts or on tips of isidia; **photobiont:** a green alga; **medulla:** white; **lower surface:** with simple rhizines. **Apothecia:** laminal, lecanorine, brown; **asci:** apically thickened, 8–32-spored; **spores:** colourless, simple. **Pycnoconidia:** cylindrical to fusiform. Upper cortex  $\text{HNO}_3^-$ .

Out of 20 species known from world, 8 are from India, of which 1 is terricolous.

*Melanohalea exasperatula* (Nyl.) O. Blanco et al. (Fig. 2.23i; Fig. 2.48)

Blanco et al., Mycol. Res. 108(8): 882. 2004.

Basionym: *Parmelia exasperatula* Nyl., Flora 56: 299. 1873.

Synonym: *Melanelia exasperatula* (Nyl.) Essl., Mycotaxon 7: 47. 1978.

**Thallus:** loosely adnate to the substratum, orbicular; **lobes:** 2–5 mm wide, flat, broadly rounded, contiguous; **upper surface:** olive-brown to darker, dull to shining at apices, pseudocyphellae absent, isidiate; **isidia:** inflated, mostly laminal, clavate to spathulate, hollow; **lower surface:** pale brown, rhizinate; **rhizines:** simple, concolorous with the thallus. **Apothecia and pycnidia:** not seen in the specimen.

**Chemistry:** Upper cortex  $\text{K}^-$ ,  $\text{HNO}_3^-$ ; medulla  $\text{K}^-$ ,  $\text{C}^-$ ,  $\text{KC}^-$ ,  $\text{P}^-$ . No lichen substance present.

**Ecology and distribution:** *Microhabitat occupied:* Terricolous. In India, the species is widely distributed Jammu and Kashmir and Uttarakhand while species growing on soil is rarely known from single locality of Uttarakhand. In the world, the species is also reported from China and Pakistan; Europe, North America and Siberia.

**SPECIMEN EXAMINED:** **INDIA: UTTARAKHAND, UTTARKASHI DISTRICT,** on way to Gomukh, right bank, 6th moraine, alt. 3,800 m, over soil, Awasthi and Singh 8540/B (LWG-AWAS).

**MYCOBILIMBIA** Rehm. (*Ramalinaceae*)

Rabenh.Krypt.-Fl., ed. 2, 1(3): 295, 327. 1890.

**Thallus:** crustose, effuse, corticated; **photobiont:** a green alga (*Chlorococcaceae*). **Apothecia:** lecidiene, hypothecium colourless, to brown black; **asci:** 8-spored; **spores:** colourless, transversely 3–4-septate, fusiform to ellipsoid.

Out of 26 species known from world, 3 are known from India; 2 terricolous.

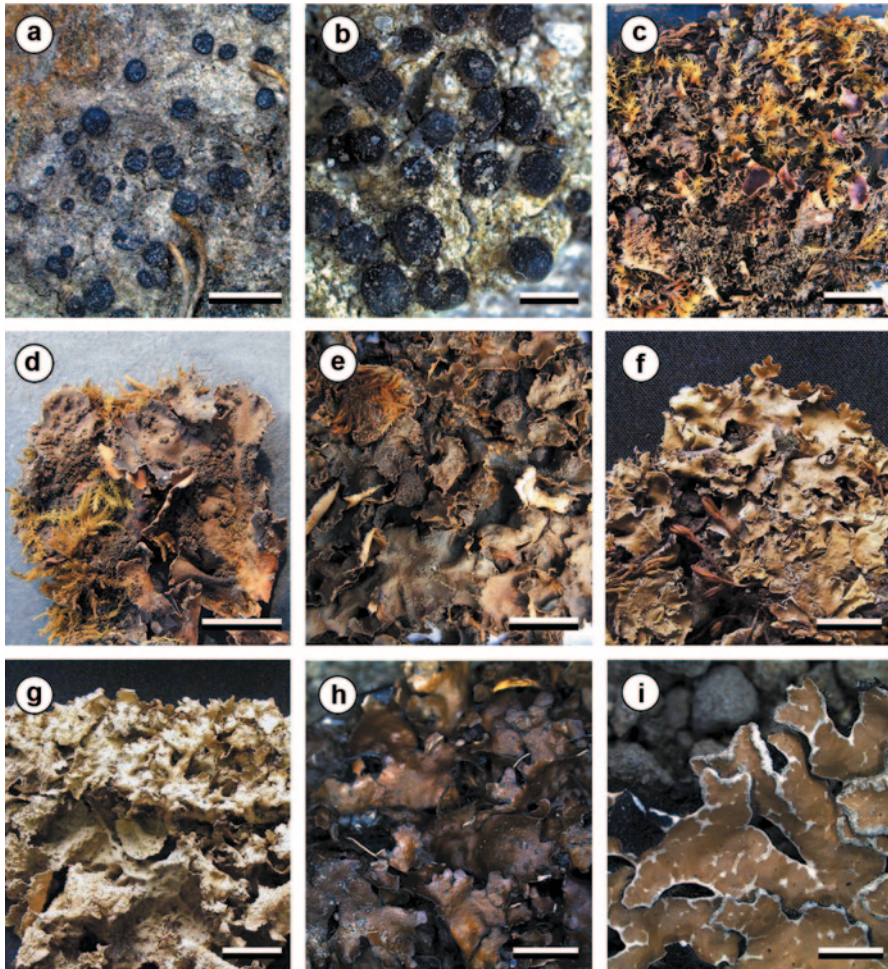
**Key to the terricolous species of *Mycobilimbia*:**

- 
- |  |                      |
|--|----------------------|
| 1. Thallus brownish, granulose, exciple $\text{K}^+$ violet-brown..... | <i>M. hunana</i>     |
| 1a. Thallus grey, exciple $\text{K}^-$ .....                           | <i>M. philippina</i> |
- 

*Mycobilimbia hunana* (Zahlbr.) D. D. Awasthi (Fig. 2.24a; Fig. 2.48)

In D. D. Awasthi, Proc. Indian Acad. Sci., Pl. Sci 97(6): 501. 1987.

Basionym: *Bacidia hunana* Zahlbr. in Hand.-Mazz., Symb. Sin. 3: 113. 1930. **Thallus:** cracked; **surface:** grey, granulose. **Apothecia:** single or in groups, 0.2–0.8 mm



**Fig. 2.24** **a** *Mycobilimbia hunana* (Zahlbr.) D. D. Awasthi, **b** *M. philippina* (Vain.) D. D. Awasthi, **c** *Nephroma helveticum* var. *helveticum* Ach., **d** *N. isidiosum* (Nyl.) Gyeln., **e** *N. parile* (Ach.) Ach., **f** *Nephromopsis ahtii* (Randlane and Saag) Randlane and Saag, **g** *N. nephromoides* (Nyl.) Ahti and Randlane, **h** *Parmelia masonii* Essl. and Poelt, **i** *P. sulcata* Taylor in J. Mackay. Scale in **b** = 1 mm; in **a**, **h**, **i** = 2 mm; in **c**, **d**, **e**, **f**, **g** = 10 mm

in diam., plane to convex; **disc**: dark brown to black, epruinose; **margin**: entire, pale yellow; **exciple**: red-brown, 54–77  $\mu\text{m}$  thick at margin, K+ violet-brown, fading below; **epithecium**: red-brown, 12–14  $\mu\text{m}$  thick, K–; **hymenium**: hyaline, 76–92  $\mu\text{m}$  thick, K–, I+ deep blue; **hypotheecium**: pale red-brown, 38–50  $\mu\text{m}$  thick, K–; **asci**: cylindrico-clavate, 8-spored; **paraphyses**: colourless, simple; **spores**: colourless, oblong-ellipsoid to rarely fusiform, both the ends rounded, sometimes one end slightly tapering than the other, transversely 3-septate, 21.4–28  $\times$  6.8–8.9  $\mu\text{m}$ .

**Chemistry:** Thallus K<sup>-</sup>, C<sup>-</sup>, KC<sup>-</sup>, P<sup>-</sup>; no secondary metabolites in TLC.

**Ecology and distribution:** *Microhabitat occupied:* Terricolous; terricolous-rupicolous. In India, the species is exclusively terricolous and widely distributed in Nagaland, Uttarakhand and West Bengal hills. Outside India, the species is also reported from China and Nepal.

**SPECIMENS EXAMINED:** **INDIA:** UTTARAKHAND, RUDRAPRAYAG DISTRICT, Guptakashi, 2 km from temple in forest, alt. 1,350 m, on rock surface over hard soil, K. Dange, 76.518 (LWG-LWU); **WEST BENGAL, DARJEELING DISTRICT,** Pashok road, at about 7 miles from Darjeeling, alt. 1,981 m, on soil by road surface, D. D. Awasthi and M. R. Agarwal 67.175 (LWG-LWU); Kalimpong division, on way to Munsong from Kalimpong, alt. 1,524 m, on hard soil by road surface, D. D. Awasthi and M. R. Agarwal 67.326 B (LWG-LWU).

*Mycobilimbia philippina* (Vain.) D. D. Awasthi (Fig. 2.24b; Fig. 2.48)

In D. D. Awasthi, Proc. Indian Acad. Sci., Pl. Sci. 97(6): 501. 1987.

Basionym: *Bilimbia philippina* Vain., Ann. Acad. Sci. Fenn., Ser. A 15(no. 6): 76. 1920.

Synonym: *Bacidia philippina* (Vain.) Zahlbr., Cat. Lich. Univ. 4: 136.1926.

**Thallus:** cracked; **upper surface:** grey, furfuraceous. **Apothecia:** single or in groups, 0.5–1 mm in diam., plane to convex; **disc:** black, epruinose; **margin:** entire, brown; **exciple:** red-brown, 68–82  $\mu\text{m}$  thick at margin, K<sup>-</sup>, fading below; **epithecium:** red-brown, 11–16  $\mu\text{m}$  thick, K<sup>-</sup>; **hymenium:** hyaline, 70–80  $\mu\text{m}$  thick, K<sup>-</sup>, I<sup>+</sup> deep blue; **hypothecium:** pale yellow, 39–46  $\mu\text{m}$  thick, K<sup>-</sup>; **asci:** cylindrico-clavate, 8-spored; **paraphyses:** colourless, simple to branched; **spores:** colourless, oblong-ellipsoid to rarely fusiform, both the ends rounded, transversely 3-septate, 19–31.2  $\times$  5.2–6.2  $\mu\text{m}$ .

**Chemistry:** Thallus K<sup>-</sup>, C<sup>-</sup>, KC<sup>-</sup>, P<sup>-</sup>; no secondary metabolites in TLC.

**Ecology and distribution:** *Microhabitat occupied:* Terricolous; terricolous-rupicolous. In India, the species is exclusively terricolous and widely distributed in Arunachal Pradesh, Manipur, Meghalaya, Nagaland, Uttarakhand and West Bengal hills. Outside India, the species is also reported only from Phillipines.

**SPECIMENS EXAMINED:** **INDIA:** ARUNACHAL PRADESH, DIBANG VALLEY DISTRICT, Sally Lake, Roing, alt. 300 m, on soil, D. K. Upreti and M. Ranjan 201565 (LWG); **MEGHALAYA, SHILLONG,** Upper Shillong peak, alt. 1,829 m, on ground, D. D. Awasthi 6458, 6479 (LWG-AWAS); **UTTARAKHAND, CHAMPAWAT DISTRICT,** Devidhura, alt. 1,700 m, on rock over calcareous soil, G. K. Mishra 10-015029 (LWG); **DEHRADUN DISTRICT,** Chakrata hills, on way to Deoban, alt. 2,438 m, on stones over soil, 22 Jun 1976, D. D. Awasthi and M. Joshi, 76.46 (LWG-LWU); **WEST BENGAL, DARJEELING DISTRICT,** Darjeeling-Pashok road, at about 6–7 miles from Darjeeling, alt. 1,981 m, on soil by road surface, D. D. Awasthi and M. R. Agarwal 67.174 (LWG-LWU); Kurseong, Dow hill, alt. 1,981 m, on soil, D. D. Awasthi and M. R. Agarwal 66.273 (LWG-LWU); Kalimpong division, way to Munsong from Kalimpong, alt. 4,750 m, on bare soil in shady area, D. D. Awasthi and M. R. Agarwal 67.326 A (LWG-AWAS).

**NEPHROMA** Ach. (*Nephromataceae*)

In Luyken, Tent. Hist. Lich.: 92. 1809

**Thallus:** foliose, wide lobed, heteromerous, corticated on both surfaces; **upper surface:** greenish yellow or brown, with or without isidia, soredia, regeneration squamules (phyllidia) and marginal teeth; **lower surface:** glabrous, tomentose or

rhizinate; medulla of loose hyphae; **photobiont**: either a green alga (*Coccomyxa*) or a cyanobacterium (*Nostoc*); **endotrophic cephalodia**: present in taxa with green alga as primary photobiont. **Apothecia**: present on the lower surface of lobe ends, rounded or reniform, nephromoid; **disc**: light to dark brown, lecanorine; **hypothecium**: colourless; **paraphyses**: simple; **asci**: clavate, 8-spored; **spores**: light brown, 3-septate, fusiform to ellipsoid.

Out of 36 species known from world, 6 are from India, of which 4 are terricolous.

#### Key to the terricolous species of *Nephroma*:

1.	Photobiont a green alga, endotrophic cephalodia with <i>Nostoc</i> present in lower part of medulla.....	<i>N. expallidum</i>
1a.	Photobiont a blue green alga ( <i>Nostoc</i> ).....	2
2.	Thallus marginally sorediate, isidia absent.....	<i>N. parile</i>
2a.	Thallus isidiolate, soredia absent.....	3
3.	Isidia along ridges and margins, simple to coralloid branched.....	<i>N. isidiosum</i>
3a.	Isidia marginal or laminal, flat to Squamulose, lower surface densely pubescent, without papillae.....	<i>N. helveticum</i>

#### *Nephroma expallidum* (Nyl.) Nyl. (Fig. 2.48)

Nylander, Flora 48: 428.1865.

Basionym: *Nephromium expallidum* Nylander, Öfvers. Kongl. Vetensk.-Akad. Förh. 17: 295. 1860.

**Thallus**: terricolous; **lobes**: large, crowded; **upper surface**: greenish grey, pruinose or pubescent; **lower surface**: dark, tomentose; **photobiont**: a green alga; **cephalodia**: with *Nostoc* in medulla near lower cortex. **Apothecia**: up to 10 mm in diam.; **spores**: 17–21 × 5–6 µm. The species description is based on D. Awasthi, 2007.

**Chemistry**: Medulla K–, P–. Zeorin and nephrin present.

**Ecology and distribution**: *Microhabitat occupied*: Terricolous. In India, the species is reported from Jammu and Kashmir (D. Awasthi 1965, 2007). Outside India, the species is also reported from arctic and alpine regions of Europe and North America. The specimen pertaining to the species was not traceable during study.

#### *Nephroma helveticum* Ach.

Acharius, Lichenogr. Universalis 523. 1810.

Synonym: *Nephromium tropicum* Müll. Arg, Flora 66: 21. 1883. -*Nephroma tropicum* (Müll. Arg.) Zahlbr., Cat. Lich. Univ. 3: 442. 1925. -var. *helveticum* (Fig. 2.24c; Fig. 2.48).

**Thallus**: continuously or irregularly forming rosettes, loosely attached, lobate, 3–6 cm across; **lobes**: irregularly branched, imbricate or discrete, 3–8 mm wide; **margin**: with indentations, broad lobules or small teeth, 0.2–0.3 mm long, with ascending tips; **upper surface**: usually medium to dark brown, or red brown, glabrous, wrinkled, shining, squamulose, tips pubescent on back of apothecia; **isidia and squamule**: usually marginal, flattened; **medulla**: white to pale brownish; **lower surface**: black to dark brown. **Apothecia**: common, immersed on lower surface at tips of lobes, cup shaped, sessile, dorsal surface scabris and often markedly honey combed,



rounded to oblong, 2–6 mm diam.; **disc:** dark brown; **exicple:** hyaline or light brown; **spores:** oblong to fusiform, 3-septate,  $18\text{--}25 \times 4\text{--}8 \mu\text{m}$ , spore wall thin light brown.

**Chemistry:** Medulla K+ pale yellow, K-, C-, KC-, P-, medulla with triterpenes.

**Ecology and distribution:** *Microhabitat occupied:* Terricolous; terricolous-rupicolous; muscicolous-terricolous; muscicolous-rupicolous. In India, the species is widely distributed in Himachal Pradesh, Manipur, Nagaland, Sikkim, Tamil Nadu and Uttarakhand while species growing on soil is known from various localities of Sikkim and Uttarakhand. Outside India, the species is also reported from Bhutan, Hawaii Islands, Nepal and Sri Lanka; Europe.

**SPECIMENS EXAMINED: INDIA: SIKKIM, NORTH SIKKIM DISTRICT,** near Yumthang, alt. 3,800 m, on soil, D. K. Upreti, S. Chatterjee and P. K. Divakar 04-004164 (LWG); Yangdi, after Thangu, alt. 4,250 m, on soil over rocks, D. K. Upreti, S. Chatterjee and P. K. Divakar 04-003955 (LWG); Lachen, alt. 3,000 m, on soil over rocks, D. K. Upreti, S. Chatterjee and P. K. Divakar 04-003743(LWG); **UTTARAKHAND, CHAMOLI DISTRICT,** between Ghangariya and Hemkund, alt. 3,600 m, on soil covered rock with mosses, A. Singh 85821(LWG); Gondar, alt. 1,850 m, on rock over soil, A. Singh and M. Ranjan 106918(LWG); en route from Ghangaria to valley of flowers, alt. 3,050 m, on rocks over soil, 20 Sep 2006, S. Rawat 06-007118 (LWG); Malari, alt. 3,300 m, on soil, S. Rawat, 06-006865 (LWG); near Badrinath way from Mana to Vasudhara, alt. 3,350 m, on rock over soil, D. K. Upreti and S. Nayaka 07-010116 (LWG); Belta, en route to NDBR, alt. 3,300 m, on rock over soil, S. Rawat 08-011024 (LWG); **PITHORAGARH DISTRICT,** Munsiyari, on way to Khaliya top, before Bhujani, alt. 2,800 m, on soil over boulders among mosses, D. K. Upreti 212905 (LWG); Dharchula, Narain Swami Ashram, alt. 2,400 m, on soil, D. K. Upreti L/ 18417 (LWG); **RUDRAPRYAG DISTRICT,** Kedarnath valley, around Kedarnath temple, alt. 3,500 m, on soil, D. K. Upreti, P. K. Divakar, B. Kumar 06-006219 B (LWG).

*Nephroma isidiosum* (Nyl.) Gyeln. (Fig. 2.24d; Fig. 2.49)

Gyelnik, Ann. Cryptog. Exot. 4: 126. 1932.

Basionym: *Nephromium tomentosum* var. *isidiosum* Nyl., Flora 69: 417. 1866.

**Thallus:** foliose, loosely attached, brown, in irregular patches, 2–4 cm across; **lobes:** broad, imbricate, ca 5 mm wide, not notably ascending; **margin:** entire to subcrenulate; **upper surface:** even, smooth to slightly scabrid, ±shining, isidiate; **isidia:** in clusters, coralloid to flattened, laminal as well as marginal; **medulla:** white; **photobiont:** *Nostoc*; **lower surface:** covered with dense, short, dark brown tomentum and scattered coarse rhizines. **Apothecia:** absent.

**Chemistry:** Methylgyrophorate, trace of gyrophoric acid and an unknown substance.

**Ecology and distribution:** *Microhabitat occupied:* Muscicolous-terricolous. In India, the species is widely distributed in Himachal Pradesh, Sikkim and Uttarakhand while species growing on soil is known from Himachal Pradesh and Sikkim. Outside India, the species is also reported from Bhutan; Scandinavia, Siberia; North America.

**SPECIMENS EXAMINED: INDIA: HIMACHAL PRADESH, KINNAUR DISTRICT,** Chitkul forest area, alt. 39–4,000 m, on soil among mosses, Upreti, Srivastava and Prakash 03-002748 (LWG); **SIKKIM, EAST SIKKIM,** Kupup, on soil, V. S. Sharma and M. Ranjan 76702 (LWG).

***Nephroma parile* (Ach.) Ach. (Fig. 2.24e; Fig. 2.49)**

Acharius. Lichenogr. Universalis: 522.1810.

Basionym: *Lichen parilis* Acharius. Lich. Suec. Prod.: 164. 1798.

**Thallus:** foliose, adnate up to 9 cm across, forming rosettes or fragmentary, lobate; **lobes:** irregular, broad, elongate, often thin, 3–15 mm wide; **apices:** usually subrotund, entire or frequently dissected marginally in teeth like pattern; **upper surface:** pale brown to dark brown, occasionally with bluish gray cast, shiny or somewhat pubescent, epruinose, soresiate; **soralia:** laminal to marginal, postulate bluish grey, maculiform; **soredia:** granular to isidioid; **medulla:** white; **photobiont:** *Nostoc*; **lower surface:** pale brown, wrinkled, with or without tomentum, smooth to rugulose. **Apothecia:** nephromoid, up to 5 mm in diam.; **margin:** soresiate; **spores:** 15–21 × 6–7 μm.

**Chemistry:** Medulla: K+ pale yellow or K-. Nephtrin, zeorin and an unidentified substance reported.

**Ecology and distribution:** *Microhabitat occupied:* Terricolous; terricolous-rupicolous; muscicolous-terricolous. In India, the species is widely distributed in Himachal Pradesh, Jammu and Kashmir, Tamil Nadu and Uttarakhand while species growing on soil is known from various localities of Himachal Pradesh, Jammu and Kashmir and Uttarakhand. Outside India, the species is also reported from Central and North America.

**SPECIMENS EXAMINED: INDIA: HIMACHAL PRADESH, KINNAUR DISTRICT,** Chitkul, alt. 3,950 m, on soil, Upreti, Srivastava and Prakash 03-002714, 03-002748, 03-002748 B (LWG); on rock over soil, Upreti, Srivastava and Prakash 03-002720 (LWG); **JAMMU AND KASHMIR, ANANTNAG DISTRICT,** Pahalgam, on way to Baiaran, alt. 2,286 m, on rock surface along with mosses over soil, K. Dange 77.59, 77.343 (LWG-LWU); **UTTARAKHAND, CHAMOLI DISTRICT,** Valley of flowers, alt. 3,200 m, on rocks over soil, S. Rawat 06-007149 (LWG); **RUDRAPRAYAG DISTRICT,** Kedarnath, hillside on west of the temple, alt. 3,603 m, on boulders over soil, K. Dange 76.183 (LWG-LWU); Kedarnath, hillside on east and north of the temple, alt. 3,650 m, on rocks over soil, K. Dange 76.294 (LWG-LWU).

**NEPHROMOPSIS** Müll. Arg. (*Parmeliaceae*)

Flora 74: 374. 1891.

**Thallus:** foliose, large, irregularly lobate; **upper surface:** greenish yellow, smooth, rugose to reticulate, lacking isidia, soredia and pseudocyphellae; marginal or laminal fibrils tipped by pycnidia often present; **lower surface:** light to dark brown or black, pseudocyphellate; sparsely rhizinate. Thallus heteromerous, corticated on both surfaces; **photobiont:** a green alga; **medulla:** white or pigmented. **Apothecia:** distinctly of two types: (i) laminal, submarginal to marginal, small (less than 5 mm in diam.), non-nephromoid, with 2-layered exciple; (ii) marginal, large (up to 32 mm across), nephromoid with 3-layered exciple; **disc:** brown; **margin:** thin; **asci:** clavate with an axial body or with an amyloid apical ring and small axial body; **spores:** simple, colourless.

Out of 26 species known from world, 8 are from India, of which 2 are terricolous.

**Key to the terricolous species of *Nephromopsis*:**

- 
- |     |                                   |                        |
|-----|-----------------------------------|------------------------|
| 1.  | Lobe margins with fibrils.....    | <i>N. ahtii</i>        |
| 1a. | Lobe margins without fibrils..... | <i>N. nephromoides</i> |
-

***Nephromopsis ahtii*** (Randlane and Saag) Randlane and Saag (Fig. 2.24f; Fig. 2.49)

In A. Thell et al., Mycol. Progr. 4(4): 311. 2005.

Basionym: *Tuckneraria ahtii* Randlane and Saag in Randlane et al., Acta Bot. Fenn. 150: 147. 1994.

**Thallus:** foliose; **lobes:** rounded, 4–10(–20) mm wide; **margins:** with black pycnidial projections or fibrils and occasionally ciliate; **upper surface:** pale grey to yellowish-brown, lacking isidia and soredia; **lower surface:** brown, pseudocyphellae white or light brown; **rhizines:** simple. **Apothecia:** marginal, nephromoid, 8–15 × 5 mm in size, reniform; **spores:** subglobose 5–7(–9) × 4–5 μm.

**Chemistry:** Cortex and medulla K–, C–, KC–, P–. Lichesterinic, protolichesterinic and caperatic acids present.

**Ecology and distribution:** *Microhabitat occupied:* Terricolous. In India, the species growing on soil is also reported from different localities of Sikkim. Outside India, the species is also reported from Bhutan, China, Nepal and Taiwan.

**SPECIMENS EXAMINED: INDIA: SIKKIM, NORTH SIKKIM DISTRICT,** above Lachen, alt. 3,000 m, on soil, D. K. Upreti, S. Chatterjee and P. K. Divakar 04-003781 (LWG); Yangdi, above Thangu, alt. 4,250 m, on soil, D. K. Upreti, S. Chatterjee and P. K. Divakar 04-003981 (LWG).

***Nephromopsis nephromoides*** (Nyl.) Ahti and Randlane (Fig. 2.24g; Fig. 2.49)

In Randlane and Saag, Cryptog. Bryol. Lichenol. 19: 183. 1998.

Basionym: *Platysma nephromoides* Nyl., Flora 52: 442. 1869.

Synonyms: *Cetraria nephromoides* (Nyl.) D. D. Awasthi, Bull. Bot. Surv. India 24: 11. 1982. *Nephromopsis stracheyi* f. *ectocarpisma* Hue, Nouv. Arch. Mus. Hist. Nat., ser. 4, 1: 218. 1899. *-Nephromopsis ectocarpisma* (Hue) Gyeln., Ann. Cryptog. Exot. 4: 173. 1931.

**Thallus:** adnate, up to 20 cm across, coriaceous; **lobes:** rounded and convoluted, up to 2(–4) cm wide, lacking fibrils along margins; **upper surface:** greenish grey to yellowish grey; **lower surface:** yellow-brown, lacunose-rugose, pseudocyphellate, rhizinate; **pseudocyphellae:** at level or depressed; **rhizines:** short; medulla white. **Apothecia:** marginal on lower side, nephromoid, semi-reniform, often reflexed, 7–9 × 3–5 mm in size; **spores:** 7–9 × 3.5 μm.

**Chemistry:** Cortex and medulla K–, C–, P–. Usnic acid in cortex; lichesterinic, protolichesterinic acids and caperatic acid (+ or –) and pigments present in medulla.

**Ecology and distribution:** *Microhabitat occupied:* Terricolous. In India, the species is widely distributed in Arunachal Pradesh, Jammu and Kashmir Sikkim, Uttarakhand and West Bengal hills while species growing on soil is rarely known from single locality of Sikkim. Outside India, the species is also reported from Bhutan, China, Japan, Nepal and Taiwan.

**SPECIMEN EXAMINED: INDIA: SIKKIM, NORTH SIKKIM DISTRICT,** above Lachen, alt. 3,000 m, on soil, D. K. Upreti, S. Chatterjee, P. K. Divakar 04-004127 (LWG).

**PARMELIA** Ach. (*Parmeliaceae*)

Acharius, Methodus: xxxiii, 153. 1803.

**Thallus:** foliose, adnate, subdichotomously or irregularly lobed; **lobes:** sublinear, variously incised; **upper surface:** grey, grey-green to brownish grey, white-maculate;

**maculae:** simple to reticulate, becoming pseudocyphellate; **pseudocyphellae:** punctate, linear or effigurate; isidia, soredia and dactyls present or absent; **lower surface:** black; **rhizines:** simple, furcate, squarrosely or dichotomously branched, black. **Apothecia:** sessile to pedicellate, lecanorine; **spores:** colourless, simple, ellipsoid. Atranorin present in upper cortex.

Out of 95 species known from world, 10 are from India, of which 2 are terricolous.

**Key to the terricolous species of *Parmelia*:**

- 
1. Thallus sorediate, soralia laminal ..... *P. sulcata*  
 1a. Thallus esorediate, medulla K– rhizines simple to furcated..... *P. masonii*
- 

***Parmelia masonii*** Essl. and Poelt (Fig. 2.24h; Fig. 2.49)

Esslinger and Poelt, Bryologist 94: 203. 1991.

**Thallus:** adnate, up to 8 cm across, fragile; **lobes:** up to 3 mm wide; **upper surface:** light to dark brown; **pseudocyphellae:** white to dark, marginal and laminal, effigurate; isidia and soredia absent; **lower surface:** black, rhizines simple to furcate. **Apothecia:** up to 12 mm in diam.; **spores:** 13–16 × 6–9 μm; epispore 1–2 μm thick.

**Chemistry:** Medulla K–, C–, P– or P+ orange red. Fumarprotocetraric acid and trace of protocetraric acid present.

**Ecology and distribution:** *Microhabitat occupied:* Terricolous. In India, the species is widely distributed in Himachal Pradesh, Sikkim, Uttarakhand and West Bengal while species growing on soil is rarely known from single locality of Uttarakhand. Outside India, the species is also reported from Bhutan, China, Japan, Nepal and Taiwan.

**SPECIMEN EXAMINED:** **INDIA: UTTARAKHAND, RUDRAPRAYAG DISTRICT,** Kedarnath temple, Garurchatti towards Kedarnath temple, alt. 2,200 m, on soil, D. K. Upreti, P. K. Divakar, B. Kumar 06-006213 (LWG).

***Parmelia sulcata*** Taylor in J. Mackay (Fig. 2.24i; Fig. 2.49)

Mackay, Fl. Hibern. 2:145. 1836.

Synonym: *Parmelia hygrophiloides* Divakar et al., Mycotaxon 88: 150–152. 2003.

**Thallus:** foliose, adnate, up to 8(–20) cm across; **lobes:** sublinear, up to 5 mm wide, subtruncate; **upper surface:** greenish to dark grey, white maculate; **maculae:** turning into pseudocyphellae; **soredia:** along the margins and ridges of pseudocyphellae, granular, coarse; **lower surface:** black, rhizines squarrosely branched; medulla white. **Apothecia:** rare, substipitate, up to 7 mm in diam.; **marginal:** sorediate; spores 8–12 × 5–7 μm.

**Chemistry:** Medulla K+ yellow turning red, C–, P+ orange-red. Salazinic, consalazinic and protocetraric acids present.

**Ecology and distribution:** *Microhabitat occupied:* Terricolous; terricolous-rupicolous and detriticolous- terricolous. In India, the species is widely distributed in Himachal Pradesh, Jammu and Kashmir, Sikkim, Tamil Nadu and Uttarakhand, while species growing on soil is known from Sikkim and Uttarakhand. Outside

India, the species is also reported from Bhutan and Nepal; widely distributed in the dry temperate and north boreal regions of the world.

**SPECIMENS EXAMINED:** **INDIA:** **SIKKIM, NORTH SIKKIM DISTRICT,** Singhbo Rhododendron Sanctuary, near Yumthang, alt. 3,500 m, on soil over rocks, D. K. Upreti, S. Chatterjee, P. K. Divakar 04-004090 (LWG); Chubuk above Thangu, alt. 4,100 m, on soil over rocks, D. K. Upreti, S. Chatterjee, P. K. Divakar 04-0043917 (LWG); Kalep before Thangu, alt. 3,900 m, on soil over rocks, D. K. Upreti, S. Chatterjee, P. K. Divakar 04-003873 (LWG); **UTTARAKHAND, UTTARKASHI DISTRICT,** Gangotri National Park, way to Rudragaria Khark, alt. 3,250 m, on soil over rock, Prashant K. Pusalkar s.n. (LWG); Gangotri, alt. 3,104 m, on ground (over degrading *Pinus* needles), Himanshu Rai and Pramod Nag 10-0014517 (LWG); alt. 3,137 m, on soil, Himanshu Rai and Pramod Nag 10-0014523 (LWG); alt. 3,133 m, on soil, Himanshu Rai and Pramod Nag 10-0014538 (LWG).

**PARMELINELLA** Elix and Hale (*Parmeliaceae*)

Elix and Hale, Mycotaxon 29: 241. 1987.

**Thallus:** foliose, coriaceous, adnate, irregularly or subdichotomously sinuate lobate; **lobes:** wide, rotund, cilia simple, usually restricted to axils of lobes; **upper surface:** yellowish to greenish grey; with or without isidia and soredia; **lower surface:** black, rhizines simple in central part; marginal zone brown, nude, shiny or papillate; **photobiont:** a green alga (*Trebouxia*); **medulla:** white. **Apothecia:** laminar; disc brown to dark brown, imperforate; **hypothecium:** colourless; **hymenium:** colourless, I+ blue; **asci:** 8-spored; **spores:** colourless, simple, ellipsoid. **Pycnospores:** bacilliform. Atranorin present in upper cortex (K+ yellow).

Out of 4 species known from world, 3 are from India, of which 1 is terricolous.

*Parmelinella wallichiana* (Taylor) Elix and Hale (Fig. 2.25a; Fig. 2.49)

Elix and Hale, Mycotaxon 29: 242.1987.

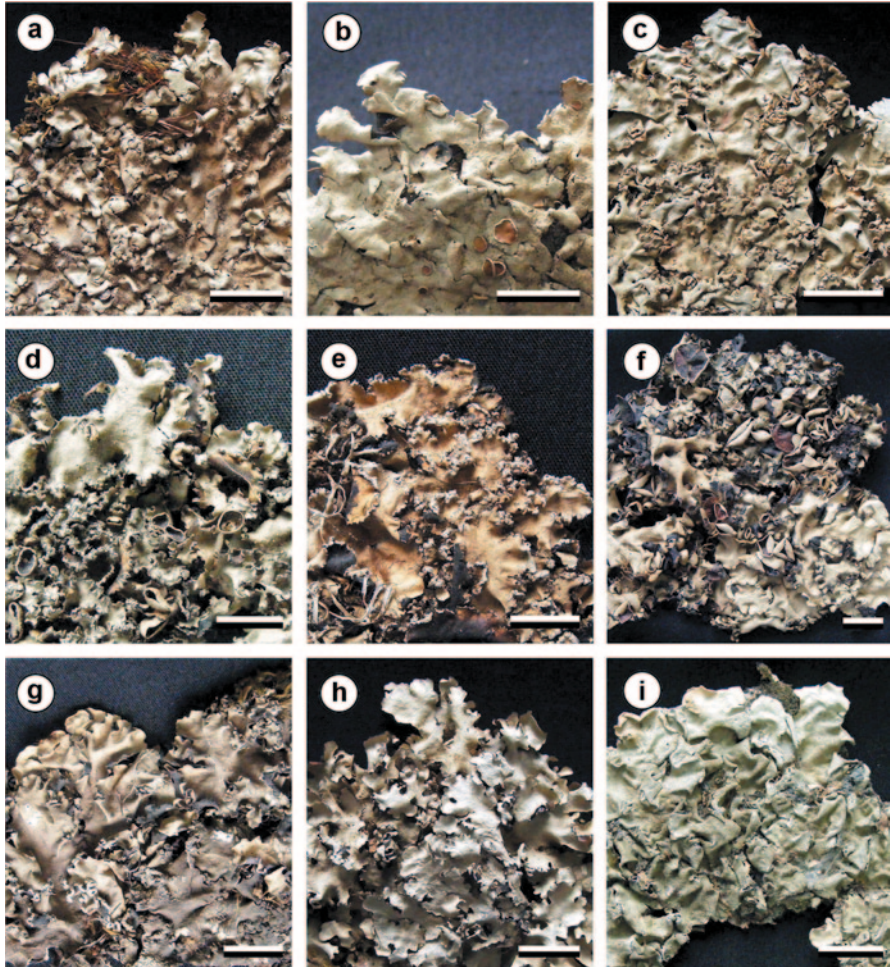
Basionym: *Parmelia wallichiana* Taylor, London J. Bot. 6: 176. 1847.

Synonyms: *Parmelina wallichiana* (Taylor) Hale, Phytologia 28:483.1974. *-Pseudoparmelia wallichiana* (Taylor) Krog and Swinscow, Lichenologist 19: 424.1987. *-Parmelia nimandairana* Zahlbr., Feddes Repert. 33: 55.1934.

**Thallus:** foliose, adnate to loosely adnate, coriaceous, up to 20 cm across; **lobes:** apices subrotund to rotund, sinuate, margin entire to crenate, ciliate in axils; **cilia:** sparse, short, especially in the axils; **upper surface:** grey to darker, irregularly cracked on the older lobes, densely isidiate; **isidia:** cylindrical, simple to branched, brown-black tipped; **medulla:** white; **lower surface:** black, rhizinate in central part, marginal zone shiny, nude or papillate; **rhizines:** mostly in centre of thallus, simple, black. **Apothecia:** rare, up to 15 mm in diam.; **spores:** (8-)10-19(-24) × 7-13 μm.

**Chemistry:** Medulla K+ yellow turning red, C-, P+ orange-red. Salazinic, consalazinic acids present.

**Ecology and distribution:** *Microhabitat occupied:* Terricolous; terricolous-rupicolous. In India, the species is widely distributed in Arunachal Pradesh, Assam, Himachal Pradesh, Karnataka, Kerala, Madhya Pradesh, Manipur, Maharashtra, Meghalaya, Nagaland, Sikkim, Tamil Nadu, Uttarakhand and West Bengal hills, while species growing on soil is reported from Meghalaya, Sikkim, Uttarakhand and West Bengal hills. Outside India, the species is also reported from Australia; Africa, Madagascar, Southern and Eastern Asia, southern Pacific area and Nepal.



**Fig. 2.25** **a** *Parmelinella wallichiana* (Taylor) Elix and Hale, **b** *Parmotrema crinitum* (Ach.) M. Choisy, **c** *P. cristiferum* (Taylor) Hale, **d** *P. grayanum* (Hue) Hale, **e** *P. mellissii* (C. W. Dodge) Hale, **f** *P. nilgherrense* (Nyl.) Hale, **g** *P. pseudonilgherrense* (Asahina) Hale, **h** *P. reticulatum* (Taylor) M. Choisy, **i** *P. tinctorum* (Despr. ex Nyl.) Hale. Scale in **b**, **d**, **e**, **g**, **h**=10 mm; in **a**, **c**, **f**, **i**=20 mm

**SPECIMENS EXAMINED: INDIA: MEGHALAYA, SHILLONG**, near Mawlai, in pinus forest, alt. 1,500 m, on hard soil, D. D. Awasthi 7906A (LWG-AWAS); **SIKKIM, EAST SIKKIM**, Tumin, alt. 2,000 m, on soil over rocks, Upreti and Chatterjee 01-67243B, 01-67250, 01-67251A(LWG); **UTTARAKHAND, UTTARKASHI DISTRICT**, Sayana Chetti, alt. 2,200 m, on soil, A. Singh and Ram Pher 76001 (LWG); **WEST BENGAL, DARJEELING DISTRICT**, Tiger Hill, alt. 2,400 m, on soil over rock, P. D. Dogra 54556 (LWG).

**PARMOTREMA** A. Massal. (*Parmeliaceae*)

Massalongo, Atti Reale Ist. Veneto Sci. Lett. Arti, Ser. 3, 5: 248. 1860.

**Thallus:** foliose, usually loosely attached to substratum, large; **lobes:** apically rotund; **margins:** with or without simple or branched cilia; **upper surface:** pale grey to grey-green; **lower surface:** brown to black, a wide marginal zone paler and nude. **Photobiont:** a green alga (*Trebouxia*). **Apothecia:** laminal, lecanorine, generally pedicellate; **disc:** brown, entire or perforate; **epithecium:** brownish; **hypothecium:** colourless; **hymenium:** colourless, l+ blue; **asci:** 8-spored; **spores:** colourless, simple, ellipsoid, thick walled. **Pycnidia:** laminal, immersed; **pycnocnidia:** sublageniform, filiform or bacilliform. Atranorin usually present in upper cortex (K+ yellow) or upper cortex (K-) with usnic acid or lichexanthone (UV+ yellow).

Out of 348 species known from world, 51 are known from India, of which 8 are terricolous.

**Key to the terricolous species of *Parmotrema*:**

1.	Thallus isidiate or sorediate .....	2
1a.	Thallus lacking isidia and soredia, lobes distinctly white maculate .....	<i>P. nilgherrense</i>
2.	Thallus isidiate, lacking soredia.....	3
2a.	Thallus marginally or submarginally sorediate, rarely isidiate-sorediate .....	4
3.	Medulla K+ orange or red, P+ orange or red.....	<i>P. crinitum</i>
3a.	Medulla K-, P-.....	<i>P. pseudocrinitum</i>
4.	Lobe margins ciliate.....	5
4a.	Lobe margins lacking cilia Medulla K+ yellow then red.....	<i>P. cristiferum</i>
5.	Maculae dense, reticulately fissured into network, soralia marginal to submarginal, capitate on palmate lacinules, or often confluent and submarginal, lower side rhizinate or nude in marginal zone .....	<i>P. reticulatum</i>
5a.	Maculae not fissured .....	6
6.	Lobes distinctly white maculate.....	<i>P. pseudonilgherrense</i>
6a.	Lobes lacking white maculae.....	7
7.	Soralia on marginal isidioid outgrowths; marginal area on lower side brown to brown black.....	<i>P. mellissii</i>
7a.	Soralia directly on lobe margins, medulla KC-.....	<i>P. grayanum</i>

***Parmotrema crinitum*** (Ach.) M. Choisy (Fig. 2.25b; Fig. 2.49)

Choisy, Bull. Mens. Soc. Linn. Lyon 21: 175. 1952.

Basionym: *Parmelia crinita* Ach., Syn. Meth. Lich.: 196. 1814.

Synonym: *Parmelia proboscidea* Taylor in Mackay, Fl. Hibern: 143. 1836.

**Thallus:** loosely attached to the substratum, up to 8 cm across; **lobes:** up to 10 mm wide, crenate or dissected and ciliate; **cilia:** black, simple to forked; **upper surface:** grey to grey green or darker, emaculate to faintly maculate, isidiate; **isidia:** laminal and marginal, simple or coralloid, often apically ciliate; **medulla:** white; **lower surface:** centrally black, marginal zone brown, nude. **Apothecia:** not observed in the specimen.

**Chemistry:** Medulla K+ yellow, C-, KC-, P+ orange, UV-. Stictic, constictic and norstictic acids present.

**Ecology and distribution:** *Microhabitat occupied:* Muscicolous-terricolous. In India, the species is widely distributed in Andhra Pradesh, Himachal Pradesh, Jammu and Kashmir, Karnataka, Kerala, Tamil Nadu and Uttarakhand, while species growing on soil is rarely known from single locality of Tamil Nadu. Outside India, the species exhibits cosmopolitan distribution and reported from Australia, China, Japan, Indonesia, New Zealand and South Africa; Europe and Central, North and South America *Parmotrema crinitum* is close to *P. crinitoides*, the latter differing by eciliate lobes.

**SPECIMEN EXAMINED:** **INDIA:** TAMIL NADU, Nilgiri hills, Ootacamund-Kotagiri road, on way to Mayani, 2 mile from Doddabetta, alt. 2,286 m, on ground with mosses, K. P. Singh 71.1104 (LWG-LWU).

***Parmotrema cristiferum*** (Taylor) Hale (Fig. 2.25c; Fig. 2.49)

Hale, Phytologia 28: 335. 1974.

Basionym: *Parmelia cristifera* Taylor, London J. Bot. 6: 165. 1847.

Synonyms: *Parmelia perforata* var. *ulophylla* Meyen and Flot., Nov. Act. Acad. Caes. Leop.-Carol. Naturf. 19, Suppl. 1: 218.1843. -*Parmelia mesotropa* Müll. Arg. var. *sorediosa* Müll. Arg., Flora 74: 377. 1891.

**Thallus:** loosely attached to the substratum, large, coriaceous, up to 25 cm across; **lobes:** 10–15 mm wide, rotund, sinuous, eciliate; **upper surface:** grey, centrally brownish, cracked; sorediate; **soralia:** marginal on lateral lobules in central part, crescent shaped or confluent; **soredia:** granular; **medulla:** white; **lower surface:** centrally black, wide marginal zone brown, nude. **Apothecia:** rare, imperforate; **spores:** absent or immature.

**Chemistry:** Medulla K+ yellow turning red, C<sup>-</sup>, P+ orange-red. Salazinic, consalazinic acids present.

**Ecology and distribution:** *Microhabitat occupied:* Terricolous-rupicolous. In India, the species is widely distributed in Arunachal Pradesh, Assam, Bihar, Jammu and Kashmir, Jharkhand, Karnataka, Kerala, Manipur, Meghalaya, Nagaland, Orissa and West Bengal hills, while species growing on soil is rarely known from single locality of West Bengal, Darjeeling district. Outside India, the species exhibits pantropical distribution and reported from Australia, Bhutan, China, Hawaii, New Zealand, Sri Lanka and Taiwan; Africa and North and Central America. *Parmotrema cristiferum* is close to *P. stuppeum*; the latter is distinguished by ciliate margins.

**SPECIMEN EXAMINED:** **INDIA:** WEST BENGAL, DARJEELING DISTRICT, Kalimpong, on soil over rock, G. Saran and party 79789 (LWG).

***Parmotrema grayanum*** (Hue) Hale (Fig. 2.25d Fig. 2.49)

Hale, Phytologia 28: 336. 1974.

Basionym: *Parmelia grayana* Hue, Nouv. Arch. Mus. Hist. Nat. ser 4, 1: 184.1899.

**Thallus:** adnate to oosely adnate to the substratum, up to 7 cm across; **lobes:** 8 mm wide, margins crenate-dentate, ascending, ciliate; **cilia:** dense, thick; **upper surface:** grey, to brownish grey, emaculate, pruinose or epruinose near apices, sorediate near the margins; **soralia:** marginal in the central part of thallus, capitate, often coalescing with submarginal soralia; **soredia:** brownish grey; **medulla:** white;



**lower surface:** centrally black, marginal zone brown, nude. **Apothecia:** rare, up to 5 mm in diam., perforated; **spores:** 13–20 × 7–11 μm.

**Chemistry:** Medulla K–, C–, KC–, P–. Protolichesterinic acid and unknown fatty acids present.

**Ecology and distribution:** *Microhabitat occupied:* Terricolous. In India, the species is widely distributed in Karnataka, Kerala, Madhya Pradesh, Tamil Nadu and Uttarakhand, while species growing on soil is rarely known from single locality of Tamil Nadu. Outside India, the species exhibits pantropical distribution and reported from Australia, New Zealand; Africa, North America and Canary Island. *Parmotrema grayanum* closely resembles another taxon, *P. praesorediosum*, in morphology of thallus, marginal soralia and chemistry, but the latter lacks marginal cilia.

**SPECIMEN EXAMINED:** INDIA: TAMIL NADU, PALNI HILLS, near Manavanur, alt. 1,829, on soil, K. P. Singh 73.27 (LWG-LWU).

***Parmotrema mellissii*** (C. W. Dodge) Hale (Fig. 2.25e; Fig. 2.49)

Hale, *Phytologia* 28: 337. 1974.

Basionym: *Parmelia mellissii* C. W. Dodge, *Ann. Missouri Bot. Gard.* 46: 134. 1959.

**Thallus:** loosely attached to the substratum, up to 12 cm across; **lobes:** 4–15 mm wide, crenate or dissected, ciliate; **cilia:** black, simple; **upper surface:** grey, emaculate, fissured, cortex flaking off in older parts, isidiate-sorediate; **soralia:** marginal and submarginal, interspersed with coarce, ciliate, coralloid isidioid outgrowths which becomes sorediate with age; granular; **medulla:** white; **lower surface:** centrally black, narrow marginal zone brown to white mottled, nude. **Apothecia:** rare, up to 8 mm in diam., imperforate; **spores:** hyaline, simple, oval to ellipsoid, 17–25 × 10–16 μm; episore 2 μm thick.

**Chemistry:** Medulla (white part) K–, C–, KC+ red, P–; medulla (pigmented part) K+ purple. Alectoronic, a-collatolic acids present.

**Ecology and distribution:** *Microhabitat occupied:* Terricolous. In India, the species is widely distributed in Karnataka, Kerala, Madhya Pradesh, Manipur, Nagaland, Sikkim, Tamil Nadu and West Bengal hills, while species growing on soil is rarely known from single locality of Tamil Nadu. Outside India, the species exhibits pantropical distribution and reported from Australia, Africa, China, Indonesia, Japan, New Zealand; Nepal and Taiwan; Central and South America. *Parmotrema mellissii* is close to *P. rampoddense*, the latter lacks isidia and has marginal soredia.

**SPECIMEN EXAMINED:** INDIA: TAMIL NADU, PALNI HILLS, Shenbaganur, on way to Korapur, alt. 1,981 m, on ground, K. P. Singh 70.1218 (LWG-LWU).

***Parmotrema nilgherrense*** (Nyl.) Hale (Fig. 2.25f; Fig. 2.49)

Hale, *Phytologia* 28: 338. 1974.

Basionym: *Parmelia nilgherrensis* Nyl., *Flora* 52: 291. 1869.

**Thallus:** loosely attached to the substratum, thick, up to 15 cm or more across, coriaceous; **lobes:** 10–20(–30) mm wide, convolute, margins ascending imbricate, ciliate; **cilia:** simple to furcated; **upper surface:** pale grey or darker, densely white-maculate, lacking isidia and soredia; **medulla:** white lower side centrally

black, wide marginal zone brown, nude. **Apothecia:** common, stipitate, large, up to 20 mm in diam., **disc:** perforated, dark brown, concave; **hymenium:** 80–120  $\mu\text{m}$  high; **spores:** (12–)20–30  $\times$  10–19  $\mu\text{m}$ ; epispore up to 2.5  $\mu\text{m}$  thick. **Pycnidia:** laminal to submarginal, immersed, ostiole black; **conidia:** sublangeniform.

**Chemistry:** Medulla K<sup>-</sup>, C<sup>-</sup>, KC<sup>+</sup> pink or red, P<sup>-</sup>. Aleatorofitic and a-collatolic acids present.

**Ecology and distribution:** *Microhabitat occupied:* Terricolous. In India, the species is widely distributed in Assam, Himachal Pradesh, Jammu and Kashmir, Kerala, Manipur, Meghalaya, Nagaland, Sikkim, Tamil Nadu, Uttarakhand and West Bengal hills, while species growing on soil is known from different localities of Himachal Pradesh, Sikkim and Tamil Nadu. Outside India, the species is also reported Bhutan, China, Nepal, Sri Lanka and Thailand; East Africa. *Parmotrema nilgherrense* is considered esorediate counterpart of *P. pseudonilgherrense*, both distributed throughout temperate Himalayas and hills of peninsular India.

**SPECIMENS EXAMINED:** **INDIA:** **HIMACHAL PRADESH, SHIMLA,** alt. 2,100 m, on soil, P. Chandra S. N. (LWG); **SIKKIM, NORTH SIKKIM,** Lachen, alt. 3,000 m, on soil, D. K. Upreti, S. Chatterjee, P. K. Divakar 04-003763, 04-003810 (LWG); Lachung Town, near Bridge, alt. 2,800 m, on soil, D. K. Upreti, S. Chatterjee and P. K. Divakar 04-004318 (LWG); **TAMIL NADU, NILGIRI HILLS,** Avalanche, Emerald Road along roadside, alt. 2,134 m, on ground, K. P. Singh 71.317 (LWG-LWU).

***Parmotrema pseudocrinitum*** (Abbayes) Hale (Fig. 2.49)

Hale, *Phytologia* 28: 338.1974.

Basionym: *Parmelia pseudocrinita* Abbayes, *Bull. Inst. Fr. Afr. Noire*, 20: 19. 1958.

**Thallus:** coriaceous, adnate to loosely attached to the substratum, up to 15 cm across; **lobes:** 10(–15) mm wide, crenate, lobulate, ciliate; **upper surface:** grey, emaculate, fissured in older parts, isidiate; **isidia:** laminal to marginal, simple to coralloid, rarely apically ciliate; **medulla:** white; **lower surface:** centrally black, wide marginal zone brown, nude. **Apothecia:** not seen in the specimen examined.

**Chemistry:** Medulla K<sup>-</sup>, C<sup>+</sup> rose, KC<sup>+</sup> red, P<sup>-</sup>. Atranorin and gyrophoric acid present.

**Ecology and distribution:** *Microhabitat occupied:* Terricolous. In India, the species exhibits restricted distribution to Eastern Himalaya and distributed in Nagaland. Outside India, the species is also reported from Nepal, Thailand; East and South Africa. *Parmotrema pseudocrinitum* is close to *P. tinctorum* and *P. crinitum*. *P. tinctorum* is eciliate and has lecanoric acid in medulla, while *P. crinitum* though ciliate has stictic acid complex in medulla.

**SPECIMEN EXAMINED:** **INDIA:** **NAGALAND,** Mokochung-Mariani roadside, alt. 1,300 m, on ground, Sinha N-868 (ASSAM).

***Parmotrema pseudonilgherrense*** (Asahina) Hale (Fig. 2.25g; Fig. 2.49)

Hale, *Mycotaxon* 5: 441. 1977.

Basionym: *Parmelia pseudonilgherrensis* Asahina, *J. Jap. Bot.* 29: 370. 1954.

**Thallus:** loosely attached to the substratum, up to 10 cm across, coriaceous; **lobes:** 10–15 mm wide, dentate at centre, marginally ciliate; **cilia:** sparse to moderately

dense, simple to furcate, conspicuous, variable; **upper surface**: grey to darker in the central region, densely white-maculate; **soralia**: marginal or submarginal, on apices of dents in central part, often confluent, sorediate lobes involute; **soredia**: granular, whitish, becoming darker to brownish; **medulla**: white; **lower surface**: centrally black, wide marginal zone brown to tan, nude. **Apothecia**: rare, 2–5 mm in diam., perforate or not; often radially split; **spores**: (12–)19–25(–30) × (8–)12–17 μm.

**Chemistry**: Medulla K–, C–, KC+ red, P–. Atranorin, alectoronic, α-collatolic acids present.

**Ecology and distribution**: *Microhabitat occupied*: Terricolous. In India, the species is widely distributed to Himachal Pradesh, Karnataka, Kerala, Maharashtra, Sikkim, Tamil Nadu and Uttarakhand, while species growing on soil is known from single locality of Tamil Nadu. Outside India, the species is also reported from Australia, China, Korea, Malaysia, Nepal, Sri Lanka and Thailand; Africa; Thailand. *Parmotrema pseudonilgherrense* is close to *P. nilgherrense*, the latter lacks marginal soredia.

**SPECIMEN EXAMINED**: **INDIA**: **TAMIL NADU**, **DINDIGUL DISTRICT**, Ootacamund-Kotagiri road, on way to Mayani, 2 miles from Doddabetta, alt. 2,286 m, on ground, K. P. Singh 71.1103 (LWG-LWU).

***Parmotrema reticulatum*** (Taylor) M. Choisy (Fig. 2.25h; Fig. 2.49)

Choisy, Bull. Mens. Soc. Linn. Lyon 21: 175. 1952.

Basionym: *Parmelia reticulata* Taylor in Mackay, Fl. Hibern. 2: 148. 1836.

Synonyms: *Rimelia reticulata* (Taylor) Hale and A. Fletcher, Bryologist 93: 28. 1990. -*Parmelia ghattensis* Hue, Nouv. Arch. Mus. Hist. Nat., ser. 4, 1: 198. 1899. -*Parmelia cetrata* var. *sorediifera* Vain., Acta Soc. Fauna Fl. Fenn. 7: 40. 1890. -*Parmotrema clavuliferum* (Räsänen) Streimann, Biblioth. Lichenol. 22: 93. 1986.

**Thallus**: up to 20 cm across; **lobes**: 5–10(–15) mm wide, ciliate; **upper surface**: grey to darker, densely white maculate; **maculae**: eventually reticulately fissured; **soralia**: either capitates on short lacinules of palmate lobes or marginal to submarginal on rounded or involute lobes; **lower surface**: centrally black, marginal zone white mottled or brown and nude or lower side black, rhizinate upto the margin; **medulla**: white. **Apothecia**: rare, up to 5 mm in diam., perforate or not; **spores**: 15–18 × 6–10 μm.

**Chemistry**: Medulla K+ yellow then red, C–, P+ orange-red. Atranorin, salazinic and consalazinic acids present.

**Ecology and distribution**: *Microhabitat occupied*: Muscicolous-terricolous. In India, the species is widely distributed to Arunachal Pradesh, Assam, Himachal Pradesh, Jammu and Kashmir, Karnataka, Kerala, Madhya Pradesh, Maharashtra, Manipur, Meghalaya, Nagaland, Sikkim, Tamil Nadu, Uttarakhand and West Bengal hills while species growing on soil is known from single locality of Uttarakhand only. The species is also reported from Bhutan, Nepal and Sri Lanka; throughout pantropical to subttemperate regions of the world.

**SPECIMEN EXAMINED**: **INDIA**: **UTTARAKHAND**, **ALMORA**, alt. 1,981 m, on ground with mosses, D. D. Awasthi and A. M. Awasthi 556 (LWG-AWAS).

***Parmotrema tinctorum*** (Despr. ex Nyl.) Hale (Fig. 2.25i; Fig. 2.49)

Hale, *Phytologia* 28: 339. 1974.

Basionym: *Parmelia tinctorum* Despr. ex Nyl., *Flora* 55: 547. 1872.

**Thallus:** usually 8–20 cm across, largest thallus seen 25 × 22 cm; **lobes:** 10–20(–30) mm wide, eciliate; **upper surface:** grey to darker, emaculate, isidiate; **isidia:** granular to filiform becoming coralloid or rarely flattened; **lower surface:** centrally black, wide marginal zone tan to brown, nude; medulla white. **Apothecia:** rare, up to 10 mm in diam., imperforate; **spores:** (13–)15–18 × 6–9(–10) μm, epispore 1.5 μm thick.

**Chemistry:** Medulla K–, C+ red, KC+ red, P–. Atranorin, lecanoric acid and traces of orsellinic acid present.

**Ecology and distribution:** *Microhabitat occupied:* Terricolous; terricolous-rupicolous. In India, the species is widely distributed to Andhra Pradesh, Arunachal Pradesh, Assam, Chhattisgarh, Himachal Pradesh, Jammu and Kashmir, Jharkhand, Karnataka, Kerala, Madhya Pradesh, Maharashtra, Manipur, Meghalaya, Nagaland, Orissa, Rajasthan, Sikkim, Tamil Nadu, Uttarakhand and West Bengal hills, while species growing on soil is reported from localities of Uttarakhand and West Bengal hills. The species is pantropical in distribution and reported from Australia, Bhutan, Nepal; Indonesia and New Zealand; Africa, North, Central and South America; China, Malaysia, Philippines, Singapore, Taiwan and Thailand.

**SPECIMENS EXAMINED:** **INDIA:** UTTARAKHAND, ALMORA DISTRICT, Tarikhet, alt. 1,600 m, on rock over soil, D. K. Upreti L 18328 (LWG); **WEST BENGAL,** DARJEELING, Kalimpong, alt. 1,247 m, on soil, G. S. Srivaratav 79787 (LWG).

**PECCANIA** A. Massal. ex Arnold (*Lichinaceae*)

*Flora* 41: 93. 1858.

**Thallus:** gelatinous when wet, crustose, squamulose, fruticose, subfruticose, umbilicate, peltate, usually with deeply divided lobes, lobules often terete; **upper surface:** black, grayish pruinose, smooth or folded, isidia lacking but cylindrical lobules or small globose granules on the lobe surface may appear as isidia; **photobiont:** a *Gloecapsa*. **Apothecia:** marginal, laminal or terminal, semi-immersed to sessile or substipitate, single ascogonia arising beneath the thallus surface; **asci:** clavate, prototunicate, thin walled, 8-spored; **spores:** hyaline, simple narrow to broadly ellipsoid or globose, 6–10 × 5–7 μm.

Out of 8 species known from world, 3 are from India.

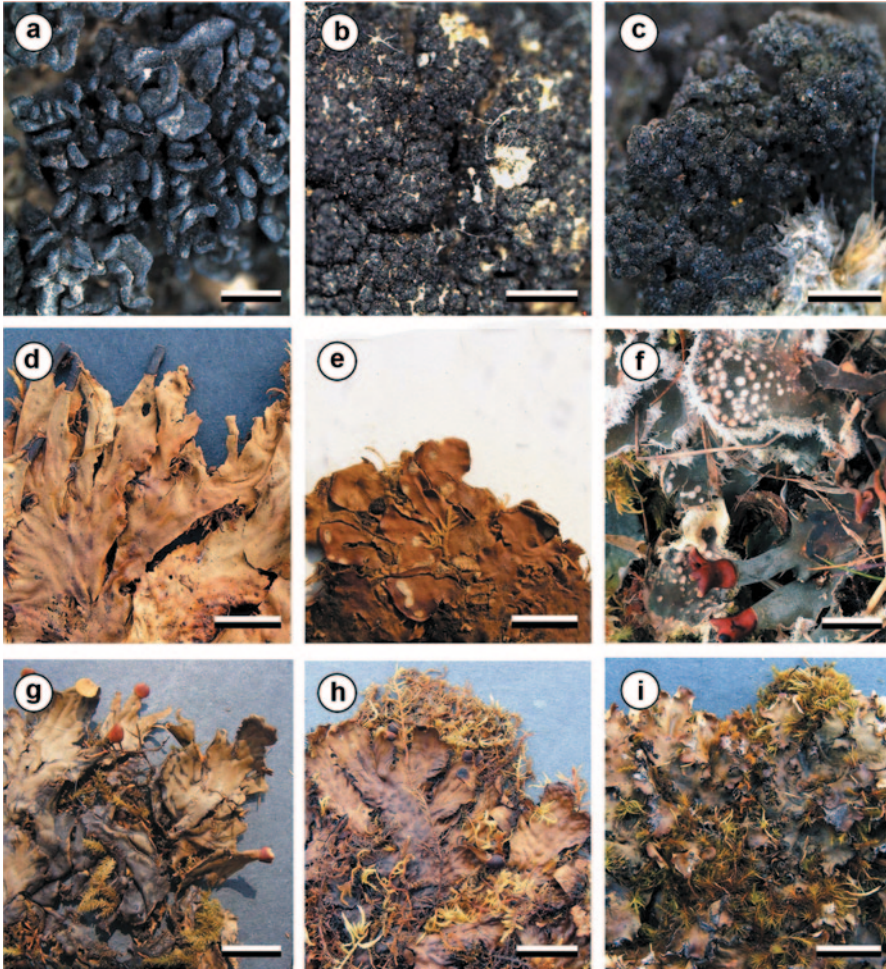
**Key to the terricolous species of *Peccania*:**

1.	Thallus fruticose or subfruticose.....	2
1a.	Thallus sub coralloid, on conglomerate boulders .....	<i>P. synaliza</i>
2.	Thallus fruticose, apothecia terminal .....	<i>P. coralloides</i>
2a.	Thallus subfruticose, apothecia apical .....	<i>P. hoegii</i>

***Peccania coralloides*** (A. Massal.) A. Massal. (Fig. 2.26a; Fig. 2.49)

Massalongo, *Atti Ist. Ven. Sc. Lett. Arti*, 3, 5: 355, 1860.

Basionym: *Corinophorus coralloides* A. Massal., *Flora*, 14: 213, 1856.



**Fig. 2.26** **a** *Peccania coralloides* (Massal.) Massal., **b** *P. hoegii* D. D. Awasthi, **c** *P. synaliza* (Ach.) Forssell, **d** *Peltigera canina* (L.) Willd., **e** *P. collina* (Ach.) Schrad., **f** *P. didactyla* (With.) J. R. Laundon, **g** *P. dolichorrhiza* (Nyl.) Nyl., **h** *P. dolichospora* (Lu) Vitik., **i** *P. elisabethae* Gyeln. Scale in **a**, **b**, **c** = 1 mm; in **e**, **f**, **g**, **i** = 5 mm; in **d**, **h** = 10 mm

**Thallus:** fruticose dry black to brown, olive when wet, often up to 2(–2.5) cm in diam. and 0.5–1 cm in height, attached to the substrate by rizomyces fascicles; **lobes:** erect surface smooth, cylindrical, central hyphal strand compact; **photobiont:** a *Gloecapsa*. **Apothecia:** terminal, emerging long, 0.5–1 mm in diam., urceolate; **disc:** concave to flat, black or dark brown; **hymenium:** tawny 100–120  $\mu\text{m}$  high, IKI (+) blue, subhymenium of 30–60  $\mu\text{m}$  in height, brown yellowish; **asci:** cylindrical clavate, 8-spored, from 50–70  $\times$  15–22  $\mu\text{m}$ ; **spores:** spherical or broadly ellipsoidal, unicellular, hyaline, of 8–15  $\times$  6–10  $\mu\text{m}$ ; **paraphyses:** septate, anastomosing.

**Chemistry:** Thallus K<sup>-</sup>, C<sup>-</sup>, KC<sup>-</sup>, P<sup>-</sup>; no secondary metabolites in TLC.

**Ecology and distribution:** *Microhabitat occupied:* Terricolous. In India, the species exhibits restricted distribution in Western Himalayas and known from Jammu and Kashmir only. Outside India, the species is also reported from Germany, Almeria. The species is characterized by fruticose black-brown thallus, with terminal emerging apothecia.

**SPECIMEN EXAMINED:** INDIA: JAMMU AND KASHMIR, LEH DISTRICT, Leh (DIHAR), alt. 11,560±100, on soil, Jatinder Kumar 10-14355 (LWG).

***Peccania hoegii*** D. D. Awasthi (Fig. 2.26b; Fig. 2.49)

D. Awasthi, Proc. Indian Acad. Sci., B, 45: 13, t. 11, f. 4, 5, 6. 1957.

**Thallus:** terricolous, effuse, minutely subfruticose, black, club-shaped, contiguous in groups or more or less isolated, 0.6–1.0 mm high. **Apothecia:** apical, 0.12 mm diam., stalked, 0.8–1.0 mm high; **disc:** concave, mostly rounded; **hymenium:** nubilated, pale brown hypothecium; **asci:** clavate, 8-spored, 46–50 × 12–15 μm; **spores:** simple, colourless, oval-ellipsoid, 10–12 × 6–8 μm.

**Chemistry:** Thallus K<sup>-</sup>, C<sup>-</sup>, KC<sup>-</sup>, P<sup>-</sup>; no secondary metabolites in TLC.

**Ecology and distribution:** *Microhabitat occupied:* Terricolous; terricolous-rupicolous. In India, the species exhibits restricted distribution in Western Himalayas and is known from Himachal Pradesh only. The species is endemic to Himalayas.

**SPECIMENS EXAMINED:** INDIA: HIMACHAL PRADESH, KANGRA DISTRICT, Kyber, on soil, O. A. Höeg s.n. (LWG-AWAS); LAHAUL AND SPITI DISTRICT, Spiti river valley, 1 mile of Sangam, alt. 3,902 m, on soil over stone, O. A Höeg 1629 (LWG-AWAS).

***Peccania synaliza*** (Ach.) Forssell (Fig. 2.26c; Fig. 2.49)

Forssell, Nova Acta Regiae Soc. Sci. Upsal., ser. 3, 13: 89. 1885.

Basionym: *Lichen synalizus* Ach., Lichenogr. Suec. Prodr.: 135. 1798.

**Thallus:** crustose, minute, sterile, black, subcoralloid branched, not pruinose; **photobiont:** a member of Chroococcales. **Apothecia:** absent.

**Chemistry:** Thallus K<sup>-</sup>, C<sup>-</sup>, KC<sup>-</sup>, P<sup>-</sup>; no secondary metabolites in TLC.

**Ecology and distribution:** *Microhabitat occupied:* Terricolous-rupicolous. In India the species exhibits its restricted distribution in Western Himalayas and known from Uttarakhand only. After 1970, the species not collected recently. The species is also reported from Europe.

**SPECIMEN EXAMINED:** INDIA: UTTARAKHAND, BAGESHWAR DISTRICT, 3 m beyond Kapkote Loharkhet, alt. 4,000 ft, on boulders over soil, D. D. Awasthi 7909 (LWG).

**PELTIGERA** Willd. (*Peltigeraceae*)

Willdenow, Fl. Berol. Prodr.: 347. 1787.

**Thallus:** foliose, dorsiventral, heteromerous, forming compact to very wide spreading rosettes; **lobes:** rounded or ± elongate, discrete, contiguous or overlapping; **upper surface:** smooth to scrobiculate, tomentose or etomentose, bluish, brownish or reddish brown. corticate; **cortex:** colourless to pale brownish, paraplectenchymatous, many layered, composed of isodiametric or vertically elongated cells; **photobiont:** blue green *Nostoc* or green *Protococcus*; **medulla:** white, loosely interwoven; **lower surface:** ecorticated, veined; **rhizines:** simple to fasciculate or

fibrillous. **Apothecia:** saddle-shaped, flattened, exciple proper; **margin:** reflexed; **disc:** red brown to brown black; **hypothecium:** colourless to pale brown; **paraphyses:** simple; **asci:** with or without tube structure in tholus, 8-spored; **spores:** colourless or brownish, fusiform or acicular, 3–9-septate. In some species with green alga as primary photobiont, **ectotrophic cephalodia:** with *Nostoc* present on upper or lower surface of thallus.

Out of 91 species known from world, 17 are from India.

**Key to the terricolous species of *Peltigera*:**

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1.	Photobiont a green alga.....	2
1a.	Photobiont a blue green alga.....	3
2.	Thallus small up to 2 cm across, cephalodia on lower surface, apothecia horizontal, veins broad .....	<i>P. venosa</i>
2a.	Thallus usually more than 5 cm across, cephalodia on upper surface, apothecia vertical, veins narrow .....	<i>P. leucophlebia</i>
3.	Thallus with isidia, phyllidia, schizidia or squamules.....	4
3a.	Thallus without isidia, phyllidia, schizidia or squamules.....	6
4.	Laminal peltate isidia present .....	<i>P. lepidophora</i>
4a.	Laminal isidia absent .....	5
5.	Upper surface tomentose, isidia, phyllidia and squamules along margins and also along cracks of the thallus.....	<i>P. praetextata</i>
5a.	Upper surface etomentose, isidia or squamiform schizidia along margin .....	<i>P. elisabethae</i>
6.	Thallus sorediate .....	7
6a.	Thallus esorediate .....	8
7.	Upper surface tomentose towards lobes apices, soralia laminal to submarginal.....	<i>P. didactyla</i>
7a.	Upper surface lacking tomentum, soralia mainly marginal .....	<i>P. collina</i>
8.	Upper surface tomentose at least toward apices .....	9
8a.	Upper surface etomentose.....	12
9.	Apothecia horizontal, spores fusiform 3-septate .....	<i>P. pindarensis</i>
9a.	Apothecia vertical, spores acicular, 3–7-septate.....	10
10.	Rhizines separate, squarrosely branched, veins raised .....	<i>P. membranacea</i>
10a.	Rhizines confluent, veins smooth, soon darkened towards centre.....	11
11.	Lobes broad, apices inflexed, veins and rhizines near margins whitish, thick, fibrillose .....	<i>P. canina</i>
11a.	Lobes narrow, thick, margins upturned, tomentum appressed, rhizines basally fused, branched .....	<i>P. rufescens</i>
12.	Upper surface rough, scabrous, apothecia horizontal .....	<i>P. dolichospora</i>
12a.	Upper surface smooth .....	13
13.	Apothecia horizontal, spores 3-septate .....	<i>P. horizontalis</i>
13a.	Apothecia vertical, spores more than 3-septate .....	14
14.	Thallus veined on lower surface .....	15
14a.	Thallus lacking veins on lower surface.....	<i>P. malacea</i>
15.	Rhizines fasciculate, thallus pruinose or not.....	<i>P. polydactylon</i>
15a.	Rhizines simple .....	16
16.	Thallus large, ca. 11 cm across .....	<i>P. dolichorhiza</i>
16a.	Thallus small, about 3 cm across .....	<i>P. macra</i>

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***Peltigera canina* (L.) Willd. (Fig. 2.26d Fig. 2.50)**

Willdenow, Fl. Berol. Prod.: 347. 1787.

Basionym: *Lichen caninus* L., Sp. Pl.: 1149. 1753.

**Thallus:** up to 10 cm across, thin, loosely attached to the substratum, irregularly spreading; **lobes:** 10–25 mm wide; **upper surface:** greenish grey when wet, brownish when dry, tomentose, dull or shiny, epruinose; **lower surface:** distinctly white to pale brown, veined with large interspaces, rhizinate; **rhizines:** simple to fasciculate, pale brown to greyish black, 1–5 mm long, fibrillose, branched; **photobiont:** a *Nostoc*; **medulla:** white. Thallus 140–400  $\mu\text{m}$  thick. **Apothecia:** brown, vertical, 3–6 mm in diam., borne singly on extended lobules, reflexed longitudinally, saddle shaped; **margin:** creamish brown, minutely crenate; **disc:** reddish brown to dark brown, slightly convex to longitudinally reflexed; **asci:** 8-spored; **spores:** acicular, straight to slightly curved, transversely 3–9-septate; (37–)45–65  $\times$  3–5  $\mu\text{m}$  in size.

**Chemistry:** Thallus K–, C–, KC–, P–; no secondary metabolites in TLC.

**Ecology and distribution:** *Microhabitat occupied:* Terricolous; terricolous-rupicolous; muscicolous-terricolous; detriticolous-terricolous. In India, the species is widely distributed in Arunachal Pradesh, Assam, Himachal Pradesh, Jammu and Kashmir, Meghalaya, Nagaland, Sikkim, Tamil Nadu, Uttarakhand and West Bengal hills. The species is pantropical in distribution and also reported from Australia, Bhutan, Indonesia, Japan, Nepal and New Zealand; Africa, Central, North and South America. The species is closely related species *P. rufescens*, but the latter has a thick rigid thallus with denser tomentum and frilled margin.

**SPECIMENS EXAMINED: INDIA: HIMACHAL PRADESH, KULLU DISTRICT,** Great Himalayan National Park, above Kundar beat area, alt. 2,800 m, on soil over rocks under coniferous trees, D. K. Upreti 217514 (LWG); **JAMMU AND KASHMIR,** Drang forest, Tangmarg, on ground among rotten leaves and mosses, G. S. Rath 11699 (LWG); Ferozpur rock, Tangmarg, alt. 2,286 m, on rock over soil, K. N. Kaul s.n. (LWG); Gulmarg, alt. 2,680 m, on soil, K. Dange 77.461 A (LWG-LWU); **SIKKIM, EAST SIKKIM,** Gangtok, near Burtuk, alt. 1,700 m, on soil, Sinha 90 (BSHC); **NORTH SIKKIM,** Lachen, Gumpa side forest, alt. 2,700 m, Sinha 1545 (BSHC); **TAMIL NADU, NILGIRI HILLS,** Avalanche along roadside in moist place, alt. 2,134 m, on ground, K. P. Singh 71.797 (LWG-LWU); **UTTARAKHAND, BAGESHWAR DISTRICT,** en route to Pindari Glacier, Loharkhet to Dhakuri, alt. 3,000 m, on soil, D. D. Awasthi and A. M. Awasthi 621 (LWG-AWAS); Dwali to Phurkia, alt. 3,210 m, on soil, S. Joshi and Y. Joshi 07-008814 (LWG); **CHAMOLI DISTRICT,** Nanda Devi Biosphere Reserve, N. W. part, on soil, H. R. Negi L-580 (LWG); Ghangharia-Hemkund, alt. 3,505 m, on soil along with mosses, A. Singh 85832, 85839 (LWG); Nanda Devi Biosphere reserve, NW Part, on soil, H. R. Negi L-580, L-129 (LWG); **DEHRADUN DISTRICT,** Charkata hills, Deoban, alt. 2,804 m, on ground, D. D. Awasthi and M. Joshi 76.85 A (LWG-AWAS); **PITHORAGARH DISTRICT,** Naher Devi en route to Milam Glacier, alt. 2,933 m, on soil, S. Joshi 07-010333 (LWG); alt. 2,578 m, on soil, S. Joshi 07-010335 (LWG); **RUDRAPRAYAG DISTRICT,** Madmaheshwar, Gondar, alt. 3,000 m, on soil, A. Singh and M. Ranjan 106992 (LWG); **TEHRI GARHWAL DISTRICT,** on Rari hill top between Silkara and Gangrani, alt. 2,134 m, on ground among mosses, D. D. Awasthi 865, 870, 870 A, 870 A (LWG-AWAS); **Uttarkashi district,** on way to Gomukh, 11 km from Gangotri, alt. 3,536 m, on soil, D. D. Awasthi and S. R. Singh 8369C (LWG-AWAS); **WEST BENGAL, DARJEELING,** near Tonglloo Dak Bunglaw, alt. 11,000 ft., on ground, D. D. Awasthi and M. R. Agarwal 67.542 (LWG-LWU); on way from Snadakhpoo to Phalut, alt. 3,658 m, on ground, D. D. Awasthi and M. R. Agarwal 67.484 (LWG-LWU); on top of Batasi hills, on way to Palmajua, alt. 2,347 m, on ground among mosses in big patches, D. D. Awasthi 171 (LWG-AWAS).



***Peltigera collina*** (Ach.) Schrad. (Fig. 2.26e; Fig. 2.50)

Schrader, J. Bot. 1: 78. 1801.

Basionym: *Lichen collinus* Acharius, Lichenogr. Suec. Prodr.: 162. 1798.

Synonym: *Peltigera scutata* (Dicks.) Duby, Bot. Gall. 2:599. 1830.

**Thallus:** adnate, up to 3 cm across; **lobes:** 4–6(–12) mm wide; **upper surface:** yellowish brown, scabrid, etomentose, marginally soraliolate with granular soredia; **lower surface:** with diffused, indistinct, brown veins; interspaces white to pale; rhizines simple to confluent; **photobiont:** *Nostoc*; **medulla:** pale brown. **Apothecia:** not present.

**Chemistry:** Gyrophoric acid, zeorin, tenuiorin and an unknown substance present.

**Ecology and distribution:** *Microhabitat occupied:* Terricolous; terricolous-rupicolous; muscicolous-terricolous. In India, the species exhibits restricted distribution to Sikkim and Tamil Nadu. The species is also reported from China, Central Europe and North America.

**SPECIMENS EXAMINED:** **INDIA:** SIKKIM, NORTH SIKKIM, Theu La base camp, south side, along river bed, alt. 4,500 m, on ground, Sinha 1706 (BSHC); **TAMIL NADU,** DINDIGUL DISTRICT, PALNI HILLS, Shenbaganur, below SH College along old ghat road, alt. 1,783 m, on ground, D. D. Awasthi 4367 (LWG-AWAS); Shenbaganur, via a shortcut road, alt. 5,750 m, over stones on soil, K. P. Singh 70.877 (LWG-LWU); on the way to Thandikudi from Panniakudi, alt. 1,372 m, on ground and soft stones, D. D. Awasthi and K. P. Singh 70.481 (LWG-LWU); on the way to Guvangi, alt. 1,676 m, on ground, K. P. Singh 73.58 (LWG-LWU).

***Peltigera didactyla*** (With.) J. R. Laundon (Fig. 2.26e; Fig. 2.50)

Laundon, Lichenologist 16(3): 217. 1984.

Basionym: *Lichen didactylus* With., Bot. Arr. Veg. Br. 2: 718. 1776.

Synonyms: *Peltigera spuria* (Ach.) Lam. and DC., Fl. Fran ç. ed. 3, 2: 406. 1805.

-*Peltigera pusilla* (Fr.) Körb., Syst. Lich.Germ.: 59. 1855. -*Peltigera erumpens* (Taylor) Vain., Etud. Lich. Bresil: 182. 1890.

**Thallus:** small to medium sized, up to 5 cm across, thin; **lobes:** imbricate, separate or overlapping, plane to mostly concave, cochleate, 10–20 mm wide; **margins:** mostly erect, entire; **upper surface:** brown, chestnut to purplish brown when dry and blackish when wet, smooth, densely tomentose towards periphery, sorediate; **soredia:** laminal to submarginal, granular, in round to irregular, ulcerose, confluent, bluish grey with brownish margin, initially erupting as small spots; **medulla:** white; **photobiont:** a *Nostoc*; **lower surface:** pale tan to cream coloured, coarsely tomentose, veined, rhizinate; **veins:** flattened to slightly raised, 0.2–0.7 mm wide, tan to darker brown towards the centre, anastomosing, confluent at lobe apices, interspace whitish, rounded to elongate, regular; **rhizines:** scattered to dense, white, simple or bottlebrush-like. **Apothecia:** absent.

**Chemistry:** Thallus K–, C–, KC–, P–; no secondary metabolites in TLC.

**Ecology and distribution:** *Microhabitat occupied:* Terricolous; terricolous-rupicolous; muscicolous-terricolous; muscicolous-rupicolous. In India, the species is widely distributed in Himachal Pradesh, Jammu and Kashmir, Tamil Nadu and Uttarakhand. The species is also reported from Australia, Japan and New Zealand;

Africa, Antarctica, Europe and North and South America. Cosmopolitan in distribution. *Peltigera didactyla* is close to *P. collina*; the latter differs in thicker thallus, tomentose upper surface and soralia only marginal.

**SPECIMENS EXAMINED INDIA:** **HIMACHAL PRADESH, SHIMLA DISTRICT,** Rohru, Chirgaon, Tikri, alt. 1,700 m, on rock, S. Nayaka and R. Srivastava 02-213878 (LWG); **JAMMU AND KASHMIR, BARAMULLA DISTRICT,** Gulmarg, on the way to Khilanmarg, alt. 2,700 m, on rock among mosses over soil, M. Sheikh 05-006007 (LWG); **UTTARAKHAND, BAGESHWAR DISTRICT,** Phurkiya to Mirtoli en route to Pindari glacier, alt. 3,505 m, over stone among mosses on soil, D. D. Awasthi 7767(LWGAWAS); **DEHRADUN DISTRICT,** Chakrata hills, on the way from Deoban to Chakrata, alt. 2,133 m, on ground among mosses, D. D. Awasthi and M. Joshi 76.206 (LWG-LWU); **RUDRAPRAYAG DISTRICT,** Mandakini River Valley, on the way from Rambara from Kedarnath; alt. 3,165 m, on rock surface over soil, K. Dange 76.362 (LWG-LWU); Badrinath, east of temple, on the way to Dhanolti village, alt. 3,250 m, on boulders over soil, K. Dange 76.840 (LWG-LWU); **PITHORAGARH DISTRICT,** Munsiyari, Khuliya top, alt. 2,900 m, on soil among mosses, D. K. Upreti, H. Rai, S. Joshi, R. Khare, A. Dwivedi and G. K. Mishra 09-015625 (LWG); **UTTARKASHI DISTRICT,** on the way to Gomukh, 11 km from Gangotri, alt. 3,536 m, on ground, D. D. Awasthi and S. R. Singh 8366 (LWG-AWAS); on the way to Gomukh, near Bhojwasa, alt. 3,658 m, on ground, D. D. Awasthi and S. R. Singh 8373 (LWG-AWAS).

***Peltigera dolichorrhiza* (Nyl.) Nyl. (Fig. 2.26g; Fig. 2.50)**

Nylander, Lich. Novae Zel.: 43. 1888.

Basionym: *Peltigera polydactyla* var. *dolichorrhiza* Nyl., Syn. Lich. 1: 327. 1860.

**Thallus:** loosely attached to the substratum, growing in large irregular patches, pale brown to brownish black, 10–25 cm across; **lobes:** elongated with broad apices, discrete; **margin:** wavy to crisped, sinuous; **upper surface:** ± scrobiculate, tomentose, dull surface dark lead-grey to blue-black when wet, pale blue-grey to olive-brown when dry, glabrous, dull to glossy; **lower surface:** pale or whitish at margins, whitish to buff or dark brown centrally, veined, rhizinate; **veins:** slightly raised, brown-black to black centrally; **rhizines:** dark brown to blackish, sparse to dense, simple to fasciculate. **Apothecia:** numerous, vertical, borne singly or in pairs or in groups on extended lobules, oblong, 3–4 × 2.5–3 mm, pale pinkish buff pale brown; **disc:** reddish brown to blackish, convex to reflexed; **proper exciple:** 112–157 µm thick; **hymenium:** 80–125 µm high; **spores:** acicular, 5–8 transversely septate, 40–90 × 3–4 µm.

**Chemistry:** Tenuiorin, dolichorrhizin and zeorin along with an unknown substances present at R<sub>f</sub> values 0.8 and 0.85 respectively.

**Ecology and distribution:** *Microhabitat occupied:* Terricolous; terricolous-rupicolous; muscicolous-terricolous; muscicolous-rupicolous. In India, the species is widely distributed in Arunachal Pradesh, Assam, Himachal Pradesh, Jammu and Kashmir, Meghalaya, Nagaland, Sikkim, Uttarakhand and West Bengal hills. The species exhibits pantropical distribution and is reported from Australia, Bhutan, Indonesia, Japan, Nepal and New Zealand; Africa and Central, North and South America.

**SPECIMENS EXAMINED:** **INDIA: ARUNACHAL PRADESH,** slopes along the route from Jabran to Purila, alt. 2,743 m, on soil, Rolla Seshagiri Rao 8183 (LWG-LWU); **HIMACHAL PRADESH,** Lakermandi, on the way to Khajjiar, alt. 2,700 m, on soil, Chopra, s.n. (LWG); **SHIMLA,**

Rohru, Chirgaon, Sandasu, alt. 1,700 m, on soil, S. Nayaka and R. Srivastava 02-81664 (LWG); **SIKKIM, EAST SIKKIM DISTRICT**, near Karponang, alt. 2,400 m, on ground among mosses, Awasthi 169 (LWG-AWAS); **UTTARAKHAND, ALMLORA DISTRICT**, Ranikhet, on soil, P. C. Pandey 79-54303 (LWG); **BAGESHWAR DISTRICT**, Loharkhet to Dhakuri, alt. 2,400 m, on mossy soil, Awasthi and Awasthi 618 (LWG-AWAS); Dhakuri to Khati (en route to Pindari glacier), alt. 2,438 m, on soil with mosses, D. D. Awasthi and A. M. Awasthi 694 (LWG-AWAS); **DEHRADUN DISTRICT**, Chakrata division near Mundali, alt. 2,590 m, on ground among mosses, D. D. Awasthi 938 (LWG-AWAS); Mussoorie, alt. 2,134 m, on ground, D. D. Awasthi 3404 (LWG-AWAS); Chawali-Chakrata, on soil, M. Ranjan 11557 (LWG); **PITHORAGARH DISTRICT**, Munsiyari, Nain Singh Top, alt. 2,700 m, on soil over rock, Upreti and Tandon L104625 (LWG); Askot near Singoli, alt. 1,676 m, on ground in shade, D. D. Awasthi 2671 (LWG-AWAS); **WEST BENGAL, DARJEELING DISTRICT**, Tiger hill, alt. 2,550 m, Awasthi and Agarwal 67.4, 67.38 and 67.59 (LWG-AWAS); Lloyd botanical garden, alt. 1,981 m, on ground among moss and grass, D. D. Awasthi 3824 (LWG-AWAS); Testa road, on soil over rock, M. Ranjan 11599 (LWG); Batasi-Palmuja, alt. 2,286 m, on ground among mosses, D. D. Awasthi 170 (LWG-AWAS).

***Peltigera dolichospora*** (D. A. Liu) Vitik. (Fig. 2.26h; Fig. 2.50)

Vitikainen, Lichenologist 18(4): 387. 1986.

Basionym: *Peltigera polydactylon* var. *dolichospora* (D. A. Liu), Acta Phytotax. Sin. 7: 264.1958.

**Thallus:** loosely attached to the substratum, up to 6 cm across; **lobes:** 5–15 mm wide, flat, discrete; **margin:** wavy to entire; **upper surface:** grey-brown to dark brown, rough, faintly to distinctly scabrose, etomentose, lacking isidia and soredia; **lower surface:** brown, veined, rhizinate; **veins:** reticulate, interspaces wide, pale brown, cottony; **rhizines:** sparse, fasciculate; **photobiont:** a *Nostoc*; **medulla:** white to pale brown. **Apothecia:** horizontal, at the submarginal area of extended lobules, generally rounded, up to 4 mm in diam.; **disc:** reddish brown to brown black; **proper exciple:** 110–180  $\mu\text{m}$  thick; **hymenium:** 120–150  $\mu\text{m}$  thick; **spores:** acicular, straight, 7–12-septate, 65–125(–134)  $\times$  3–6  $\mu\text{m}$ .

**Chemistry:** Dolichorhizin and 1 or 2 triterpenoids present, zeorin (+ or –).

**Ecology and distribution:** *Microhabitat occupied:* Terricolous. In India, the species is restrictedly distributed to eastern Himalayas and known from Sikkim and West Bengal hills. Outside India, the species is also reported from Bhutan, China and Nepal.

**SPECIMENS EXAMINED: INDIA: SIKKIM, NORTH SIKKIM DISTRICT**, near Yumthang, alt. 3,800 m, on soil, D. K. Upreti, S. Chatterjee and P. K. Divakar 04-004162, 04-04218 (LWG); **WEST BENGAL, DARJEELING DISTRICT**, on the way from Saandakhpoo to Phalut, alt. 3,600 m, on soil, Awasthi and Agarwal 67.416 (LWG-LWU).

***Peltigera elisabethae*** Gyeln. (Fig. 2.26i; Fig. 2.50)

Gyelnik, Bot. Közlemények 24: 135. 1927.

Synonyms: *Peltigera polydactyla* f. *microphylla* Anders, Lotus 76: 320. 1928. -*Peltigera microphylla* (Anders) Gyeln., Bryologist 34: 18. 1931.

**Thallus:** foliose, medium to large, 5–15 cm in diam.; **lobes:** flattened elongated, imbricate or separate; **upper surface:** brown when dry, blackish green when wet, smooth, shiny, etomentose, without isidia, isidioid schizidia becoming squamiform or lobulate along margin or along cracks in lamina; **medulla:** white, with thick,  $\pm$

loosely interwoven hyphae; **photobiont**: a *Nostoc*; **lower surface**: brown-black at centre, veinless, with small pale or white interstices; **rhizines**: fasciculate, blunt. **Apothecia**: absent.

**Chemistry**: Gyrophoric acid, tenuiorin and zeorin present.

**Ecology and distribution**: *Microhabitat occupied*: Terricolous; terricolous-rupicolous; muscicolous-terricolous; muscicolous-rupicolous. In India, the species is widely distributed in Arunachal Pradesh, Himachal Pradesh, Jammu and Kashmir, Sikkim and Uttarakhand. The species is also reported from China and Japan; North America. *Peltigera elisabethae* is close to *P. polydactylon*; the latter differs in the presence of distinct veins and absence of isidia and schizidia.

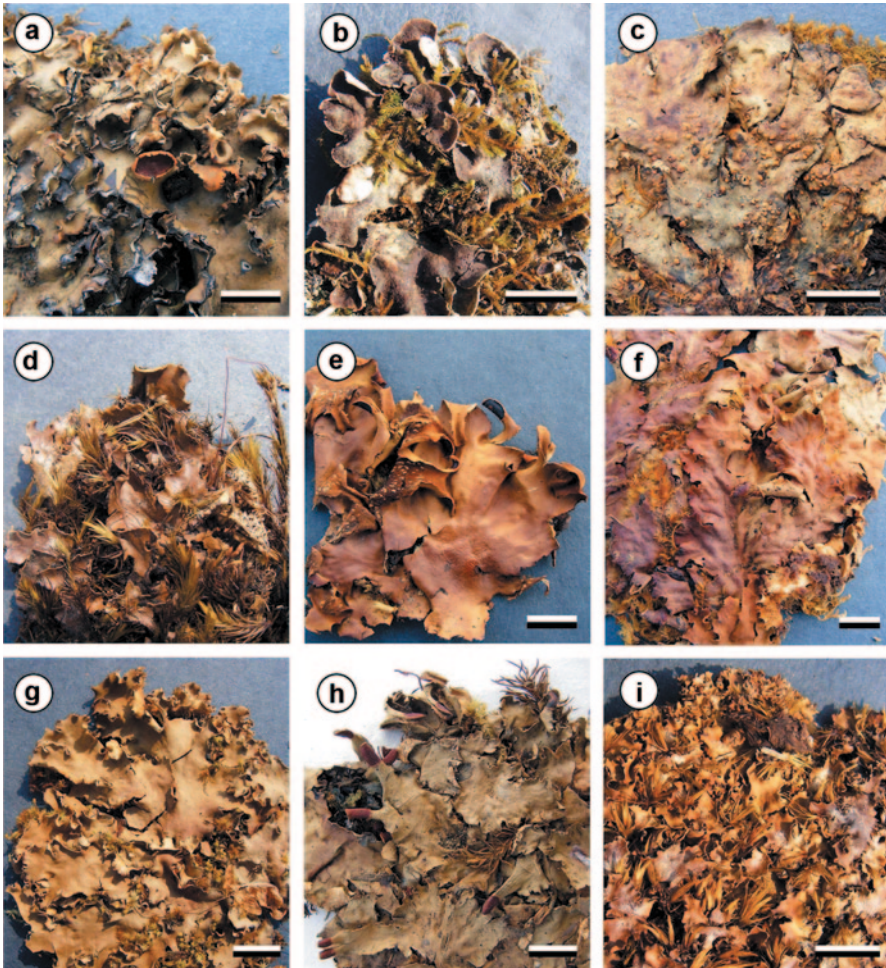
**SPECIMENS EXAMINED**: **INDIA**: **ARUNACHAL PRADESH**, WEST KAMENG DISTRICT, 7 km before Sela Pass, alt. 3,835 m, on soil, D. K. Upreti, U. Dubey, R. Khare and G. K. Mishra 08-009357 (LWG); **JAMMU AND KASHMIR**, ANANTNAG DISTRICT, Baltal, alt. 2,700 m, on soil, A. Singh and D. K. Upreti 13925 (LWG); **BARAMULLA DISTRICT**, Gulmarg, on the way to Khilanmarg, alt. 2,600 m, on exposed rocks among mosses over soil, M. A. Sheikh 05-006058 (LWG); Budgam, Yusmarg, on the way to Dhood Ganga, alt. 2,200 m, on unexposed rocks among mosses over soil, M. A. Sheikh 04-004810 (LWG); **SRINAGAR DISTRICT**, Harwan, Dachigam National Park, alt. 2,230 m, on unexposed rocks among mosses over soil, 02.08.05, M. Sheikh 05-006167 (LWG); Pahalgam, on the way to Aru, alt. 2,400 m, on rock surface along with mosses over soil, K. Dange 77.236 (LWG-LWU); **HIMACHAL PRADESH**, **CHAMBA DISTRICT**, Chamba, around Joth, alt. 2,000–3,000 m, on rock over soil, D. K. Upreti and S. Nayaka 01-75545 (LWG); **KULLU DISTRICT**, Great Himalayan National Park, Rolla, alt. 2,000 m, on soil over rocks, D. K. Upreti 99-52682 (LWG); **KINNAUR DISTRICT**, Chitkul forest area, alt. 3,950 m, on mosses over soil, Upreti, Srivastava and Prakash 03-002709 (LWG); **SHIMLA**, Rohru, Jubbal, along Sandali Naala, alt. 1,650 m, on soil over moss, S. Nayaka and R. Srivastava 02-213866 (LWG); **SIKKIM**, **NORTH SIKKIM DISTRICT**, Near Yumthang, alt. 3,800 m, on soil, D. K. Upreti, S. Chatterjee and P. K. Divakar 04-004194 (LWG); **UTTARAKHAND**, **CHAMOLI DISTRICT**, between Waan and Bhuna, alt. 3,450 m, on soil covered bark at base, A. Singh, s.n. (LWG); **DEHRADUN DISTRICT**, Lal tibba forest, alt. 1,700 m, on moist soil under *Quercus* forest, D.K. Upreti L11555 (LWG); **PITHORAGARH DISTRICT**, Bogudiyar to Nahar Devi, en route to Milam Glacier, alt. 2,450–2,705 m, on soil, Santosh Joshi 07-010340 (LWG); **RUDRAPRAYAG DISTRICT**, Mandakini river valley, on the way from Kedarnath to Rambara, alt. 3,165 m, on rock surface over soil, K. Dange 76.326 (LWG-LWU).

***Peltigera horizontalis*** (Huds.) Baumg. (Fig. 2.27a; Fig. 2.50)

Baumgarten, Fl. Lips.: 562. 1790.

Basionym: *Lichen horizontalis* Hudson, Fl. Angl.: 543. 1762.

**Thallus**: medium to large, 5–10 cm in diam., closely to loosely adnate to the substratum; **lobes**: flattened to elongated, 1–2 cm wide and up to 4 cm long, imbricate or separate; **upper surface**: tinged brown when dry, blackish green when wet, smooth, shiny, epruinose, etomentose; **medulla**: white, ± loosely interwoven hyphae, **photobiont**: *Nostoc*; **lower surface**: white, veined, rhizinate; **veins**: with anastomosing, smooth flattened veins, becoming darker centrally, interspaces small; **rhizines**: sparse, brown to black. **Apothecia**: horizontal, submarginal at the edge of lobes or on extended lobules, usually round, 3–7 mm; **disc**: reddish brown to dark brown; **proper exciple**: 96–160 µm; **hymenium**: 100–200 µm thick; **spores**: fusiform, transversely 3-septate, (19–)25–38 × 5–8.5 µm in size.



**Fig. 2.27** **a** *Peltigera horizontalis* (Huds.) Baumg., **b** *P. lepidophora* (Nyl.) Bitter, **c** *P. leucophlebia* (Nyl.) Gyeln., **d** *P. macra* Vain., **e** *P. malacea* (Ach.) Funck., **f** *P. membranacea* (Ach.) Nyl., **g** *P. pindarensis* D. D. Awasthi and M. Joshi, **h** *P. polydactylon* var. *polydactylon* (Neck.) Hoffm., **i** *P. polydactylon* var. *pruinosa* Gyeln. Scale in **a**, **b**=5 mm; in **c**, **d**, **e**, **f**, **g**, **h**, **i**=10 mm

**Chemistry:** Tenuiorin, methyl gyrophorate, gyrophoric acid and unidentified terpenoids.

**Ecology and distribution:** *Microhabitat occupied:* Terricolous; terricolous-rupicolous; muscicolous-terricolous; muscicolous-rupicolous. In India, the species is widely distributed in Himachal Pradesh, Jammu and Kashmir, Sikkim and Uttarakhand. The species is also reported from Bhutan and China; widely distributed in temperate regions of Europe and North America. *P. horizontalis* is closely similar to *P. pindarensis*, but the latter differs in tomentose upper surface and the absence

of lichen products. The species shows affinity to European species (Awasthi and Joshi 1982).

**SPECIMENS EXAMINED: INDIA: HIMACHAL PRADESH, KULLU DISTRICT**, Great Himalayan National Park, Sainj Wildlife sanctuary, Maraur, alt. 2,600 m, on rock over mosses, R. Srivastava 04-003281 (LWG); Kangra district, Tatwani on the way to hot water spring, alt. 2,200 m, on soil over rock, R. Khare and S. Mohabe 10-0014564 (LWG); **JAMMU AND KASHMIR, BARAMULLA DISTRICT**, Drang forest, Tangmarg, on soil among mosses, G. C. Rath, s.n. (LWG); Gulmarg on the way to Khalinmarg, alt. 2,600 m, on soil among mosses, M. Sheikh 05-006017 (LWG); Gulmarg at south east side, alt. 2,680 m, on soil, K. Dange 77-461 B (LWG-LWU); **SIKKIM, EAST SIKKIM**, Gangtok, Baluakhani, on soil among mosses, Chatterjee and Divakar 20-77013 (LWG); **UTTARAKHAND, CHAMOLI DISTRICT**, Ghangharia-Hemkund, on moss covered rock over soil, A. Singh, 85848 (LWG); **PITHORAGARH DISTRICT**, Sandev Botanical Hotspot, alt. 1,700–2050 m, on soil, Vikas Pant 02-000967 (LWG); **UTTARKASHI DISTRICT**, Bhojwasa, alt. 3,700 m, on soil, S. Chatterjee and P. K. Divakar 02-000201 (LWG).

***Peltigera lepidophora* (Nyl.) Bitter (Fig. 2.27b; Fig. 2.50)**

Bitter, Ber.Deutsch. Bot. Ges. 22: 251. 1904.

Basionym: *Peltigera canina* var. *lepidophora* Nyl., Medeland Soc. Fauna Fl. Fennica 2: 49. 1878.

**Thallus:** orbicular, 1–1.5 cm in diam., adnate; **lobes:** flattened, 0.5–0.8 cm wide and up to 1 cm long, concave; **margins:** mostly entire, slightly sinuous, ± inrolled; **upper surface:** dark slatey blue-black to brownish when wet, olive-brown to red-brown when dry, coriaceous, bluish gray when wet, ± scabrid, dull, isidiate; **isidia:** laminal, initially button-like to peltate, becoming lobed, pale to dark red-brown, with thickened margins, occasionally white-pruinose, scattered to densely crowded, 0.2–0.5(–1.5) mm wide peltate; **medulla:** white; **photobiont:** *Nostoc*; **lower surface:** pale yellow-buff to greyish or brownish, coarsely tomentose, veined, rhizinate; **veins:** pale anastomosing, smooth flattened to slightly raised; **rhizines:** scattered, simple to ± fasciculate, pale buff to brownish, irregular. **Apothecia:** not seen.

**Chemistry:** Thallus K–, C–, KC–, P–; no secondary metabolites in TLC.

**Ecology and distribution:** *Microhabitat occupied:* Terricolous. Earlier, the species is reported from temperate and boreal regions of North America, Europe and Asia, South America, Australia, and Hawaii. In the present study, the species extends its distribution in India and is known only from Uttarakhand. It is found to be growing on soil at an altitude of 3,617 m. It is a new record for lichen flora of India. The species is easily distinguished by its laminal, peltate isidia.

**SPECIMEN EXAMINED: INDIA: UTTARAKHAND, CHAMOLI DISTRICT**, Badrinath, alt. 3,617 m, 30°44'46.6"N and 79°28'54.9"E on soil, Himanshu Rai, Roshni Khare, Preeti Shukla 11-0014563 (LWG).

***Peltigera leucophlebia* (Nyl.) Gyeln. (Fig. 2.27c; Fig. 2.50)**

Gyelnik, Magyar Bot. Lapok 24: 79. 1926.

Basionym: *Peltigera aphthosa* var. *leucophlebia* Nyl., Syn. Lich. 1(2): 323. 1860.

Synonyms: *Peltigera aphthosa* var. *variolosa* A. Massal., Sched. Crit. Lich. Exs. Ital. 3: 64. 1856. -*Peltigera variolosa* (A. Massal.) Gyeln., Magyar Bot. Lapok 25:252. 1927.

**Thallus:** loosely attached to the substratum, to 5 cm across; **lobes:** 5–15 mm wide; **upper surface:** yellowish brown to dark brown, marginally tomentose, isidia and soredia absent, cephalodiate; **cephalodia:** external, rounded to irregular on whole surface of thallus, cerebriform containing *Nostoc*, 120–140  $\mu\text{m}$  thick and 225–565  $\mu\text{m}$  wide; **lower surface:** veined, rhizinate; **veins:** reticulate, distinct brown to brown-black; **rhizines:** sparse, simple or tufted to fasciculate, 1–4 mm long; **photobiont:** a green alga; **medulla:** white. **Apothecia:** absent.

**Chemistry:** Gyrophoric acid, tenuiorin and unknown substance present.

**Ecology and distribution:** *Microhabitat occupied:* Terricolous; terricolous-rupicolous; muscicolous-rupicolous. In India, the species is distributed in Himachal Pradesh and Uttarakhand. The species is also reported from China and Japan; temperate Europe and North America. The species is easily distinguished by the green algal photobiont, warty external cephalodia and distinct veined lower surface. *P. leucophlebia* shows similarity to *P. venosa*, but latter differs in presence of internal cephalodia.

**SPECIMENS EXAMINED:** **INDIA:** HIMACHAL PRADESH, KULLU DISTRICT, Great Himalayan National Park, from Dhela to Lapah, alt. 3,000 m, on soil, D. K. Upreti 99-54087 (LWG); **UTTARAKHAND, BAGESHWAR DISTRICT,** on the way Phurkia to Mirtoli, alt. 3,505 m, on ground and boulders among mosses, D. D. Awasthi 7753 (LWG-AWAS); en route to Pindari Glacier, between Dwali to Kafni, on soil over rock, Upreti, Chatterjee and Tandon L69080/K (LWG).

*Peltigera macra* Vain. (Fig. 2.27d; Fig. 2.50)

Vainio, Philipp. J. Sci. C, 8 (2): 114. 1913.

**Thallus:** closely appressed to substratum, 1–3 cm in size; **lobes:** flat, discrete, 5–10 mm wide; **margin:** entire to wavy; **upper surface:** pale brown to brown, smooth epruinose, etomentose, isidia and soredia absent; **lower surface:** pale brown, veined, rhizinate; **veins:** pale brown reticulate at the margin, brownish black and diffused at the central part; **rhizine:** simple, dense, confluent, 4–8 mm long, sometimes with pedicellate surface; **photobiont:** *Nostoc*; **medulla:** white. **Apothecia:** vertical, on extended lobules, 2–4 mm in diam., rounded; **disc:** reddish brown; **proper exciple:** 125–189  $\mu\text{m}$  thick; **hymenium:** 84–100  $\mu\text{m}$  thick; **spores:** acicular, usually curved, transversely 5–7-septate, 43–72  $\times$  5  $\mu\text{m}$ , not easily liberated from ascus.

**Chemistry:** Yellow spot of tenuiorin at  $R_f$  value 0.67, purple-grey spot of dolichorrhizin at  $R_f$  value 0.5 and an unidentified grey spot at  $R_f$  value 0.77.

**Ecology and distribution:** *INDIA, Microhabitat occupied:* Muscicolous-terricolous. In India, the species is restrictedly distributed to Meghalaya and Sikkim. The species is also reported from the Philippines, Europe and North America. It resembles *P. dolichorrhiza*, but latter has thinner thallus, is sparsely distributed, and has nonconfluent rhizines.

**SPECIMEN EXAMINED:** **INDIA:** SIKKIM, EAST SIKKIM DISTRICT, Bhusuk area, alt. 2,000 m, on soil among mosses, Upreti and Chatterjee 01-26627 (LWG).

*Peltigera malacea* (Ach.) Funck. (Fig. 2.27e; Fig. 2.50)

Funck, Cryptog. Gewächse 33: 5. 1827.

Basionym: *Peltidea malacea* Ach., Syn. Meth. Lich.: 240. 1814.

**Thallus:** foliose, close appressed to the substratum, large, 5–10 cm in diam., adnate; **lobes:** flat, discrete, flattened to elongate, up to 3 cm wide to 4 cm long, dichotomously branched; **upper surface:** brownish when dry, deep bluish green to olive green when wet, smooth; **photobiont:** *Nostoc*; **medulla:** white; **lower surface:** ± uniformly tomentose, brown to brown black veins almost absent with few interstices; **rhizines:** sparse, fasciculate and 2–6 mm long. **Apothecia:** vertical, on extended lobules, rounded, 3–6 mm in diam., **disc:** reddish brown to brown, epruinose; **proper exciple:** 110–150 µm thick; **hymenium:** hyaline to pale brown, 100–140 µm high; **hypothecium:** pale brown to brown, 50–54 µm thick; **spores:** acicular, transversely 4–6-septate, 50–80 × 3–6.5 µm.

**Chemistry:** Cortex and medulla K–, C–, KC–, P–. Gyrophoric acid, tenuiorin, zeorin and triterpenoids present.

**Ecology and distribution:** *Microhabitat occupied:* Terricolous; terricolous-rupicolous; terricolous-muscicolous. In India, the species is commonly distributed in Arunachal Pradesh, Himachal Pradesh, Jammu and Kashmir, Sikkim and West Bengal hills. The species exhibits bipolar distribution and is reported from China, Japan, Nepal, New Zealand and the Philippines; Europe, North America. It differs from *P. elisabethae*, which has a glossy and nontomentose upper surface.

**SPECIMENS EXAMINED: INDIA: HIMACHAL PRADESH, KULLU DISTRICT,** Great Himalayan National Park, on the way from Dhela to Lapah, alt. 3,000 m, on soil over rocks, D. K. Upreti 99-54086 (LWG); **SIKKIM, EAST SIKKIM,** Gangtok, Tashi view point surroundings, alt. 2,000 m, on ground, Sinha 96 (BSHC); **UTTARAKHAND, CHAMOLI DISTRICT,** on the way to Hemkund, alt. 4,500 m, on soil, A. Singh 85824 (LWG); **WEST BENGAL, DARJEELING DISTRICT,** Tiger hill, Senchal lake area, alt. 2,210 m, on soil, D. D. Awasthi 64.106 (LWG-AWAS); on the way from Sandakhpoo to Phalut, alt. 3,658 m, on soil, D. D. Awasthi and M. R. Agrawal 67.422 (LWG-LWU).

*Peltigera membranacea* (Ach.) Nyl. (Fig. 2.27f; Fig. 2.50)

Nylander, Bull. Soc. Linn. Normandie, ser. 4, 1: 74. 1887.

Basionym: *Peltidea canina* var. *membranacea* Ach, Lichenogr. Universalis: 518. 1810.

**Thallus:** foliose, loosely attached to the substratum, large, thin 5–15 cm in diam., thin, adnate; **lobes:** flattened and elongated, imbricate, thin, dichotomously branched; **upper surface:** brown when dry, bluish gray or blackish green when wet; **medulla:** white; **photobiont:** *Nostoc*; **lower surface:** shining at the central part, but indistinct at the marginal region because of dense growth of rhizines white, veined, rhizinate; **veins:** with anastomosing, pale, narrow or raised; **rhizines:** white to pale brown, simple or squarrosely branched, scattered with penicillate fuzzy growth at the marginal area. **Apothecia:** vertical, ± round to oblong, becoming saddle shaped, semi-immersed on short ascending lobes, up to 6 mm in diam., margin smooth to crenulated; **disc:** flat, dark brown to black, smooth; **proper exciple:** 160–190 µm thick; **hymenium:** 98–135 µm high; **spores:** colourless to pale brown, acicular, transversely 5–7-septate, 45–50 × 3–5 µm.

**Chemistry:** Thallus K–, C–, KC–, P–; no secondary metabolites in TLC.



**Ecology and distribution:** *Microhabitat occupied:* Terricolous; terricolous-rupicolous. In India, the species is widely distributed in Himachal Pradesh, Kerala, Punjab, Sikkim, Uttarakhand and West Bengal hills. The species is cosmopolitan in distribution from Bhutan, China, Japan, Nepal, New Zealand and Tasmania; Europe, North America. It differs from *P. canina*, which do not have flat and darker veins and bushy rhizines form confluent mats.

**SPECIMENS EXAMINED:** **INDIA:** **SIKKIM, EAST SIKKIM DISTRICT,** Bhusuk area, alt. 2,000 m, on soil, Upreti and Chatterjee 01-26625 (LWG); **UTTARAKHAND, ALMORA DISTRICT,** Ranikhet, Chaubattia, alt. 1,981 m, on soil, D. D. Awasthi 3539 (LWG-AWAS); **BAGESHWAR DISTRICT,** Rargariudiyar (Lilam-Bogudiyar), Milam Glacier, on soil, Santosh Joshi 07-010331 (LWG); **CHAMOLI DISTRICT,** Malari area, alt. 3,300 m, on soil, S. Rawat 06-006851 (LWG); **PITHORAGARH DISTRICT,** Naher Devi to Mapang, en route to Milam glacier, alt. 2,933 m, on soil, S. Joshi 07-010330 (LWG); **UTTARKASHI DISTRICT,** 4 km after Gangotri towards Chirwasa, alt. 3,200 m, on soil, S. Chatterjee and P. K. Divakar 02-000175/B (LWG); **WEST BENGAL, DARJEELING DISTRICT,** Tiger Hill Reserve, alt. 8,000 ft., on ground, D. D. Awasthi 3135 (LWG-LWU); Tiger hill, alt. 2,362 m, on rock over soil, M. N. Bose 6208 (LWG-AWAS); Pashok road, at about 5–6 miles from Darjeeling, alt. 1,981 m, on ground, D. D. Awasthi and M. R. Agarwal 67.169 (LWG-LWU).

*Peltigera pindarensis* D. D. Awasthi and M. Joshi (Fig. 2.27g; Fig. 2.50)  
Awasthi and Joshi, Kavaka 10: 58. 1982.

**Thallus:** up to 6 cm across, loosely attached to the substratum; subdichotomously lobed; **lobes:** 5–17 mm wide, subrotund; **margin:** wavy to crisp; **upper surface:** pale brown to brown, densely tomentose, tomenta persist in the central part; **photobiont:** *Nostoc*; **lower surface:** creamish buff, veined, rhizinate; **veins:** distinct pale brown at margin and dark brown in the central part, interspaces pale brown; **rhizine:** simple, 2–6 mm long. **Apothecia:** horizontal, submarginal on the edge of the lobes, 2–7 mm in diam., rounded; **disc:** reddish brown, epruinose, margin distinct, pale brown, tomentose, crenate; **proper exciple:** 120–155  $\mu\text{m}$  thick; **hymenium:** 95–115  $\mu\text{m}$  high; **asci:** 8-spored; **spores:** colourless, fusiform, 3 transversely septate, 25–38  $\times$  5–8  $\mu\text{m}$  in size; **paraphyses:** simple, 2.5  $\mu\text{m}$  thick, with swollen brown apices.

**Chemistry:** Thallus K–, C–, KC–, P–; no secondary metabolites in TLC.

**Ecology and distribution:** *Microhabitat occupied:* Terricolous; terricolous-rupicolous; muscicolous-terricolous. In India, the species is commonly distributed in Himachal Pradesh and Uttarakhand. Outside of India, the species is also reported from Bhutan and Thailand. It shows close resemblance to *P. canina* in the presence of tomentum and chemistry, but in *P. canina*, the apothecia are vertical and spores acicular, 3–7-septate. It also shows similarity to *P. horizontalis* in nature of apothecia and spores.

**SPECIMENS EXAMINED:** **INDIA:** **HIMACHAL PRADESH, KULLU DISTRICT,** Greater Himalayan National Park, on the way from Dhela-Lopah, alt. 3,000 m, on ground along with mosses under *Rhododendron* bushes, D. K. Upreti 99-54088 (LWG); on the way to Ropa from Rolla, alt. 2,100 m, on moss over soil, S. Nayaka and R. Srivastava 02.001062 (LWG); **UTTARAKHAND, CHAMOLI DISTRICT,** Belta (en route to Nanda Devi Biosphere Reserve), alt. 3,300 m, on soil, 06 June 2008, S. Rawat and D. Rawat, 08-011083 (LWG); Badrinath, alt. 3,376 m, 30°44'47.9"N and 79°30'06.4"E, on soil, 14.05.11, Himanshu Rai, Roshni Khare

and Preeti Shukla (LWG); **PITHORAGARH DISTRICT**, Gori Ganga catchment, Deochula, alt. 1,800 m, on rocks over soil, Vikas Pant 20-67951 (LWG).

***Peltigera polydactylon*** (Neck) Hoffm.

Hoffmann, Descr. Pl. Cl. Crypt. 1: 19. 1789.

Basionym: *Lichen polydactylon* Neck., Meth. Musc.: 85. 1771.

var. ***polydactylon*** (Fig. 2.27h; Fig. 2.50)

**Thallus:** large, up to 10 cm across, orbicular to irregularly spreading, closely adnate to substrate, thick, coriaceous, irregularly lobed; **lobes:** flat, rotund to subrotund, discrete, irregular; **upper surface:** glabrous, dark lead-grey to blue-black when wet, chestnut-coloured to dark red-brown when dry; **lower surface:** pale or whitish at the margins to buff or dark brown centrally, veined, rhizinate; **veins:** broad, flat, brown-black, distinctly reticulate in younger parts and diffused in older parts, frequent, oval to rounded, white; **rhizine:** simple to fasciculate, pale buff to dark brown or blackened, in rows. **Apothecia:** vertical, erect, borne in groups of 2–7 on narrow erect lobules, oval to oblong, rounded to saddle-shaped, 4–7 × 2–4(–5) mm; **disc:** disc pale to dark red-brown, epruinose; **hymenium:** 97–125 µm high; **spores:** colourless, acicular, straight to curved, 5–9 transversely septate, 34–96 × 3.5–5 µm.

**Chemistry:** Gyrophoric acid, tenuiorin, dolichorhizin and undetermined brown spot at  $R_f$  value 0.8 and grey-yellow spot at  $R_f$  value 0.67.

**Ecology and distribution:** *Microhabitat occupied:* Terricolous; terricolous-rupicolous; muscicolous-terricolous. In India, the species is widely distributed in Arunachal Pradesh, Assam, Himachal Pradesh, Jammu and Kashmir, Manipur, Meghalaya, Sikkim, Uttarakhand and West Bengal hills. The species is also reported from Bhutan, Japan and Nepal; Europe, North America. It is distinguished by tomentose smooth upper surface, wide black, reticulate veins on lower surface. The species is closely related to *P. horizontalis*, which has horizontal apothecia and 4-celled spores, but in sterile stage both species look indistinguishable.

**SPECIMENS EXAMINED: INDIA: HIMACHAL PRADESH, KULLU DISTRICT**, on the way to Manali, alt. 1,800 m, on soil, D. D. Awasthi 1867 (LWG-AWAS); Greater Himalayan National Park, Sainj Wildlife sanctuary, Shakti, alt. 2,200 m, on mosses over soil, Upreti, Srivastava and Prakash 04-003294 (LWG); Manali, alt. 1,981 m, on soil, D. D. Awasthi, M. R. Agarwal and M.Sc. students 08284 (LWG-LWU); **CHAMBA DISTRICT**, Brahmaur Hadsar, Mani Mahesh Doonch, alt. 2,150 m, on soil, D. K. Upreti and S. Nayaka 0175498 (LWG); **KANGRA DISTRICT**, Bir forest area, on soil, R. Khare and S. Mahobe 10-014137 (LWG); **KINNAUR DISTRICT**, Chitkul forest area, alt. 3,950 m, on mosses over soil, Upreti, Srivastava and Prakash 03-002708 03-002708 B 03-002730 B (LWG); **MANDI DISTRICT**, en route from Barot to Winch, alt. 2,200 m, on soil, 213544 (LWG); **JAMMU AND KASHMIR, ANANTNAG DISTRICT**, Pahalgam, on the way to Aru, alt. 2,400 m, on rock surface over soil at right bank of river, K. Dange 76.256 (LWG-LWU); on the way to Chandanwari, alt. 2,700 m, on rock surface along with mosses over soil, K. Dange 76.359 (LWG-LWU); Babarishi, on rock over soil, K. N. Kaul s.n. (LWG); Foroipur nala, on rock surface over soil, K. N. Kaul s.n. (LWG); **BARAMULLA DISTRICT**, Gulmarg on the way to Khilanmarg, alt. 2,655 m, on rock surface over soil, K. Dange 76.508 (LWG-LWU); Gulmarg, at Gulmarg on southeast side, alt. 2,680 m, on soil, K. Dange 77.473 (LWG-LWU); **MEGHALAYA, SHILLONG**, Upper Shillong peak, alt. 1,800 m, D. D. Awasthi 6449, 6452 (LWG-AWAS); Nongstain village, Panigrahi 16514 (LWG-AWAS); **SIKKIM, GANGTOK**, Tashi view point, alt. 1,750 m, on soil

over rock, Chatterjee and Divakar 20-7 7183 (LWG); **EAST SIKKIM**, 5 km from Tashi view point to Karbi, alt. 1,800 m, on soil over rock in vertical road side, Upreti and Chatterjee 01-26657 (LWG); Tumin area, alt. 2,000 m, on soil along road side, Upreti and Chatterjee 01-67240 (LWG); **NORTH SIKKIM**, Lachen, alt. 3,000 m, on soil, D.K. Upreti, S. Chatterjee and P.K. Divakar 04-003782 (LWG); Singhbo Rhododendron Sanctuary, near Yumthang, alt. 3,500 m, on soil, D.K. Upreti, S. Chatterjee and P.K. Divakar 04-004130(LWG); Sakyong, on rock over soil, Arvind Saklani s.n. (LWG); **UTTARAKHAND, BAGESHWAR DISTRICT**, en route to Sunderdhunga glacier, between Loharkhet to Dhakuri, alt. 2,700 m, on soil, Upreti and Tandon 213366(LWG); en route to Sunderdhunga glacier, between Loharkhet and Dhakuri, alt. 2,700 m, on soil, Upreti and Tandon 213366 (LWG); **CHAMOLI DISTRICT**, Govindghat-Ghangharia, alt. 2,700 m, on soil growing along with mosses, Ajay Singh, 85801 (LWG); Badrinath, south of the temple, near brahmini village, alt. 3,163 m, on rock surface over soil, K. Dange, 76.730 (LWG-LWU); **PITHORAGARH DISTRICT**, Gori Ganga catchment area, alt. 2,300 m, on soil, Vikas Pant 20-67549 (LWG); **RUDRAPRAYAG DISTRICT**, Kedarnath, hillside on east and north of the temple, alt. 3,650 m, on rock surface over soil, K. Dange 76.253 (LWG-LWU); Chopta-Tungnath, alt. 3,200 m, on soil, D. K. Upreti and S. Nayaka 07-010174 (LWG); **UTTARKASHI DISTRICT**, Gomukh area, right bank, 3rd and 4th moraine, alt. 3,871 m, on soil, D. D. Awasthi and S. R. Singh, 8461 (LWG-AWAS); Yamunotri-Jankichatti, alt. 3,100 m, on soil covered with mosses, A. Singh, 76081 (LWG).

var. *pruinosa* Gyeln. (Fig. 2.27i; Fig. 2.50)

Gyelnik, Magyar Bot. Lapok 25: 253. 1926.

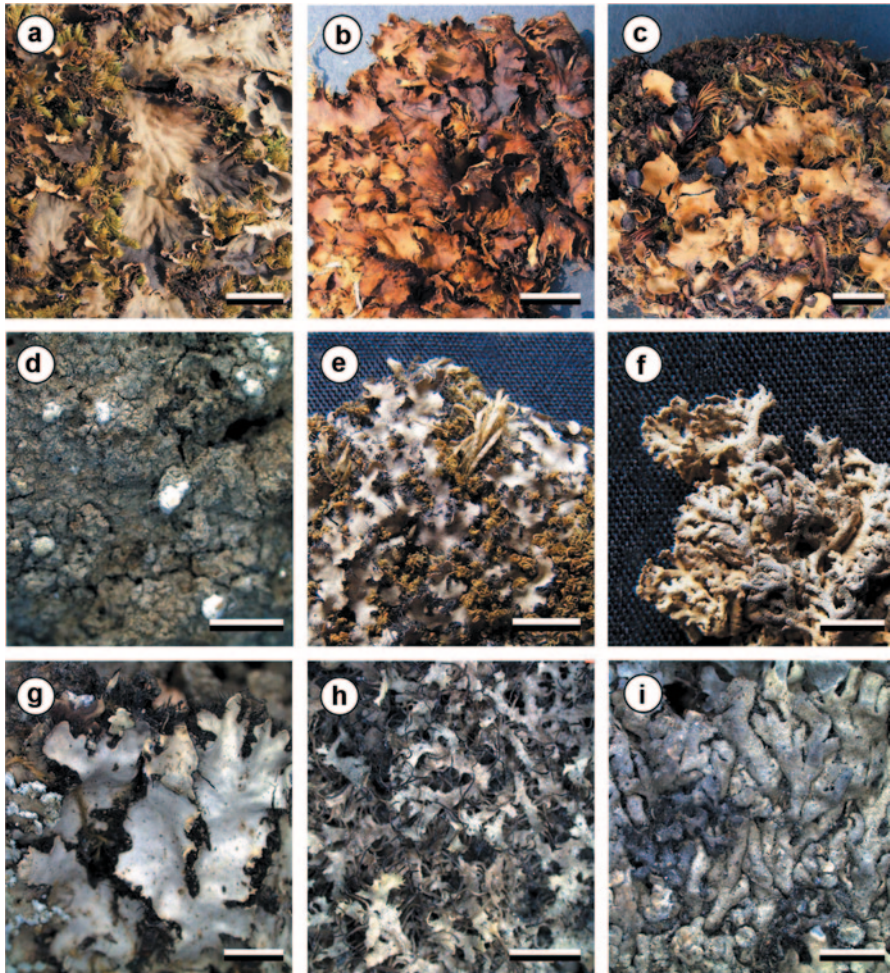
Synonym: *Peltigera pruinosa* (Gyelnk.) Inum., Act. Phytotax.Geobot. 12: 11. 1943.

**Thallus:** large up to 10 cm across, closely adnate to substrate, thick, coriaceous, irregularly lobed; **lobes:** flat, rotund to subrotund, discrete; **upper surface:** greyish brown to brown, scattered pruinose, may be extensive and as spots; **lower surface:** with broad, flat, brown-black veins, interspaces small, rhizinate short, sparse fasciculate. **Apothecia:** vertical, borne in groups of 2–7 on narrow erect lobules, oval to oblong, 4–7 × 2–4(–5) mm; **proper exciple:** 150–197 μm, **hymenium:** 97–125 μm; **spores:** colourless, acicular, straight to curved, 5–9 transversely septate, 34–96 × 3.5–5 μm.

**Chemistry:** Gyrophoric acid, tenuiorin, dolichorhizin and undetermined brown spot at  $R_f$  value 0.8 and grey-yellow spot at  $R_f$  value 0.67.

**Ecology and distribution:** *Microhabitat occupied:* Terricolous; terricolous-rupicolous; muscicolous-terricolous. In India, the species is widely distributed in Himachal Pradesh, Jammu and Kashmir, Sikkim, Uttarakhand and West Bengal hills. The species is also reported from Japan and Nepal. Var. *pruinosa* differs from var. *polydactylon* in the presence of scattered pruinosity on upper surface, pruina may be in the form of spots and distributed evenly.

**SPECIMENS EXAMINED:** **INDIA: HIMACHAL PRADESH, MANALI**, alt. 1,981 m, on soil, D. D. Awasthi, M. R. Agarwal, M.Sc. students 08284 (LWG-LWU); **JAMMU AND KASHMIR, BARAMULLA DISTRICT**, Khilanmarg, on soil, K. N. Kaul and party s.n. (LWG); Babarishi, alt. 2,268 m, on soil covered rock, K. N. Kaul and party s.n. (LWG); **SIKKIM, GANGTOK**, Darjeeling road, alt. 1,500 m, on soil along with mosses, K. P. Srivastava s.n. (LWG); **UTTARAKHAND, CHAMOLI DISTRICT**, on the way to Sonprayag to Trijuginarayan, alt. 1,800–2,400 m, Dange 76.393 (LWG-LWU); between Govind ghat to Ghangharia, alt. 2,700 m, on soil growing along with mosses, Ajay Singh 85801 (LWG); **WEST BENGAL, DARJEELING**, alt. 1,829 m, on ground, D. D. Awasthi 3122 (LWG-AWAS); Loyd Botanic Garden, alt. 1,950 m, on ground, D. D. Awasthi 3825 (LWG-AWAS); Kurseong, near St. Marry College, alt. 5,750 m, on soil, D. D. Awasthi and M. R. Agarwal 66.176 (LWG-LWU).



**Fig. 2.28** **a** *Peltigera praetextata* (Flörke) Zopf, **b** *P. rufescens* (Weiss.) Humb., **c** *P. venosa* (L.) Hoffm., **d** *Pertusaria puffina* A. W. Archer and Elix, **e** *Phaeophyscia ciliata* (Hoffm.) Moberg, **f** *P. constipata* (Norrl. and Nyl.) Moberg, **g** *P. hispidula* (Ach.) Moberg, **h** *Physcia adscendens* (Fr.) H. Olivier, **i** *P. caesia* (Hoffm.) Fűrnr. Scale in **d**, **g**, **h**, **i**=2 mm; in **e**, **f**=5 mm; in **a**, **c**=10 mm; in **b**=20 mm

***Peltigera praetextata*** (Flörke) Zopf (Fig. 2.28a; Fig. 2.50)

Ann. Chem. 364: 299. 1909.

Basionym: *Peltigera ulorrhiza* var. *praetextata* Flörke in Sommerf., Suppl. Fl. Lappon: 123. 1826.

**Thallus:** rounded to irregular, large up to 16 cm across, loosely to closely adnate to substratum; **lobes:** 7–25(30) mm wide, sublinear to irregular, discrete, flat; **margins:** thickened below, inrolled or downrolled, undulate, entire or phyllidiate-dissected, crenate to wavy; **upper surface:** pale brown to dark brown, marginally tomentose, isidiate; **isidia:** marginal or along the margin of cracks, squamuliform,

scattered to densely crowded, concolorous with the upper surface or darker; **lower surface**: pale buff at the margin, darkening centrally; **veins**: pale brown reticulate at margin and brown to dark brown at centre, conspicuous, raised; **rhizine**: simple, pale to medium brown. **Apothecia**: on extended lobules,  $\pm$  rounded, finger-shaped 2–10 mm in diam.; **disc**: reddish brown to dark brown, margin pale buff, coarsely corrugate-scabrid, crenate; **proper exciple**: 90–150  $\mu\text{m}$  thick; **hymenium**: 80–120  $\mu\text{m}$  high; **spores**: acicular, straight to slightly curved, 3–7 transversely septate,  $32\text{--}75 \times 3\text{--}5 \mu\text{m}$  in size.

**Chemistry**: Thallus K<sup>-</sup>, C<sup>-</sup>, KC<sup>-</sup>, P<sup>-</sup>; no secondary metabolites in TLC.

**Ecology and distribution**: *Microhabitat occupied*: Terricolous; terricolous-rupicolous; muscicolous-terricolous. In India, the species is widely distributed in Himachal Pradesh, Jammu and Kashmir, Nagaland, Sikkim and Uttarakhand. The species is cosmopolitan in distribution and also reported from Bhutan, China and Japan; East Africa; Europe, North America. *P. praetextata* is characterized by tomentose upper surface, pale brown reticulate veins and squamiform isidia. It shows similarity to *P. canina*, which though in nonisidiate.

**SPECIMENS EXAMINED**: **INDIA**: **ARUNACHAL PRADESH**, **WEST KAMENG DISTRICT**, near Sella pass, on soil, D. K. Upreti, U. Dubey, R. Khare and G. K. Mishra 08-009399 (LWG); **HIMACHAL PRADESH**, **CHAMBA DISTRICT**, on the way from to Khajjar from Dalhousie, alt. 2,350 m, on soil, D. K. Upreti and S. Nayaka 01-75434 Dup, 0175437 (LWG); Hadsar, Mani Mahesh, Doonch, alt. 2,150 m, on soil, D. K. Upreti and S. Nayaka 01-75505, 01-75497 (LWG); **KANGRA DISTRICT**, Palampur Bagh Nalla, alt. 1,700 m, on soil, D. K. Upreti 213650 (LWG); **KULLU DISTRICT**, Greater Himalayan National Park, Shilt, alt. 2,800 m, on soil, S. Nayaka and R. Srivastava 02.001065 (LWG); **SHIMLA**, Rohru, Jubbal, Kharapatter towards Giri Ganga, alt. 2,500 m, on soil, S. Nayaka and R. Srivastava 02-102874 (LWG); **SOLAN DISTRICT**, Kandaghat, Koel, alt. 1,615 m, on soil, S. Nayaka 02-85761 (LWG); **JAMMU AND KASHMIR**, **ANANTNAG DISTRICT**, Pahalgam, on the way to baisaran, alt. 2,400 m, K. Dange 77.74 (LWG-LWU); **UDHAMPUR DISTRICT**, Patnitop, Sanasar road, alt. 2,400 m, on rocks over soil, M. Sheikh 05-006678 (LWG); **SIKKIM**, **GANGTOK**, Bulwakhani, alt. 1,700 m, on rock over soil, Chatterjee and Divakar 20-77004 (LWG); **EAST SIKKIM**, Turin area, alt. 2,000 m, on soil along road side, Upreti and Chatterjee 01-67241 (LWG); Tamil Nadu, Nilgiri hills, Avalanche, behind the forest rest house, alt. 2,134 m, on ground with mosses, K. P. Singh 71.674 (LWG-LWU); **UTTARAKHAND**, **ALMORA DISTRICT**, Gwaldam-Ranikhet, alt. 1,950 m, on soil, Ajay Singh 90213 (LWG); **BAGESHWAR DISTRICT**, Dhakuri to Khati (en route to Pindari glacier), alt. 2,210 m, on soil, S. Joshi and Y. Joshi 07-08822 (LWG); **CHAMOLI DISTRICT**, Ali Bugyal to Waan, alt. 3,200 m, on soil, Ajay Singh, 90383 (LWG); Nanda Devi Biosphere reserve, NW Part, on soil, H. R. Negi, L-550, 1004, 1293, 1019 (LWG); Valley of flower, alt. 3,200, on soil, S. Rawat, 06-007119 (LWG); Ghangharia, en route to valley of flowers, alt. 3,150 m, on soil, S. Rawat, 06-007128 (LWG); **DEHRADUN DISTRICT**, Mussoorie, alt. 2,100 m, on soil, M. Ranjan, 11559 (LWG); Charkata hills, Deoban, near forest rest house, alt. 2,896 m, on ground, D. D. Awasthi and M. Joshi, 76.184 (LWG-LWU); **NAINITAL DISTRICT**, on the way to Naina peak, alt. 2,591 m, on the rock surface along with mosses over soil, D. D. Awasthi and K. Dange 74.14 (LWG-LWU); **PITHORAGARH DISTRICT**, Narain Swami Ashram, alt. 2,715 m, on soil, Upreti, Rai, Joshi, Khare, Dwivedi, Misra 09-0014565 (LWG); **RUDRAPRAYAG DISTRICT**, Madmaheshwar, Gondar, on rock over soil, Ajay Singh and M. Ranjan 107000, 107050 (LWG); Chopta, alt. 3,200 m, on soil, S. Rawat 06-006889 (LWG); Kedarnath valley, Garurchatti, alt. 2,200 m, on soil over rock, D. K. Upreti, P. K. Divakar, B. Kumar 06-006208 (LWG); **UTTARKASHI DISTRICT**, Gomukh area, right bank, 5th moraine, alt. 3,840 m, on soil, D. D. Awasthi and S. R. Singh 8476, 8476 Dup (LWG-AWAS); Gangotri, alt. 3,075 m, on soil, Himanshu

Rai and Pramod Nag 10-0014513 (LWG); Govind Wildlife Sanctuary, way to Osla from Taluka, alt. 2,144 m, on rock over soil along with mosses, D. K. Upreti, S. Nayaka, R. Bajpai 11-015667 (LWG); way to Kedarkantha, alt. 2,119 m, on soil, D. K. Upreti, S. Nayaka, R. Bajpai 11-016078 (LWG).

***Peltigera rufescens*** (Weiss.) Humb. (Fig. 2.28b; Fig. 2.50)

Humboldt, Fl. Friburg.: 2. 1793.

Basionym: *Lichen caninus* var. *rufescens* Weiss, Pl. Crypt. Fl. Goett.: 79. 1770.

**Thallus:** orbicular to irregularly spreading, closely adnate to the substratum, up to 8 cm across, thick, rigid; **lobes:** linear to rounded, flat, discrete, 2–10 mm wide; **margin:** wavy, flat, reflexed, undulate, frilled, strongly upturned, lobulate or phyllidiate; **upper surface:** pale brown to dark brown, densely tomentose, smooth in central parts; **lower surface:** tomentose, pale brown, veined, rhizinate; **veins:** rather flattened to slightly raised, 0.5–1.0 mm wide, pale buff to brown at the margins, darkening to brown-black centrally, anastomosing, with pale or whitish lenticular interstices; **rhizines:** simple at the margins, becoming tangled and confluent in a dense row along veins,  $\pm$  concolorous with veins, 1–2 mm long; **photobiont:** *Nostoc*; **medulla:** white. **Apothecia:** vertical, on extended lobules, rounded, 3–6 mm in diam.; **disc:** reddish brown to dark brown, matt; **proper exciple:** 100–145  $\mu$ m thick; **hymenium:** 80–110  $\mu$ m high; **spores:** acicular, 5–7 transversely septate, 45–75  $\times$  3–6  $\mu$ m in size.

**Chemistry:** Thallus K<sup>-</sup>, C<sup>-</sup>, KC<sup>-</sup>, P<sup>-</sup>; no secondary metabolites in TLC.

**Ecology and distribution:** *Microhabitat occupied:* Terricolous; terricolous-rupicolous; muscicolous-terricolous. In India, the species is widely distributed in Arunachal Pradesh, Himachal Pradesh, Jammu and Kashmir, Nagaland, Sikkim, Uttarakhand and West Bengal hills. The species is cosmopolitan in distribution and reported from Australia, Bhutan, Japan and New Zealand; Europe, North and South America. *P. rufescens* is closely related to *P. canina*, from which it is differentiated by thicker thallus, wavy frilled margin, dense and parallel arranged veins. The species usually grow directly on soil and rocks while *P. canina* prefers a mossy substrate.

**SPECIMENS EXAMINED:** **INDIA:** ARUNACHAL PRADESH, WEST KAMENG DISTRICT, Tawang, alt. 4,000 m, on soil with mosses, Jaishree Rout s.n (LWG); HIMACHAL PRADESH, KINNAUR DISTRICT, Chitkul forest area, alt. 3,950 m, on mosses over soil, Upreti, Srivastava, Prakash 03-002730 A (LWG); LAHAUL SPITI DISTRICT, Lahaul valley, Chhatru, 3200 m, on soil, Upreti and Divakar 02-000046 (LWG); JAMMU AND KASHMIR, ANANTNAG DISTRICT, Kuler-nag, alt. 1,829 m, on ground among mosses, D. D. Awasthi 2630 (LWG-AWAS); Gulmarg, alt. 2,680 m, on rock surface on mud, K. Dange 77.426 (LWG-LWU); SRINAGAR, Shankaracharya hill, alt. 1,829 m, on ground among mosses, D. D. Awasthi 2646 (LWG-AWAS); SIKKIM, NORTH SIKKIM, Singbo Rhododendron Sanctuary, alt. 3,500 m, on soil, D. K. Upreti, S. Chatterjee and P. K. Divakar 04-004093 (LWG); Lachung town, near Bridge, alt. 2,800 m, on soil, D. K. Upreti, S. Chatterjee and P. K. Divakar 04-004317 (LWG); UTTARAKHAND, ALMORA DISTRICT, Ranikhet on the way of Chaubattia, alt. 1,981 m, in moist shady places on rocks over soil, D. D. Awasthi and K. Dange 74.113 (LWG-LWU); BAGESHWAR DISTRICT, Dhakuri to Khati, alt. 1,981 m, on soil among mosses, D. D. Awasthi and A. M. Awasthi 689 (LWG-AWAS); Khati to Dwali (en route to Pindari glacier), alt. 2,472 m, on soil, S Joshi and Y Joshi 07-008806 (LWG); CHAMOLI DISTRICT, Ghangharia-Hemkund, alt. 3,505 m, on soil, A. Singh, 85829 (LWG); en route to valley of flowers, on soil, A.

Singh, 85883 (LWG); Ghangharia-Hemkund, alt. 3,505 m, on soil, A. Singh, 85835, 85850 (LWG); Nanda Devi Biosphere reserve, NW part, on soil, H. R. Negi, L-534, 574, 2540 (LWG); Malari, alt. 3,400 m, on soil, S. Rawat, 07-008611 (LWG); alt. 3,000 m, on soil, S. Rawat, 07-008627 (LWG); **DEHRADUN DISTRICT**, Mussoorie, Landour, north of GB Hospital, alt. 1876 m, on ground, Ö. A. Höeg 1447 (LWG-AWAS); **PITHORAGARH DISTRICT**, Askot, Langam Kanta forest, alt. 1,900 m, on soil, D. K. Upreti 212975 (LWG); **RUDRAPRAYAG DISTRICT**, Kedarnath, hill side on west of the temple, alt. 2,603 m, on rock surface over soil, K. Dange 76.189 (LWG-LWU); Baniyakund, Ukhimath, alt. 1,900 m, on soil, S. Rawat 06-007186 (LWG); Chopta, alt. 3,000 m, on soil, S. Rawat 06-007270 (LWG); **TEHRI GARHWAL**, Dhanaulti, alt. 2,250 m, on soil, A. Singh 77561 (LWG); **UTTARKASHI DISTRICT**, on the way to Gangotri, 4 km from Bhainro ghati, alt. 3,048 m, on soil over a boulder, D. D. Awasthi and S. R. Singh 8168 (LWG-AWAS); Gangotri, alt. 3,118 m, on soil, Himanshu Rai and Pramod Nag 10-0014504 (LWG); Govind wildlife sanctuary, way from Sankri to Taluka, Poorti khand, alt. 2,100 m, on soil, D. K. Upreti, S. Nayaka, R. Bajpai 11-013286 (LWG); **WEST BENGAL, DARJEELING DISTRICT**, on the way to Sandakhpoo, about 2 miles below Sandakhpoo, alt. 10000 ft., on soil over rock, D. D. Awasthi and M. R. Agrawal 67.339 (LWG-LWU).

***Peltigera venosa* (L.) Hoffm.** (Fig. 2.28c; Fig. 2.50)

Hoffmann, Descr. Pl. Cl. Crypt. 1: 31. 1789.

Basionym: *Lichen venosus* L., Sp. Pl: 1148. 1753.

**Thallus:** to 2 cm across, lobes to 5 mm wide, rounded; **upper surface:** grey-brown or greenish brown, tomentose, lacking isidia and soredia; **lower surface:** dark, veins fan shaped, villous, haptera at lobe ends, rhizines absent; **cephalodia:** internal, nodulose present (*Nostoc* within); **photobiont:** a green alga (*Coccomyxa*); **haptera:** at lobe ends. **Apothecia:** horizontal, 1–6 per lobe, marginal, flattened, 1–3 mm in diam.; **spores:** acicular, 3-septate,  $32\text{--}44 \times 4\text{--}8 \mu\text{m}$ .

**Chemistry:** Gyrophoric acid, methylgyrophorate, phlebic acid, tenuiorin and terpenoids present.

**Ecology and distribution:** *Microhabitat occupied:* Terricolous; muscicolous-terricolous. In India, the species is distributed in Himachal Pradesh and Sikkim. The species is also reported from China and Japan; Northern Europe; North America. The species is easily distinguished by the green algal photobiont, internal cephalodia and distinct veined lower surface. *P. leucophlebia* shows similarity to *P. venosa* but latter differs in presence of internal cephalodia.

**SPECIMENS EXAMINED: INDIA: HIMACHAL PRADESH, KINNAUR DISTRICT**, Chitkul forest area, alt. 4,000 m, on soil among mosses, Upreti, Srivastava and Prakash 03-002723 (LWG); **LAHAUL SPITI DISTRICT**, Lahaul valley, Chhatru alt. 3,200 m, on soil at vertical face, Upreti and Divakar 02-000047 (LWG); **SIKKIM, NORTH SIKKIM DISTRICT**, Giagaon, Above Thangu, alt. 4,600 m, on soil, D. K. Upreti, S. Chatterjee and P. K. Divakar 04-003994 (LWG).

**PERTUSARIA DC.** In Lam. and DC. (*Pertusariaceae*)

Fl. Franç., ed. 3, 2: 319. 1805.

**Thallus:** crustose, smooth, granular or verrucose, fissured or areolate, corticated; **photobiont:** green alga (*Trebouxia*). **Apothecia:** generally elevated and innate in fertile verrucae, single or several in each verruca, **disc:** wide, lecanorine or small, punctiform; **paraphyses:** branched and variously reticulately anastomosing; **asci:** thick walled, 1–8-spored; **spores:** colourless, oval ellipsoid, spore wall thick, single, double or triple layered, often costulate and rarely laminate.

Out of 525 species known from the world, 50 species are known from India, of which 1 is terricolous.

***Pertusaria puffina*** A. W. Archer and Elix (Fig. 2.28d; Fig. 2.50)

Archer and Elix, *Telopea* 6(1): 22. 1994.

**Thallus:** dull yellow, thin, cracked, surface smooth; lacking isidia, sorediate; **soredia:** white to off-white, numerous, scattered, disciform, 0.4–0.8 mm diam.

**Apothecia:** unknown.

**Chemistry:** K<sup>-</sup>, C<sup>-</sup>, KC<sup>-</sup>, P<sup>-</sup>; 2,4-dichlorolichexanthone (major), 2,5-dichlorolichexanthone (major), 2,4,5-trichlorolichexanthone (major), 2-chlorolichexanthone (minor), stictic acid (minor) and constictic acid (minor).

**Ecology and distribution:** *Microhabitat occupied:* Terricolous. Earlier, the species was known from Australia and Papua New Guinea and for the first time it is reported in India. It is a new record for Indian lichen flora and known only from Himachal Pradesh.

**SPECIMEN EXAMINED:** **INDIA: HIMACHAL PRADESH, SHIMLA,** Chaupal, Nerva Rankyar, alt. 2,000 m, on soil, S. Nayaka and R. Srivastava 02-77791 (LWG).

**PHAEOPHYSCIA** Moberg (*Physciaceae*)

Moberg, *Symb. Bot. Upsal.* 22(1): 29.1977.

**Thallus:** foliose, loosely adnate, lobes radiating; **upper surface:** greenish brown to brown; **lower surface:** brown to black, rhizinate. Thallus heteromerous, both surfaces paraplectenchymatously corticated; **photobiont:** a green alga (*Trebouxia*-type); **medulla:** white, sometimes reddish in lower part. **Apothecia:** laminal, lecanorine, mostly rhizinate at base (coronate); **disc:** brown to black; **hymenium:** colourless; **hypothecium:** colourless; **paraphyses:** apically thickened; **asci:** 8-spored; **spores:** brown, 2-celled, *Physcia*- or *Pachysporaria*-type. Atranorin always absent in upper cortex.

Out of 28 species known from the world, 13 species are known from India, of which 4 are terricolous.

**Key to the terricolous species of *Phaeophyscia*:**

1.	Thallus sorediate .....	<i>P. hispidula</i>
1a.	Thallus lacking soredia .....	2
2.	Lower side white to light brown, thallus terricolous, lobes subfruticose, ascending in tufts .....	<i>P. constipata</i>
2a.	Lower side brown black or black.....	3
3.	Lower side black, lobes up to 1.5 mm wide, concave to flat, thallus to 5 cm across.....	<i>P. ciliata</i>
3a.	Lower side brown black.....	<i>P. decolor</i>

***Phaeophyscia ciliata*** (Hoffm.) Moberg (Fig. 2.28e; Fig. 2.51)

Moberg, *Symb. Bot. Upsal.* 22(1): 30.1977.

Basionym: *Lichen ciliatus* Hoffm., *Enum. Lich.*: 69. 1784.

Synonym: *Physcia ciliata* (Hoffm.) Du Rietz, *Svensk. Bot. Tidskr.* 15:168. 1921.

**Thallus:** usually up to 5 cm across; **lobes:** up to 1.5 mm wide; upper side grey-brown to brown-black, lacking isidia and soredia; **lower surface:** black, rhizinate;



**photobiont:** green, layer irregularly thick; **medulla:** white, thin. **Apothecia:** up to 3 mm in diam., coronate; **spores:** *Physcia*-type, (18–)20–26(–28) × 8–12(–15) μm.

**Chemistry:** Thallus K<sup>-</sup>, C<sup>-</sup>, KC<sup>-</sup>, P<sup>-</sup>; no secondary metabolites in TLC.

**Ecology and distribution:** *Microhabitat occupied:* Terricolous; terricolous-rupicolous. In India, the species is distributed in Himachal Pradesh, Madhya Pradesh, Rajasthan, Tamil Nadu and Uttarakhand, whereas the species growing on soil is known from Himachal Pradesh and Uttarakhand. Outside India, the species is also reported from China; Europe, North America.

**SPECIMENS EXAMINED:** **INDIA: HIMACHAL PRADESH, KULLU DISTRICT,** Marhi, alt. 3,200 m, on soil over rocks, Upreti and Divakar 02-00015/B (LWG); **UTTARAKHAND, BAGESHWAR DISTRICT,** near Pindari Glacier, Mirtoli, alt. 3,597 m, on soil, D. D. Awasthi 7722 (LWG-AWAS); **UTTARKASHI DISTRICT,** Gangotri, towards Kedartal, on soil over rocks, alt. 3,100 m, S. Chatterjee and P. K. Divakar 02-000403/A (LWG); Gomukh area, right bank, 5<sup>th</sup> moraine, alt. 3,840 m, on soil, D. D. Awasthi and S. R. Singh 8532 (LWG-AWAS).

*Phaeophyscia constipata* (Norrl. and Nyl.) Moberg (Fig. 2.28f; Fig. 2.51)

Moberg, Symb. Bot. Upsal. 22(1): 33. 1977.

Basionym: *Physcia constipata* Norrl. and Nyl. in Norrl., Med. Soc. Fauna. Fl. Fenn. 1: 20. 1876.

**Thallus:** erect, foliose to fruticose; **lobes:** up to 1 mm wide in tufts; **upper surface:** brownish, lacking isidia and soredia; **lower surface:** pale brown, rhizinate; medulla white. **Apothecia:** up to 3 mm in diam., ecoronate; **spores:** *Physcia*-type, 15–27 × 7–13 μm.

**Chemistry:** Thallus K<sup>-</sup>, C<sup>-</sup>, KC<sup>-</sup>, P<sup>-</sup>; no secondary metabolites in TLC.

**Ecology and distribution:** *Microhabitat occupied:* Terricolous; terricolous-rupicolous. In India, the species is distributed in Himachal Pradesh, Jammu and Kashmir and Uttarakhand, whereas the species growing on soil is known from Uttarakhand. Outside India, the species is also reported from Arctic and alpine regions of Europe and North America.

**SPECIMENS EXAMINED:** **INDIA: JAMMU AND KASHMIR,** Ladakh, Hemis National Park, Rumbak valley, alt. 3,600 m, on rocks over soil, H. R. Negi L4 (CES); **HIMACHAL PRADESH, LAHAUL AND SPITI DISTRICT,** Darcha, alt. 3,200 m, on soil in moist place, D. K. Upreti and S. Chatterjee 03-001725 (LWG); **SIKKIM, NORTH SIKKIM,** Giagaon, above Thangu, alt. 4,600 m, on soil, D. K. Upreti, S. Chatterjee and P. K. Divakar 04-003997 (LWG); **UTTARAKHAND, UTTARKASHI DISTRICT,** Bhojwasa, alt. 3,700 m, on soil, S. Chatterjee and P. K. Divakar 02-000204 (LWG).

*Phaeophyscia decolor* (Kashiw.) Essl. (Fig. 2.51)

Esslinger, Mycotaxon 7: 299.1978.

Basionym: *Physcia decolor* Kashiw., Ginkgoana 3: 42. 1975.

**Thallus:** closely adnate, in suborbicular patches, dark brown to blackish, 4–5 cm across; **lobes:** repeatedly dichotomously or irregularly branched, imbricate, 0.5–1 mm wide in tufts; **upper surface:** smooth, epruinose; **lower surface:** brown-black, rhizinate; **medulla:** white. **Apothecia:** scattered, sessile, up to 0.5–0.8 mm in diam., without basal hairs, ecoronate; **spores:** *Physcia*-type, 18–21 × 7–14 μm.

**Chemistry:** Thallus K<sup>-</sup>, C<sup>-</sup>, KC<sup>-</sup>, P<sup>-</sup>; no secondary metabolites in TLC.

**Ecology and distribution:** *Microhabitat occupied:* Terricolous-rupicolous. In India the species is exclusively terricolous and exhibits restricted distribution to

Eastern Himalayas and known only from Sikkim. Outside India, the species is also reported from Japan; Europe, North America.

**SPECIMEN EXAMINED: INDIA: SIKKIM, NORTH SIKKIM,** Llonakh valley, Muguthang, alt. 4,500 m, over thick soil covering on boulders, Sinha 1561 (BSHC).

***Phaeophyscia hispidula* (Ach.) Moberg (Fig. 2.28g; Fig. 2.51)**

Moberg, Bot. Not. 131: 260. 1978.

Basionym: *Parmelia hispidula* Ach., Lichenogr. Universalis 468. 1810.

Synonyms: *Physcia hispidula* (Ach.) Frey, Ber. Schweiz. Bot. Ges. 73: 474. 1963. -*Physcia setosa* (Ach.) Nyl., Syn. Lich. 1(2): 429. 1860.

**Thallus:** foliose, to 8 cm across; **lobes:** 2–3(–5) mm wide, with rounded apices; **upper surface:** grey-brown; **soralia:** laminal, capitate, often extending up to margin; **soredia:** rarely becoming granular; **lower surface:** black, rhizines long, black, projecting beyond the lobes; **medulla:** white. **Apothecia:** to 3 mm in diam., coronate; **spores:** *Physcia* to *Pachysporaria*-type, 18–27(–30) × 9–12(–15) μm.

**Chemistry:** Thallus K–, C–, KC–, P–; no secondary metabolites in TLC.

**Ecology and distribution:** *Microhabitat occupied:* Terricolous; terricolous-rupicolous; muscicolous-rupicolous. In India the species is distributed in Arunachal Pradesh, Himachal Pradesh, Jammu and Kashmir, Kerala, Madhya Pradesh, Maharashtra, Manipur, Nagaland, Rajasthan, Sikkim, Tamil Nadu and Uttarakhand, whereas the species growing on soil is known from Himachal Pradesh, Kerala, Rajasthan and Uttarakhand. The species is also reported from Australia, Bhutan, Nepal, New Zealand and Taiwan; Africa, Europe, North America and seems to be cosmopolitan in distribution.

**SPECIMENS EXAMINED: INDIA: HIMACHAL PRADESH, KULLU DISTRICT,** Aound Sainj Forest Guest House, alt. 1,500 m, on soil in moist place, D. K. Upreti 217539 (LWG); **SHIMLA DISTRICT,** Shashan, alt. 1,500 m, on soil, T. S. Rana s.n. (LWG); **KERALA, IDUKKI DISTRICT,** Anayiramgal dam, Munnar, alt. 1,550 m, on soil, Biju Haridas 06-014657 (LWG); **RAJASTHAN, SIROHI DISTRICT,** Mt. Abu, near Machgaon, alt. 1,219 m, on mossy soil over boulder, S. R. Singh 78.29 (LWG-LWU); **UTTARAKHAND, ALMORA DISTRICT,** Jageshwar, alt. 1,800 m, on soil over rock, A. Singh L 89427 (LWG); **CHAMOLI DISTRICT,** Badrinath, alt. 3,200 m, on soil, K. Dange, 76.927 (LWG-LWU); way of Nanda Biosphere Reserve, Srenikhal, alt. 3,650 m, on soil, Shobha Rawat and D. Rawat 08-010934 (LWG); **PAURI-GARHWAL DISTRICT,** Khirsu reserve forest, alt. 1,796 m, on soil with mosses, Himanshu Rai, 11-0014552 (LWG); **PITHORAGARH DISTRICT,** Askot-Sandev Botanical Hot spot, Adichaura area, alt. 2,300 m, on soil over rocks, Vikas Pant 02-103906 (LWG).

**PHYSICIA** (Schreb.) Michx. (*Physciaceae*)

Michaux, Fl. Bor. Amer. 2: 326. 1803.

**Thallus:** foliose, loosely attached, radially lobate; **upper surface:** pale grey to darker, heteromerous, corticated on both sides, with or without isidia and soredia; **lower surface:** pale brown to black, with concolorous rhizines; **photobiont:** a green alga (*Trebouxia*-type); **medulla:** white. **Apothecia:** laminal, lecanorine; **disc:** brown to black; **paraphyses:** branched, brown at apices; **asci:** 8-spored; **spores:** *Physcia*- or *Pachysporaria*-type, brown, 2-celled, ellipsoid. **Pycnidia:** laminal; **pycnoconidia:** subcylindrical, 4–6 μm long. Atranorin always present in upper cortex (K+ yellow).

Out of 73 species known from world, 17 are known from India, of which 4 are terricolous.

**Key to the terricolous species of *Physcia*:**

1.	Thallus lobes ciliate along margins, cilia large, sorediate, soredia helmet shaped, usually expanding on lower surface.....	<i>P. adscendens</i>
1a.	Thallus lacking cilia along margins .....	2
2.	Thallus sorediate .....	3
2a.	Thallus esorediate, lower surface pale grey to pale brown, maculae absent .....	<i>P. dilatata</i>
3.	Lower cortex paraplectenchymatous, soralia on short lobes, capitates to lip shaped, white maculae on upper surface .....	<i>P. caesia</i>
3a.	Lower cortex prosoplectenchymatous, sonilia marginal, expanding irregularly, lower side grey to brownish .....	<i>P. tribacoides</i>

***Physcia adscendens* (Fr.) H. Olivier (Fig. 2.28h; Fig. 2.51)**

H. Olivier, Fl. Lich. Orne 1: 79. 1882.

Basionym: *Parmelia stellaris* var. *adscendens* Fr., Summa Veget. Scand., Sect. 1: 105. 1845.

**Thallus:** foliose; **lobes:** short or long, ascendant; margins ciliate; **upper surface:** whitish grey to darker; **soralia:** marginal, helmet shaped, expanding on lower surface; **lower surface:** pale brown; **lower cortex:** prosoplectenchymatous. **Apothecia:** absent.

**Chemistry:** K<sup>+</sup> yellow. Atranorin present.

**Ecology and distribution:** *Microhabitat occupied:* Terricolous. In India, the species is widely distributed in Arunachal Pradesh, Himachal Pradesh, Madhya Pradesh, Maharashtra, Manipur, Nagaland, Sikkim Tamil Nadu and Uttarakhand, whereas the species growing on soil is known from a single locality of Uttarakhand. Outside India, the species is also reported from Australia, Bhutan, Japan, Nepal and New Zealand; Europe.

**SPECIMEN EXAMINED:** INDIA: UTTARAKHAND, UTTARKASHI DISTRICT, Gomukh area, right bank 5th moraine, alt. 3,840 m, on soil, D. D. Awasthi and S. R. Singh 8506 (LWG-AWAS).

***Physcia caesia* (Hoffm.) Fűrnr. (Fig. 2.28i; Fig. 2.51)**

Fűrnr., Naturh. Topogr. Regensburg 2: 250. 1839.

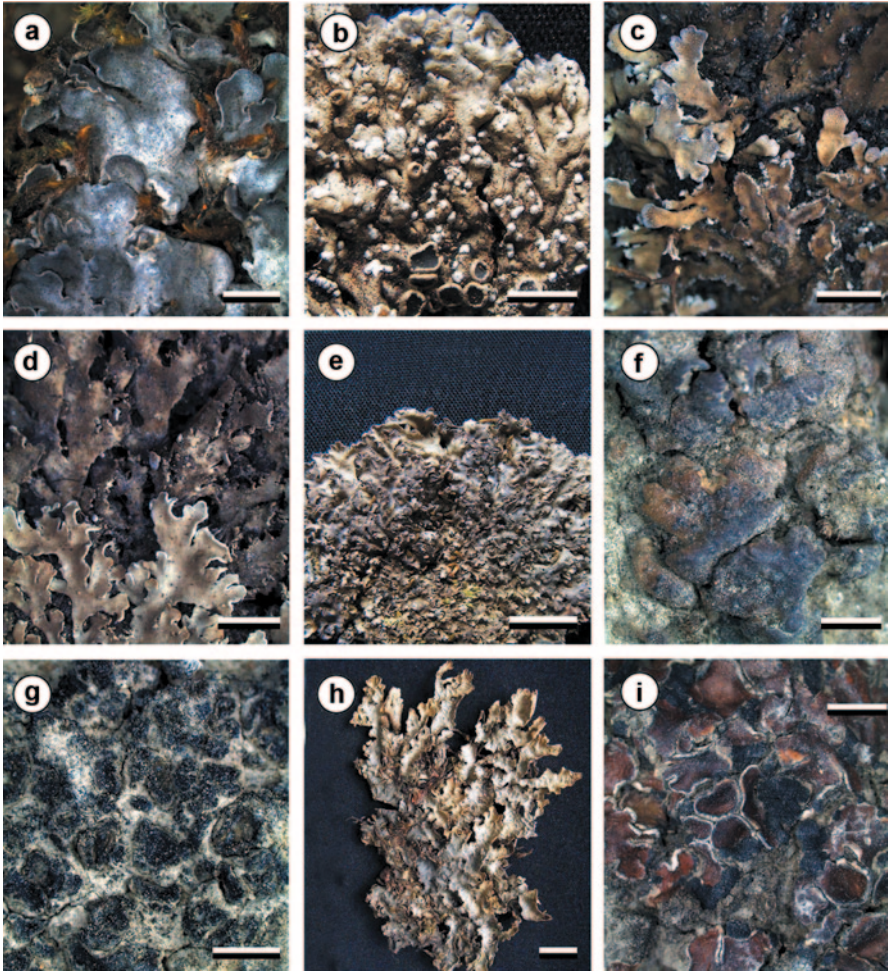
Basionym: *Lichen caesius* Hoffm., Enum. Lich.: 65. 1784.

Synonym: *Physcia wainioi* Riisanen, Medd. Soc. Fauna Fl. Fenn. 46:166. 1921.

**Thallus:** 5–7 cm across; **lobes:** 3 mm wide; **upper surface:** whitish grey to darker, white-maculate; **soralia:** terminal on short lobes, capitate to lip-shaped, and occasionally laminal, capitate to crater-like; **soredia:** bluish grey; **lower surface:** brownish; **lower cortex:** prosoplectenchymatous. **Apothecia:** absent.

**Chemistry:** Medulla K<sup>+</sup> yellow. Zeorin present.

**Ecology and distribution:** *Microhabitat occupied:* Terricolous-rupicolous. In India, the species is widely distributed in Himachal Pradesh, Jammu and Kashmir, Manipur, Nagaland, Rajasthan, Sikkim and Uttarakhand, whereas the species growing on soil is known from a single locality of Uttarakhand. Outside India, the species is also reported from Bhutan, Japan and Nepal; East Africa; Antarctica, Europe, North America.



**Fig. 2.29** **a** *Physcia dilatata* Nyl., **b** *P. tribacoides* Nyl., **c** *Physconia detersa* (Nyl.) Poelt, **d** *P. grisea* (Lam.) Poelt, **e** *P. muscigena* (Ach.) Poelt, **f** *Placidium lachneum* (Ach.) de Lesd., **g** *P. squamulosum* (Ach.) Breuss, **h** *Pseudocyphellaria ceylonensis* H. Magn., **i** *Psora decipiens* (Hedw.) Hoffm. Scale in **a**, **b**, **c**, **d**, **f**, **g**, **i** = 2 mm; in **e**, **h** = 10 mm

**SPECIMEN EXAMINED: INDIA: UTTARAKHAND, UTTARKASHI DISTRICT, Gomukh, alt. 3,841 m, on boulders over soil, D. D. Awasthi and S. R. Singh 8545 (LWG-AWAS).**

***Physcia dilatata*** Nyl. (Fig. 2.29a; Fig. 2.51)

Nylander, Syn. Lich. 1(2): 425. 1860.

Synonym: *Physcia askotensis* D. D. Awasthi, Proc. Indian Acad. Sci. 45 B: 131. 1957.

**Thallus:** foliose, (2–)5–10 cm across; **lobes:** 2–5(–10) mm wide; **upper surface:** whitish grey to grey, pruinose, lacking isidia and soredia; **lower surface:** grey

to darker; **lower cortex**: paraplectenchymatous. **Apothecia**: up to 1.5 mm in diam; **spores**: (18–)21–32 × 10–13(–15) μm.

**Chemistry**: Medulla K+ yellow. Zeorin present.

**Ecology and distribution**: *Microhabitat occupied*: Terricolous. In India, the species is widely distributed in Himachal Pradesh, Madhya Pradesh, Manipur, Sikkim and Uttarakhand, whereas the species growing on soil is known from a single locality of Uttarakhand. Outside India, the species is also reported from Nepal and Africa.

**SPECIMEN EXAMINED**: **INDIA**: **UTTARAKHAND**, **UTTARKASHI DISTRICT**, on the way to Gomukh, 11 Km from Gangotri, alt. 3,505 m, on ground, 07 Jul 1976, D. D. Awasthi and S. R. Singh 8609 (LWG-AWAS).

*Physcia tribacoides* Nyl. (Fig. 2.29b; Fig. 2.51)

Nylander, Flora 57: 307. 1874.

**Thallus**: up to 5 cm across; lobes 3(10) mm wide, lobulate to crenate at tips; **upper surface**: grey, pruinose; **soralia**: marginal, later expanded, callus-like, covering lobe ends; **lower surface**: grey, lower cortex paraplectenchymatous, thick-walled. **Apothecia**: 1 mm in diam.; **spores**: not seen.

**Chemistry**: Medulla K+ yellow. Zeorin and traces of unidentified substance present.

**Ecology and distribution**: *Microhabitat occupied*: Terricolous; terricolous-rupicolous. In India, the species is widely distributed in Arunachal Pradesh, Himachal Pradesh, Madhya Pradesh, Maharashtra, Manipur, Nagaland, Sikkim and Tamil Nadu, whereas the species growing on soil is known from Himachal Pradesh and Tamil Nadu. Outside India, the species is also reported from Australia, Bhutan, Japan, Nepal and New Zealand; Europe.

**SPECIMENS EXAMINED**: **INDIA**: **HIMACHAL PRADESH**, **KINNAUR DISTRICT**, Chitkul Forest area, alt. 3,950 m, on rock over soil, Upreti and party 03-002724 C (LWG); **TAMIL NADU**, **DINDIGUL**, **PALNI HILLS**, Kodaikanal, Croaker's walk, along road side, alt. 2,133.6 m, on ground and stones, K. P. Singh 70.502 (LWG-LWU).

**PHYSCONIA** Poelt (*Physciaceae*)

Nova Hedwigia 9: 30. 1965.

**Thallus**: foliose, loosely adnate; lobes radiating; **upper surface**: grey-brown to brown, usually white pruinose; **lower surface**: white or black, rhizinate; **rhizines**: simple or squarrose; **photobiont**: a green alga. **Apothecia**: laminal, lecanorine, lobulate on margin; **paraphyses**: simple; **asci**: 8-spored; **spores**: brown, 2-celled, uniformly thick walled with large lumina. **Pycnidia**: laminal. Atranorin absent in upper cortex (K-).

Out of 26 species known from world, 6 species known from India, of which 3 are terricolous.

**Key to the terricolous species of *Physconia*:**

1.	Thallus isidiate or sorediate .....	2
1a.	Thallus lacking isidia or soredia .....	<i>P. muscigena</i>
2.	Rhizines simple, rarely branched at tips, isidia becomes sorediate .....	<i>P. grisea</i>
2a.	Rhizines squarrosely branched, only soralia present, medulla and soralia K- .....	<i>P. detersa</i>

***Physconia detersa*** (Nyl.) Poelt (Fig. 2.29c; Fig. 2.51)

Poelt, Nova Hedwigia 9: 30. 1965.

Basionym: *Parmelia pulverulenta* var. *detersa* Nyl., Syn. Lich. 1(2): 420. 1860.

Synonym: *Physcia detersa* (Nyl.) Nyl., Flora 52: 332. 1869.

**Thallus:** foliose, up to 6 cm across; **lobes:** up to 3 mm wide; **upper surface:** grey-brown, completely pruinose, sorediate; **soralia:** marginal, bluish tinged; **lower surface:** black. **Apothecia:** infrequent, sessile, up to 3 mm in diam., soon becomes sorediate; **spores:** 28–34 × 13–19 μm.

**Chemistry:** Thallus K–, C–, KC–, P–; no secondary metabolites in TLC.

**Ecology and distribution:** *Microhabitat occupied:* Terricolous. In India, the species is distributed in Himachal Pradesh, Jammu and Kashmir, Sikkim and Uttarakhand, whereas the species growing on soil is known from a single locality of Uttarakhand. Outside India, the species is also reported from Bhutan and China; Europe, North America.

**SPECIMEN EXAMINED: INDIA: UTTARAKHAND, UTTARKASHI DISTRICT,** Gangotri, alt. 3,133 m, on soil (ground), Himanshu Rai and Pramod Nag, 10-0014507 (LWG).

***Physconia grisea*** (Lam.) Poelt (Fig. 29d; Fig. 51)

Poelt, Nova Hedwigia 9: 30. 1965.

Basionym: *Lichen griseus* Lamarck, Encyclopedia Meth. Bot. 3: 48. 1789.

Synonyms: *Physcia ferrea* (Ach.) Vain., Meddel. Soc. Fauna Fl. Fenn. 6:132. 1881; *Physconia ferrea* (Ach.) Poelt, Nova Hedwigia 9: 30.1965.

**Thallus:** foliose, up to 5 cm across; lobes to 3 mm wide; **upper surface:** greyish brown, maculately pruinose, isidiate; **isidia:** laminal or marginal, becoming sorediate; **rhizines:** simple, rarely branched at tips. **Apothecia:** immature or absent.

**Chemistry:** Thallus K–, C–, KC–, P–; no secondary metabolites in TLC.

**Ecology and distribution:** *Microhabitat occupied:* Terricolous-rupicolous. In India the species is distributed in Himachal Pradesh, Jammu and Kashmir and Uttarakhand, whereas the species growing on soil is known from a single locality of Uttarakhand. Outside India, the species is also reported from Bhutan, China and Nepal; Europe, North America.

**SPECIMEN EXAMINED: INDIA: UTTARAKHAND, RUDRAPRAYAG DISTRICT,** Tungnath Bugyal, alt. 3,400 m, on soil over rock in open grassland, Himanshu Rai and Pramod Nag 08-0012245(LWG).

***Physconia muscigena*** (Ach.) Poelt (Fig. 2.29e; Fig. 2.51)

Poelt, Nova Hedwigia 9: 30. 1965.

Basionym: *Parmelia muscigena* Acharius, Lichenogr. Universalis: 472. 1810.

Synonym: *Physcia muscigena* (Ach.) Nyl., Acta Soc. Linn. Bordeaux 21: 308. 1856.

**Thallus:** to 10 cm across; **lobes:** 1–1.5 (apically 3) mm wide; **upper surface:** brownish, lacking isidia and soredia; **lower surface:** black, rhizinate; **rhizines:** squarrosely branched. **Apothecia:** to 5 mm indiam; **spores:** 23–32(–35) × 12–16 μm. No lichen substance present.

**Chemistry:** Thallus K–, C–, KC–, P–; no secondary metabolites in TLC.

**Ecology and distribution:** *Microhabitat occupied:* Muscicolous-erricolous. In India, the species is distributed in Himachal Pradesh, Sikkim, Jammu and Kashmir and Uttarakhand, whereas the species growing on soil is known from a single locality of Jammu and Kashmir. Outside India, the species is also reported from China, Nepal and Taiwan; Africa, North and South America.

**SPECIMEN EXAMINED:** **INDIA: JAMMU AND KASHMIR, SRINAGAR,** Shankaracharya Hill, alt. 1,676 m, on ground among mosses, D. D. Awasthi 2639 (LWG-AWAS).

**PLACIDIUM** A. Massal. (*Verrucariaceae*)

Symm. Lich. Nov.: 75. 1855.

**Thallus:** squamulose; **squamules:** scattered, contiguous or imbricate, loosely or closely attached, rounded to irregular, entire to deeply lobed, corticate above, with or without a lower cortex, anchored by a mat of rhizohyphae. **Perithecia:** immersed in the thallus, broadly pyriform to subglobose, up to 0.5(0.65) mm diam., without an involucrellum; **asci:** cylindrical, 8-spored; **spores:** uniseriate, ellipsoidal, broadly ellipsoidal or subglobose, simple, colourless. **Pycnidia:** laminal and immersed or marginal; **conidia:** oblong-ellipsoidal or bacilliform.

Out of 30 species known from world, 2 terricolous species are known from India.

**Key to the terricolous species of *Placidium*:**

- 
- |     |   |                       |
|-----|---|-----------------------|
| 1.  | Perithecia usually bulging the lower surface of squamules ..... | <i>P. squamulosum</i> |
| 1a. | Perithecia not bulging the lower surface of squamules .....     | <i>P. lachneum</i>    |
- 

***Placidium lachneum*** (Ach.) de Lesd. (Fig. 2.29f; Fig. 2.51)

Ann. Cryptog. Exot. 5: 100. 1932.

Basionym: *Lichen lachneus* Ach., Lichenogr. Suec. Prodr.: 140. 1798.

Synonyms: *Catapyrenium lachneum* (Ach.) R. Sant. in D. Hawksw. and al., Lichenologist 12(1): 106. 1980.

**Thallus:** squamulose; **squamules:** scattered to adjacent or slightly overlapping, up to 10 mm wide, roundish to lobate; **upper surface:** dark brown or red brown, dull, smooth; **lower surface:** black throughout, naked where free from the substrate, the remaining part attached with a dense hyphal weft; **rhizohyphae:** hyaline or slightly brownish in proximal parts. **Perithecia:** broadly pyriform, with colourless walls, normally not bulging the lower surface of the squamules; **periphyses:** 40–50 × 2.5–3.5 μm; **asci:** cylindrical, 70–90 × 12–15 μm, 8-spored; **spores:** uniseriate, ellipsoid, 15–18 × 6.5–8 μm. **Pycnidia:** marginal, prominent as black globular knobs; **conidia:** bacilliform, 5–7 × 1–2 μm.

**Chemistry:** Thallus K–, C–, KC–, P–; no secondary metabolites in TLC.

**Ecology and distribution:** *Microhabitat occupied:* Terricolous. In India, the species is distributed in Himachal Pradesh and Maharashtra, whereas the species growing on soil is known from different localities of Himachal Pradesh. The species is also reported from Algeria and Europe.

**SPECIMENS EXAMINED:** **INDIA: HIMACHAL PRADESH, KINNAUR DISTRICT,** in and around Puh, alt. 3,000 m, on soil, Upreti, Srivastava and Prakash 03-002602 B (LWG); **KULLU DISTRICT,** Great Himalayan National Park, around Patal, alt. 2,800 m, on soil, D. K. Upreti 99-53662 (LWG).

***Placidium squamulosum*** (Ach.) Breuss (Fig. 2.29g; Fig. 2.51)

Breuss, Ann. Naturhist. Mus. Wien 98 B Suppl.: 39. 1996.

Basionym: *Endocarpon squamulosum* Ach., Methodus: 126. 1803.

Synonyms: *Catapyrenium squamulosum* (Ach.) Breuss in Poelt and H. Mayrhofer, Ber. Bayer. Bot. Ges. 98(3–4): 389. 1985. -*Dermatocarpella squamulosa* (Ach.) H. Harda, Nat. Hist. Res. 2(2): 139. 1993.

**Thallus:** squamulose; **squamules:** 2–7 mm wide, c. 0.2–0.4 mm thick, discrete to adjacent to slightly overlapping, round to lobed; **upper surface:** pale to dark brown, dull; **lower surface:** usually pale, but also blackening, attached with a dense rhizoidal weft. **Perithecia:** broadly pyriform, up to more than 0.5 mm wide and usually bulging the lower surface of squamules; **exciple:** hyaline or yellowish, 25–30  $\mu\text{m}$  thick; **periphyses:** 30–40  $\times$  3–4  $\mu\text{m}$ ; **asci:** cylindrical, 70–90  $\times$  10–15  $\mu\text{m}$ , 8-spored; **spores:** uniseriate, ellipsoid, 12–16  $\times$  5.5–7.5  $\mu\text{m}$ . **Pycnidia:** frequent, laminal, immersed; **conidia:** oblong-ellipsoid, 2.5–4  $\times$  1.3–2  $\mu\text{m}$ .

**Chemistry:** Thallus K–, C–, KC–, P–; no secondary metabolites in TLC.

**Ecology and distribution:** *Microhabitat occupied:* Terricolous. In India the species growing over soil is known from Jammu and Kashmir and Himachal Pradesh. The species is also reported from Nepal, widespread in all continents except Antarctica and seems to be cosmopolitan in distribution.

**SPECIMENS EXAMINED:** **INDIA:** HIMACHAL PRADESH, LAHAUL AND SPITI DISTRICT, Patsio, alt. 3,800 m, on soil, D.K. Upreti and S. Chatterjee 03-001745 (LWG); **JAMMU AND KASHMIR, LEH DISTRICT,** Yeru, alt. 3,600 m, on soil, D.K. Upreti and S. Chatterjee 03-001792 A (LWG).

**PSEUDOCYPHELLARIA** Vain. (*Lobariaceae*)

Vainio, Acta Soc. Fauna Fl. Fenn. 7(1). 182. 1890.

**Thallus:** foliose, adnate, dorsiventral; **upper surface:** pale to grey-brown, smooth or foveolate, heteromerous, with or without isidia and soredia; **lower surface:** tomentose, reddish brown, with round, white or yellow pseudocyphellae; **photobiont:** a green alga (*Dictyochloris*- or *Chlorella*-like) or cyanobacterium (*Nostoc*); **medulla:** white or yellow. **Endotrophic cephalodia:** with *Nostoc* present in taxa with green alga as primary photobiont. **Apothecia:** hemiangiocarpic, laminal; **asci:** 8-spored; **spores:** colourless or brown, 1–3-septate at maturity. **Pycnoconidia:** bacilliform.

Out of 170 species known from world, 6 species are from India, of which 1 is terricolous.

***Pseudocyphellaria ceylonensis*** H. Magn. (Fig. 2.29h; Fig. 2.51)

Magnusson, Meddel. Göteborg. Bot. Trädg. 14: 23. 1940.

**Thallus:** to 10 cm across; lobes somewhat imbricate, 3–7 mm wide, with incised (to 2 mm wide) apices; **upper surface:** yellowish brown; **isidia:** laminal or marginal, often broken and  $\pm$  sorediate at apices; **lower surface:** with yellow pseudocyphellae; **photobiont:** a *Nostoc*. **Apothecia:** to 2.5 mm in diam., marginal to laminal; **disc:** brown-black; **spores:** yellowish brown, 2-celled, 22–27  $\times$  8–10  $\mu\text{m}$ .

**Chemistry:** Medulla K+ pale yellowish, KC–, P–; soralia P+ orange, apothecial margin K+ yellowish-red.



**Ecology and distribution:** *Microhabitat occupied:* Terricolous. Earlier the species was only known from type locality in Sri Lanka and for the first time it is reported outside the type locality. It is a new record for Indian lichen flora and known only from Kerala.

**SPECIMEN EXAMINED:** **INDIA: KERALA,** Munnar towards Rajamala, alt. 1,420 m, on soil, B. Haridas 06-014772 (LWG).

**PSORA** Hoffm. (*Psoraceae*)

Hoffmann, *Deutschl. Fl.* 2: 161. 1796.

**Thallus:** squamulose; **squamules:** pale yellow, grey-brown, red to reddish brown; heteromerous; **photobiont:** a green alga; **medulla:** well developed. **Apothecia:** laminal or marginal, often convex; **disc:** brown black, often pruinose; **hypothecium:** pale brown; **hymenium:** I+ blue; **epithecium:** red-brown, K+ red; **paraphyses:** branched and anastomosing, apical cell swollen; **asci:** clavate, with amyloid tube in tholus, lacking ocular chamber, 8-spored; **spores:** colourless, simple, ellipsoid. **Pycnidia:** immersed; **pycnocnidia:** bacilliform.

Out of 31 species known from world, 2 terricolous species are from India.

**Key to the terricolous species of *Psora*:**

- 
- |     |  |                      |
|-----|--|----------------------|
| 1.  | Squamules bright red to brown red, often white pruinose, lower surface whitish .....     | <i>P. decipiens</i>  |
| 1a. | Squamules brown, distinctly white pruinose along margins, lower surface pale brown ..... | <i>P. himalayana</i> |
- 

***Psora decipiens*** (Hedw.) Hoffm. (Fig. 2.29i; Fig. 2.51)

Hoffm., *Descr. Adumbr. Pl. Cl. Crypt.* 2: 68. 1794.

Basionym: *Lichen decipiens* Hedw., *Descr. Adumbr. Muscor. Frond.* 2:7. 1789.

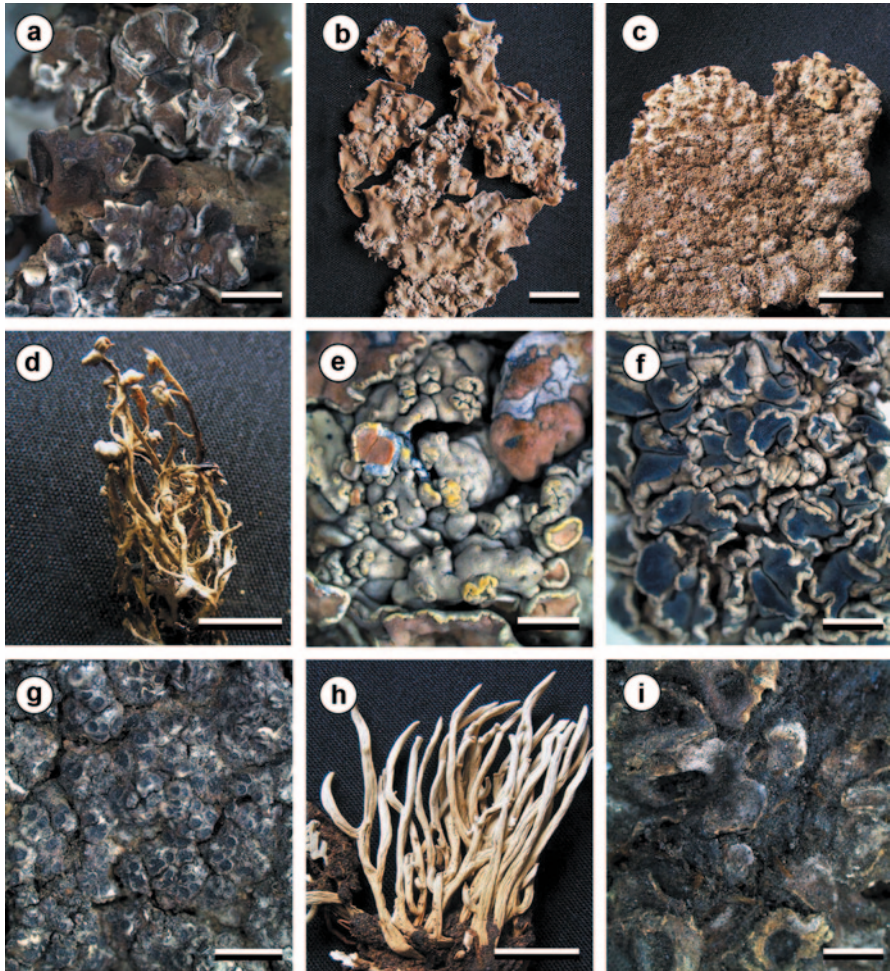
Synonym: *Lecidea decipiens* (Hedw.) Ach., *Methodus*: 80. 1803.

**Thallus:** squamulose; **squamules:** to 6 mm across; **upper surface:** bright red to brownish red, fissured; margins upturned, white; **lower surface:** whitish. **Apothecia:** to 2 mm in diam., attached marginally to the squamules, sessile, simple, plane to weakly convex when young, soon becoming strongly convex to hemispherical, pruinose; **asci:** 8-spored; **spores:** hyaline, simple, ellipsoid, smooth, 11–18 × 6–8 μm.

**Chemistry:** Medulla with or without norstictic acid/ hyposalazinic acid.

**Ecology and distribution:** *Microhabitat occupied:* Terricolous. In India the species is exclusively terricolous and widely distributed in Himachal Pradesh and Uttarakhand. The species is also reported from Australia, Mexico, Nepal, New Zealand, and Europe and seems to be cosmopolitan in distribution. *P. decipiens* is closely related to *P. crenata* (Taylor) Reinke, differs mainly in having broader and thicker squamules with a regular central depression and down-turned, more or less entire margin.

**SPECIMENS EXAMINED:** **INDIA: HIMACHAL PRADESH, LAHAUL AND SPITI DISTRICT,** Lahaul Valley, 6 km before Chhatru from Koksar side, alt. 3,900 m, on soil, D. K. Upreti and P. K. Divakar 02-00161/A (LWG); Baralachala Pass, alt. 4,700 m, on soil, D. K. Upreti and S. Chatterjee 03-00 1770 (LWG); **UTTARAKHAND, PITHORAGARH DISTRICT,** Rilkot to Burfu, en route to Milam Glacier, alt. 3,200–3,250 m, on soil, Santosh Joshi 07-010353 (LWG).



**Fig. 2.30** **a** *Psora himalayana* (C. Bab.) Timdal, **b** *Punctelia borneri* (Sm.) Krog, **c** *P. rudecta* (Ach.) Krog, **d** *Ramalina hossei* Vain., **e** *Rhizoplaca chrysoleuca* var. *chrysoleuca* (Sm.) Zopf, **f** *R. melanophthalma* var. *obscura* (J. Steiner) D. D. Awasthi, **g** *Rinodina turfacea* (Wahlenb.) Körb., **h** *Siphula ceratites* var. *ceratites* (Wahlenb.) Fr., **i** *Solorina bispora* Nyl. Scale in **a**, **e**, **f**, **g**, **i** = 2 mm; in **b**, **c**, **d**, **h** = 10 mm

***Psora himalayana*** (C.Bab.) Timdal (Fig. 2.30a; Fig. 2.51)

Timdal, Bryologist 89 (4): 262. 1986.

Basionym: *Biatora himalayana* C. Bab., Hooker's J. Bot. Kew Gard. Misc. 4: 251. 1852.

Synonym: *Lecidea himalayana* (C. Bab.) Zahlbr., Cat. Lich. Univ. 3: 878. 1925.

**Thallus:** squamulose; **squamules:** to 4 mm across; **upper surface:** reddish brown to dark brown, fissured, white pruinose along margins; **lower surface:** pale brown. **Apothecia:** to 2 mm in diam., attached laminally to the squamules, simple,

strongly convex to hemispherical even when young, dark brown to black, dull or shiny, dark brown to black, convex, epruinose or slightly pruinose; **asci**: 8-spored; **spores**: hyaline, simple, smooth,  $11-14 \times 7-9 \mu\text{m}$ .

**Chemistry**: Thallus K<sup>-</sup>, C<sup>-</sup>, KC<sup>-</sup>, P<sup>-</sup>; no secondary metabolites in TLC.

**Ecology and distribution**: *Microhabitat occupied*: Terricolous; terricolous-rupicolous. In India the species is exclusively terricolous and widely distributed in Himachal Pradesh and Uttarakhand. Outside India, the species is also reported from Asia, Europe, North America. Cosmopolitan in distribution. *P. himalayana* differs from *P. globifera* mainly in having smaller, distinctly white edged and more regularly imbricate squamules containing calcium oxalate in the medulla and/or the lower cortex.

**SPECIMENS EXAMINED**: **INDIA**: **HIMACHAL PRADESH, KANGRA DISTRICT**, junction of Pin and Spiti rivers, alt. 3,600 m, on rocks over soil, 30.07. 1952, O.A. Höeg (LWG-AWAS); **LAHAUL AND SPITI DISTRICT**, Lahaul Valley, 6 km before Chhatru from Koksar side, alt. 3,900 m, on soil, D. K. Upreti and P. K. Divakar 02-00141 (LWG); **UTTARAKHAND, BAGESHWAR DISTRICT**, Johar, near Mirtoli, alt. 1,2000 ft., on soil over stones, D. D. Awasthi 841 (LWG-AWAS); **PITHORAGARH DISTRICT**, Rilkot and Milam Glacier, alt. 3,150 m, on soil, A. Singh 102811 (LWG).

### **PUNCTELIA** Krog (*Parmeliaceae*)

Krog, *Nordic. J. Bot.* 2: 290. 1982.

**Thallus**: foliose, adnate, irregularly lobate, eciliate; **upper surface**: grey, with punctiform to suborbicular pseudocyphellae; isidia and soredia present or absent; **lower surface**: brown to black, rhizines simple. Thallus heteromerous, corticated on both surfaces; **photobiont**: a green alga; **medulla**: white. **Apothecia**: laminal, lecanorine; **disc**: brown; **asci**: 8-spored; **spores**: colourless, simple, ellipsoid. **Pycnidia**: laminal; **pycnoconidia**: punctiform or filiform. Atranorin present in upper cortex (K<sup>+</sup> yellow).

Out of 42 species known from the world, 4 species are from India, of which 2 are terricolous.

### **Key to the terricolous species of *Punctelia*:**

- 
- |     |  |                    |
|-----|--|--------------------|
| 1.  | Thallus isidiate, medulla with lecanoric acid.....               | <i>P. rudecta</i>  |
| 1a. | Thallus eventually sorediate, medulla with gyrophoric acid ..... | <i>P. borrieri</i> |
- 

### ***Punctelia borrieri* (Sm.) Krog (Fig. 2.30b; Fig. 2.51)**

Krog, *Nordic. J. Bot.* 2: 291. 1982.

Basionym: *Lichen borrieri* Sm. In Sm. and Sowerby, *Engl. Bot.* 25: pl. 1780. 1807.

Synonym: *Parmelia borrieri* (Sm.) Turner, *Trans. Linn. Soc. London* 9: 148. 1808.

**Thallus**: loosely adnate to the substratum, 6–8 cm across; **lobes**: often crowded, round but somewhat dissected, ascending, imbricate, (2–)4–6 mm wide, rounded; **upper surface**: grey to bluish grey, pseudocyphellate, sorediate; **pseudocyphellae**: small, punctiform, near the margins; **soralia**: laminal, derived from pseudocyphellae, clustered centrally, punctiform to confluent; **soredia**: farinose, white to grey

white; **lower surface**: black, marginal area pale brown with rhizinal papillate or nude. **Apothecia**: not found in the specimen.

**Chemistry**: Medulla K<sup>-</sup>, C<sup>+</sup> red, KC<sup>+</sup> red, P<sup>-</sup>. Atranorin and gyrophoric acid present.

**Ecology and distribution**: *Microhabitat occupied*: Terricolous. In India the species is widely distributed to Himachal Pradesh, Jammu and Kashmir, Sikkim, Tamil Nadu and Uttarakhand while species growing on soil is reported from single locality of Himachal Pradesh. Outside India, the species is also reported from Australia, Bhutan and New Zealand; Europe, North and South America, Japan and Taiwan. Cosmopolitan in distribution.

**SPECIMEN EXAMINED**: **INDIA**: **HIMACHAL PRADESH**, **KANGRA DISTRICT**, 1–2 km from Manali on road towards Hamtafa, alt. 2,286 m, over ground, Höeg 1851 (LWG-AWAS).

***Punctelia rudecta*** (Ach.) Krog (Fig. 2.30c; Fig. 2.51)

Krog, Nordic. J. Bot. 2: 291. 1982.

Basionym: *Parmelia rudecta* Acharius, Syn. Meth. Lich.: 197. 1814.

**Thallus**: closely to loosely adnate to the substratum, to 6–8(–10) cm across, crisp to fragile; **lobes**: 3–6 mm wide; **upper surface**: grey to dark, isidiate, pseudocyphellate; **pseudocyphellae**: punctiform to elongate; **isidia**: simple, coralloid and lacinulate; **lower surface**: pale brown. **Apothecia**: rare, to 5 mm in diam; **spores**: 10–17 × 5–10 μm.

**Chemistry**: Medulla K<sup>-</sup>, C<sup>+</sup> red, KC<sup>+</sup> red, P<sup>-</sup>. Atranorin and lecanoric acid present.

**Ecology and distribution**: *Microhabitat occupied*: Terricolous; terricolous-rupicolous. In India the species is widely distributed to Himachal Pradesh, Jammu and Kashmir, Kerala, Nagaland, Sikkim, Tamil Nadu and Uttarakhand while species growing on soil is reported from different localities of Sikkim and Tamil Nadu. The species is also distributed in Nepal; tropical to temperate regions of the world.

**SPECIMENS EXAMINED**: **INDIA**: **SIKKIM**, **NORTH SIKKIM DISTRICT**, Lachen, alt. 3,000 m, on rocks over soil, D. K. Upreti, S. Chatterjee, P. K. Divakar 04-003774 (LWG); **TAMIL NADU**, **NILGIRI**, **NILGIRI HILLS**, Coonoor, Kattari Road Station, along railway track, alt. 1,524 m, on soft ground, K. P. Singh 71.812 (LWG-LWU); **MADURAI**, Shenbaganur-Kodaikanal, along heaving path, alt. 1,836 m, over ground, G. Foreau and D. D. Awasthi 4304 (LWG-AWAS).

**RAMALINA** Ach. (*Ramalinaceae*)

Lichenogr. Universalis.: 122, 598. 1810.

**Thallus**: fruticose, erect or pendulous, variously branched; **branches**: circular, narrow strap-shaped or wide-lobed; **lobes**: greenish grey, yellowish grey to yellowish brown; soralia and pseudocyphellae present or absent; **photobiont**: a green alga; **medulla**: loose or arachnoid. **Apothecia**: laminal or terminal; **disc**: yellow ochraceous, often pruinose; **asci**: unitunicate, 8-spored; **spores**: colourless, ellipsoid to fusiform, straight or slightly curved. Usnic acid and rarely atranorin present in cortex.

Out of 246 species known from world, 22 species are known from India, of which 4 are terricolous.

**Key to the terricolous species of *Ramalina*:**

1.	Medulla usually arachnoid, partly or completely hollow, thallus elongate, finely branched with capitate to subcapitate soralia, sekikaic acid in medulla.....	<i>R. roesleri</i>
1a.	Medulla solid, composed of loose hyphae or arachnoid.....	2
2.	Thallus small, delicate, to 3 cm tall, branches less than 1 mm wide .....	<i>R. intermedia</i>
2a.	Thallus larger and longer than 3 cm, branches more than 1 mm wide ...	3
3.	Soralia with spinules from rim.....	<i>R. hossei</i>
3a.	Soralia dense, lacking spinules from rim.....	<i>R. taitensis</i>

***Ramalina hossei* Vain.** (Fig. 2.30d; Fig. 2.51)

Vainio. Ann. Soc. Zool. Bot. Fenn. 'Vanamo' 1(3): 36. 1921.

**Thallus:** fruticose, tufted, erect, to 6 cm tall, yellowish grey to brownish, branched; **branches:** to 2 mm wide, nervose; **pseudocyphellae:** marginal turning into soralia; minute spinules from rim of soralia; **soredia:** granular; chondroid tissue cracked; **medulla:** solid. **Apothecia:** to 1 mm in diam.; **spores:** straight to slightly curved, 13–16 × 4–6 µm.

**Chemistry:** Cortex K<sup>+</sup> yellow; medulla K<sup>-</sup>, P<sup>-</sup>. Usnic acid and sekikaic acid aggregate present.

**Ecology and distribution:** *Microhabitat occupied:* Terricolous-rupicolous. In India the species is distributed in Meghalaya, Uttarakhand and West Bengal hills while species growing on soil is reported from localities of Uttarakhand. The species on soil is reported first time in India. Outside India, the species is also reported from Bhutan, Nepal, Taiwan and Thailand.

**SPECIMENS EXAMINED: INDIA: UTTARAKHAND, RUDRAPRAYAG DISTRICT,** Chopta, alt. 2,850 m, on soil over rock, Himanshu Rai and Pramod Nag 08-0012242 (LWG); Tungnath Bugyal, alt. 3,400 m, on soil over rocky slope in open grassland, Himanshu Rai and Pramod Nag 08-0012246 (LWG).

***Ramalina intermedia* (Delise ex Nyl.) Nyl.** (Fig. 2.52)

Nylander, Flora 56: 66.1873.

**Basionym:** *Ramalina minuscula*\**intermedia* Delise ex Nyl., Bull. Soc. Linn. Normandie ser. 2. 4: 141. 1870.

**Thallus:** fruticose, caespitose, up to 3 cm long, tufted; **branching:** sparingly branched from a narrow holdfast; **branches:** flattened near base, irregular in thickness in cross section, terete upwards and modified into coralloid structures tips often ending in soralia, up to 1.5 mm wide; **surface:** greenish yellow, shiny, smooth, sorediate; **soredia:** granular, subcorticate, usually with isidioid branchlets, in subterminal or marginal soralia that are 0.4–0.5 mm in diam.; **pseudocyphellae:** occasional, ellipsoid, laminal, often forming soredia; **cortex:** thin; chondroid strands: continuous, cracked. **Apothecia:** not present. The detailed description of the species is based on D. Awasthi, 2007.

**Chemistry:** Cortex K<sup>-</sup>, C<sup>-</sup>, KC<sup>+</sup> yellow, P<sup>-</sup>; medulla K<sup>-</sup>, C<sup>-</sup>, KC<sup>-</sup>, P<sup>-</sup>. Sekikaic acid aggregate present.

**Ecology and distribution:** *Microhabitat occupied:* Terricolous-rupicolous. In India the species is distributed in Uttarakhand while species growing on soil is

reported from Gomukh area of Uttarakhand at alt. ca. 3,800 m (Awasthi and Singh 1978). Sample pertaining to the species is untraceable during study. Outside India, the species is also reported from Japan; Europe, North America.

***Ramalina roesleri*** (Hochst.) Hue (Fig. 2.52)

Hue, Rev. Bot. Bull. Mens. 6: 151. 1887.

Basionym: *Ramalina fraxinea* var. *roesleri* Hochst in Schaer, Enum. Criti. Lich. Eur.: 9. 1850.

**Thallus:** fruticose, to 5 cm tall, continuous, erect to subpendulous, loosely tufted, greenish to yellowish brown; **branching:** subdichotomous; **branches:** flat, 0.5–1.5 mm wide, inseparable into upper and lower surfaces; **branchlets:** dense, often repeatedly branched with finely divided apices ending into hooked terete branchlets; **surfaces:** ±shining, striated, sparsely fenestrated, sorediate; **soralia:** soralia terminal to subterminal, punctiform to rounded; **medulla:** hollow in parts. **Apothecia:** absent. The detailed description of the species is based on D. Awasthi, 2007.

**Chemistry:** Cortex K<sup>+</sup> yellow; medulla K<sup>-</sup>, C<sup>-</sup>, P<sup>-</sup>. Usnic acid and sekikaic acid aggregate present.

**Ecology and distribution:** *Microhabitat occupied:* Terricolous-rupicolous. In India the species is distributed in Himachal Pradesh, Nagaland, Sikkim, Tamil Nadu, Uttarakhand and West Bengal hills (Awasthi 2007; Singh and Sinha 2010). The terricolous sample pertaining to the species is untraceable in during study. Outside India, the species is also reported from Japan and Nepal; Northern Europe; North America.

***Ramalina taitensis*** Nyl (Fig. 2.52)

Nylander, Bull. Soc. Linn. Normandie, ser. 2, 4: 119. 1870.

**Thallus:** loosely tufted, pale grey, 3–5 cm long, densely branched; **branches:** 1–2 mm wide, with numerous apically tapering branchlets; **surface:** ±smooth, inseparable into upper and lower, flat to canaliculated; **pseudocypbellae:** submarginal, punctiform, later becomes sorediate; **soredia:** ±granular; chondroid tissue cracked; **medulla:** loose, not hollow. **Apothecia:** absent. The detailed description of the species is based on D. Awasthi, 2007.

**Chemistry:** Medulla K<sup>-</sup>, C<sup>-</sup>, P<sup>-</sup>. Sekikaic acid aggregate present.

**Ecology and distribution:** *Microhabitat occupied:* Terricolous-rupicolous. In India the species is restricted to Eastern Himalaya and known from Sikkim and West Bengal hills (Pant and Awasthi 2003; Awasthi 2007). The terricolous sample pertaining to the species is untraceable during study. Outside India, the species is also reported from Tahiti Island.

**RHIZOPLACA** Zopf (*Lecanoraceae*)

Mitt. -Ann. Chern. 340: 291. 1905.

**Thallus:** foliose, umbilicate; **upper surface:** yellowish to brownish green; lower surface often brownish blue. **Apothecia:** sunken to superficial, lecanorine; **disc:** variously coloured; **paraphyses:** capitate; **asci:** with distinct amyloid thallus, 8-spored; **spores:** colourless, simple, ellipsoidal. **Pycnoconidia:** filiform, mostly curved. Usnic acid present in upper cortex (K<sup>-</sup>).

Out of 11 species known from world, 3 species are from India, of which 2 are terricolous.

**Key to the terricolous species of *Rhizoplaca*:**

- 
- |     |  |  |
|-----|--|--|
| 1.  | Apothecial disc orange red to red .....  | <i>R. chrysoleuca</i>                        |
| 1a. | Apothecial disc yellow green when young, black blue<br>when mature, pruinose, thallus yellowish green..... | <i>R. melanophthalma</i> var. <i>obscura</i> |
- 

***Rhizoplaca chrysoleuca* (Sm.) Zopf**

Zopf, Mitt.—Ann. Chem. 340: 291. 1905.

Basionym: *Lichen chrysoleucus* Sm., Trans. Linn. Soc. London 1: 82, 1791.

Synonyms: *Lecanora chrysoleuca* (Sm.) Ach., Lichenogr. Universalis: 411. 1810. -*Lecanora rubina* (Vill.) Ach., Lichenogr. Universalis: 412. 1810. *Lichen rubinus* Vill., Hist. Pl. Dauphine 3: 977. 1789.

var. ***chrysoleuca*** (Fig. 2.30e; Fig. 2.52)

**Thallus:** foliose, umbilicate, monophyllous or polyphyllous, with thick lobes united by a stalk at centre; **lower surface:** brown at centre, bluish black in outer part. **Apothecia:** to 5 mm in diam.; **disc:** orange-red to red, pruinose; **spores:** 8.5–12 × 3.5–6 µm.

**Chemistry:** Medulla K<sup>-</sup>, P<sup>+</sup> yellowish. Placodialic acid present.

**Ecology and distribution:** *Microhabitat occupied:* Terricolous-rupicolous. In India the species is widely distributed in Jammu and Kashmir, Sikkim and Uttarakhand while species growing on soil is reported from single locality from temperate region of Uttarakhand. Outside India, the species is also reported from Bhutan and Nepal; Eurasia; North America.

**SPECIMEN EXAMINED: INDIA: UTTARAKHAND, UTTARKASHI DISTRICT,** Gangotri, between Bhojwasa to Gomukh, alt. 3,152 m, on hard soil over rock, Himanshu Rai and Pramod Nag, 10-0017406 (LWG).

***Rhizoplaca melanophthalma* (DC.) Leuckert and Poelt**

Leuckert and Poelt, Nova Hedwigia 28: 72. 1976.

Basionym: *Squamaria melanophthalma* DC. in Lam. and DC., Fl. Franc. ed. 3, 2: 376. 1805.

Synonym: *Lecanora melanophthalma* (DC.) Ramond, Mem. Acad. Roy. Sci. Inst. de France. 6: 133. 1823 (1827).

var. ***obscura*** (J. Steiner) D. D. Awasthi (Fig. 2.30f; Fig. 2.52)

D. D. Awasthi, Comp. Macrolich. India, Nepal and Sri Lanka: 446. 2007.

**Thallus:** peltate, monophyllous, up to 3 cm across, polyphyllous with several lobes united by a stalk; **lobes:** round to crenate; **lower surface:** reddish brown. **Apothecia:** to 3 mm diam., sessile; **disc:** bluish brown to black; **spores:** 9–11.5 × 5–5.5 µm.

**Chemistry:** Medulla P<sup>+</sup> yellow. Placodialic acid and rarely psoromic acid present.

**Ecology and distribution:** *Microhabitat occupied:* Terricolous-rupicolous. In India the species is widely distributed in alpine regions of Himachal Pradesh, Jammu and Kashmir, Sikkim and Uttarakhand while species growing on soil is reported from single locality of Uttarakhand. Outside India, the species is also reported from Africa, Europe.

**SPECIMEN EXAMINED: INDIA: UTTARAKHAND, UTTARKASHI DISTRICT,** Gangotri, between Chirwasa to Bhojwasa, alt. 3,452 m, on hard soil over rock, Himanshu Rai and Pramod Nag 10-0017405 (LWG).

**RINODINA** (Ach.) Gray (*Physciaceae*)

Gray, Nat. Arr. Brit. Pl. 1: 448. 1821.

**Thallus:** crustose to subsquamulose, continuous, rimose or areolate, pale to dark grey, yellow, yellow-brown or dark brown. **Ascomata:** apothecial, discoid, immersed to sessile, lecanorine, pseudolecanorine, biatorine; **disc:** brown to black, plane to convex; **margin:** concolorous with the thallus; **excipulum:** usually colourless; **hymenium:** colourless, amyloid; **hypothecium:** colourless; **paraphyses:** septate, simple or with short branches near the apices, apices; **asci:** *Lecanora*-type, clavate, (4–)8-spored; **spores:** olive-green or pale or dark brown, 1–5-septate, mainly double-walled, ellipsoidal, septa well developed at maturity.

Out of 265 species known from world; 11 species are from India; 2 terricolous.

**Key to the terricolous species of *Rinodina*:**

- 
- |     |  |                    |
|-----|--|--------------------|
| 1.  | Spores 3-septate or muriform, thallus olive brown to dark brown, apothecia upto 1.5 mm diam., brown black..... | <i>R. conradii</i> |
| 1a. | Spores 1-septate, thallus ashy white, apothecia concave to plane, to 1–1.5 mm diam. ....                       | <i>R. turfacea</i> |
- 

***Rinodina conradii*** Krb. (Fig. 2.52)

Krb., Syst. Lich. Germ.: 123. 1855.

**Thallus:** thin and disappearing, pale grey to brown grey, continuous, flat, cracked or  $\pm$  discrete warts, effuse; **prothallus:** inconspicuous. **Apothecia:** 0.3–0.85 mm diam., sessile, often contiguous; **thalline exciple:** 0.05 mm wide, concolorous with thallus, entire and persistent; **disc:** often dark brown soon becoming black, flat, plane to convex; **epithecium:** brown or more usually red brown; **hymenium:** 90–130  $\mu$ m high; **asci:** *Lecanora* type; **spores:** 25–31  $\times$  10–15  $\mu$ m, smooth, lumina rounded, uniformly thick walled, *Conradii*-type.

**Chemistry:** Thallus K–, C–, KC–, P–; no secondary metabolites in TLC.

**Ecology and distribution:** *Microhabitat occupied:* Terricolous. In India the species is exclusive terricolous and shown its restricted distribution in Eastern Himalayas and known to be only from West Bengal hills (Awasthi and Agarwal 1968; Awasthi 1991). The terricolous sample of the species is untraceable during study. Outside India, the species is also reported from Australia, Bhutan, New Guinea and New Zealand; temperate regions of Central and Southern Europe; North America. *Rinodina conradii* is characterised by its thin thallus, its abundant and convex apothecia and its conradii type spores.



***Rinodina turfacea*** (Wahlenb.) Körb. (Fig. 2.30g; Fig. 2.52)

Körber, Syst. Lich. Germ.: 123. 1855.

Basionym: *Lichen turfaceus* Wahlenb., Fl. Lappon.: 408. 1812.

Synonym: *Rinodina orbata* (Ach.) Vain., Ark. Bot. 8(4): 71. 1909.

**Thallus:** thin or thick, brownish-grey, ochraceous to copper brown, convex areoles; surface plane or rugose, matt or glossy; **prothallus:** lacking. **Apothecia:** frequent or often becoming contiguous, 1–1.5 mm diam., concave or plane; **disc:** brown black; **thalline exciple:** 0.05–0.10 mm wide, concolorous with thallus, entire and persistent; **epithecium:** brown or more usually red brown; **hymenium:** 90–140 µm high, not inspersed; **asci:** *Lecanora* type; **spores:** 8 per ascus, 26–35 × 11–15 µm, with a 5–8 µm thick septum.

**Chemistry:** Thallus K–, C–, KC–, P–; no secondary metabolites in TLC.

**Ecology and distribution:** *Microhabitat occupied:* Terricolous; muscicolous-terricolous. In India the species is exclusively terricolous and widely distributed in Himachal Pradesh and Jammu and Kashmir. Outside India, the species is also reported from Europe. It has a widespread or arctic distribution in Northern Hemisphere but absent from Antarctica.

**SPECIMENS EXAMINED: INDIA: HIMACHAL PRADESH, LAHAUL AND SPITI DISTRICT,** Baralacha la Pass, alt. 4,700 m, on soil, D. K. Upreti and Chatterjee 03-001770/C (LWG); Patsio, alt. 3,800 m, on mosses over soil, D. K. Upreti and Chatterjee 03-001746 (LWG); Lahaul valley, Rohtang pass, alt. 3,750 m, on soil in moist places, D. K. Upreti and Divakar 02-000019 DUP (LWG).

**SIPHULA** Fr. (*Icmadophilaceae*)

Fries, Lichenogr. Eur. Ref.: 406. 1831.

**Thallus:** fruticose, erect or prostrate, attached to substratum by rhizine like rooting system; podetia-like upright growth creamish, coralloid branched or sparsely branched, often fragile; corticated on all sides; heteromerous; **photobiont:** a green alga (Protococcoid); **medulla:** solid. Apothecia and pycnidia not known.

Out of 33 species known from the world, 1 terricolous species is known from India.

***Siphula ceratites*** (Wahlenb.) Fr.

Fries, Lichenogr. Eur. Ref.: 406. 1831.

Basionym: *Baeomyces ceratites* Wahlenberg, Fl. Lappon.: 459.1812.

var. ***ceratites*** (Fig. 2.30h; Fig. 2.52)

**Thallus:** podetia-like, erect, forming compact tufts, branched, caespitose, 0.5–1 cm tall, 1 mm in diam., smooth to rugulose, scattered in small patches; **branches:** up to 2 mm in diam., white to whitish, longitudinally plicate or furrowed, particularly towards a rooting base; **medulla:** white to croceous.

**Chemistry:** Cortex K+ yellow, C+ yellow brown, KC+ yellow orange, P–; medulla UV+ violet-glaucous. Siphulin present.

**Ecology and distribution:** *Microhabitat occupied:* Muscicolous-terricolous. In India the species is exclusively terricolous and exhibits its rare distribution in alpine region of Sikkim. Outside India, the species is also reported from Nepal;

cold temperate boreal areas of the world. Small thalli of *Thamnolia vermicularis* show some morphological resemblances with this species, but the former has pitted apices, hollow branches and different chemistry.

**SPECIMEN EXAMINED: INDIA: SIKKIM, EAST SIKKIM,** Kupup, north borderside, on soil among mosses, alt. 4,100–4,200 m, G. P.Sinha (BSHC).

var. *himalayensis* Räsänen (Fig. 2.52)

Räsänen, Arch. Soc. Zool. Bot. 'Vanamo' 5: 26. 1950.

Type: India, Himalaya orient., Sikkim, 4,000 m, ad terram muscosam, 1947, D. D. Awasthi (H-holotype; LWG-Awasthi isotype).

**Thallus:** podetia-like, smooth, simple to sparsely branched, ca. 2 mm long, 0.6 mm thick, digitate, white to greyish white.

**Chemistry:** Thallus K<sup>-</sup>, C<sup>-</sup>, P<sup>-</sup>. No secondary metabolites in TLC.

**Ecology and distribution:** *Microhabitat occupied:* Terricolous. In India the species is exclusively terricolous and exhibits its rare distribution in alpine region of Sikkim. It is endemic species in India and known by type collection only (Awasthi 2007).

### SOLORINA Ach. (*Peltigeraceae*)

Kongl. Vetensk.-Acad. Nya Handl. 29: 228. 1808.

**Thallus:** foliose, dorsiventral, heteromerous, wide spreading or in rosettes, lobate; **lobes:** rounded, margin slightly raised; **upper surface:** smooth to scabrid, slightly shiny, green grey, ± bright green when wet; **photobiont:** green, *Coccomyxa*, internal or external blue green cephalodia containing *Nostoc* also present; **lower surface:** tomentose and obscurely veined. **Apothecia:** laminal, rounded, irregularly scattered, immersed on the upper surface; **disc:** dark red-brown, slightly to very deeply concave; **thalline exciple:** absent; **asci:** clavate, 2–8-spored; **spores:** brown, ellipsoid to fusiform, single septate, spore wall ornamented or ± warted.

Out of 10 species known from world, 3 terricolous species are from India.

#### Key to the terricolous species of *Solorina*:

1.	Photobiont a cyanobacterium ( <i>Nostoc</i> ), asci 4-spored.....	<i>S. simensis</i>
1a.	Photobiont a green alga.....	2
2.	Medulla orange, asci 6–8-spored.....	<i>S. crocea</i>
2a.	Medulla white, asci 2-spored.....	<i>S. bispora</i>

### *Solorina bispora* Nyl. (Fig. 2.30i; Fig. 2.52)

Nylander, Syn. Lich. 1:331. 1860.

**Thallus:** lobes rounded, ca. 10 mm wide; **upper surface:** white pruinose, lacking isidia and soredia; **photobiont:** a green alga. **Apothecia:** immersed in thallus, urceolate, to 4 mm in diam.; **asci:** 2-spored; **spores:** ellipsoid, (55) 65–88 × 33–42 μm, slightly constricted at septum; wall ornamented

**Chemistry:** Thallus K<sup>-</sup>, C<sup>-</sup>, KC<sup>-</sup>, P<sup>-</sup>; no secondary metabolites in TLC.

**Ecology and distribution:** *Microhabitat occupied:* Terricolous. In India the species exhibits restricted distribution to Western Himalayas and is known only from Jammu and Kashmir. The species is also reported from Nepal.

**SPECIMEN EXAMINED:** INDIA: JAMMU AND KASHMIR, ANANTNAG DISTRICT, between Baltal and Amarnath, alt. 3,750 m, on soil, A. Singh and D.K. Upreti 13951 (LWG).

***Solorina crocea*** (L.) Ach. (Fig. 2.52)

Acharius, Kongl. Vetensk. Acad. Nya Handl. 29: 228. 1808.

Basionym: *Lichen croceus* Linnaeus. Sp. Pl.: 1149. 1753.

**Thallus:** growing in extensive orbicular patches; **upper surface:** greenish to red brown; **lobes:** rounded; **margin:** subapically pruinose, raised; **lower surface:** bright orange; **photobiont:** a green alga; **internal cephalodia:** present in lower part of orange coloured medulla. **Apothecia:** frequent, dark brown, deeply sunk in depression in upper surface; to 1 cm in diam.; **asci:** 6–8-spored; **spores:** oblong-ellipsoid, becoming brown, 25–45 × 10–17 µm.

**Chemistry:** Cortex and medulla K+ purple, C–, KC–, P–. Solorinic acid present.

**Ecology and distribution:** *Microhabitat occupied:* Terricolous. In India the species is exclusively terricolous and reported from Himachal Pradesh and Sikkim (Awasthi 2007; Sinha and Singh 2005). The species has shown bipolar distribution in New Zealand; temperate regions of Europe and North America.

**SPECIMEN EXAMINED:** INDIA: SIKKIM, NORTH SIKKIM, Tholung Kissong foot track, on soil over rocks, Sinha 600 (BSHC).

***Solorina simensis*** Hochst. (Fig. 2.31a; Fig. 2.52)

In Flotow, Linnaea 17: 17. 1843.

Synonym: *Solorinina simensis* (Hochst.) Nyl., Le Naturaliste 6: 387. 1884.

**Thallus:** spreading, bright green when wet, pale grey when dry, 4–7 cm across; **lobes:** rounded, 6–10 mm wide; **margin:** entire, wavy; **lower surface:** stramineous, pale yellow veined; **photobiont:** *Nostoc*. **Apothecia:** 2–4 mm in diam.; **asci:** 4-spored; **spores:** ellipsoid, oblong, 34–46 × 16–21 µm, epispore granularly ornamented.

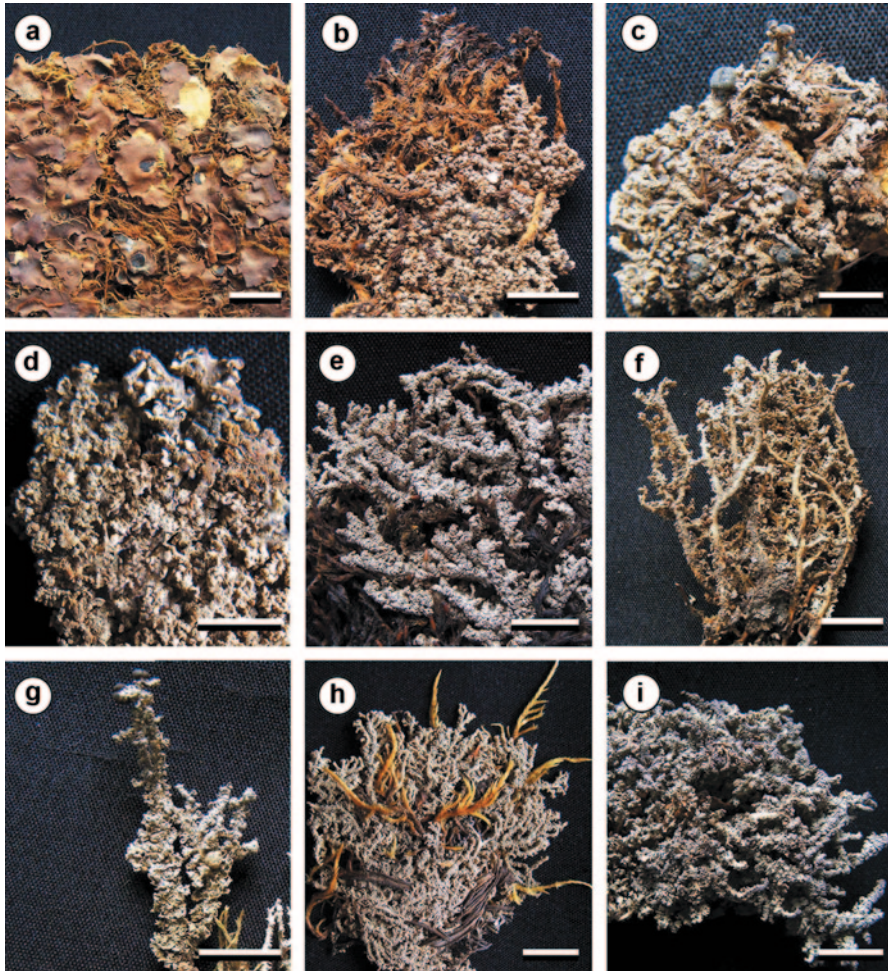
**Chemistry:** Methyl gyrophorate and tenuiorin present.

**Ecology and distribution:** *Microhabitat occupied:* Terricolous; terricolous-rupicolous; muscicolous-terricolous. In India the species is widely distributed in temperate regions of Sikkim, Tamil Nadu, Uttarakhand and West Bengal. The species is also reported from regions of Northern hemisphere.

**SPECIMENS EXAMINED:** INDIA: SIKKIM, NORTH SIKKIM, on way to Tsango lake, alt. 3,500 m, on soil over rocks, Chatterjee and Divakar 20-77124 (LWG); UTTARAKHAND, BAGESHWAR DISTRICT, 3 miles to Dwali, alt. 2,591 m, along roadside on ground in shade, D.D. Awasthi 7624 (LWG-AWAS); en route Pindari Glacier, from Khati to Dwali, alt. 2,210–2,734 m, on soil, S. Joshi and Y. Joshi 07-008801 (DUP-LWG); near Phurkiya, en route to Pindari glacier, alt. 3,048 m, on mossy soil among mosses, D.D. Awasthi and M.R. Agarwal 736 (LWG-AWAS); Dwali-Phurkiya (on way to Pindari glacier), alt. 2,896 m, on mossy soil, D.D. Awasthi and A.M. Awasthi 723 (LWG-AWAS); WEST BENGAL, DARJEELING DISTRICT, 5–6 miles from Darjeeling, alt. 2,057 m, on stone wall over soil by roadside, near a dry stream, D.D. Awasthi and M.R. Agarwal 67.94 (LWG-LWU); Tiger hill Senchal lake area, alt. 2,362 m, on soil, D.D. Awasthi 4 (LWG-AWAS).

**SQUAMARINA** Poelt (*Stereocaulaceae*)

Mitt. Bot. Staatssmml. München 2: 524. 1958 em. Hafellner, Bieh. Hova Hedwigia 79: 342. 1984.



**Fig. 2.31** **a** *Solorina simensis* Hochst., **b** *Stereocaulon alpinum* Laurer, **c** *S. austroindicum* I. M. Lamb, **d** *S. coniophyllum* I. M. Lamb, **e** *S. foliolosum* var. *botryophorum* (Müll. Arg.) I. M. Lamb, **f** *S. foliolosum* var. *foliolosum* Nyl., **g** *S. foliolosum* var. *strictum* (Bab.) I. M. Lamb, **h** *S. glareosum* (Savicz) H. Magn., **i** *S. himalayense* D. D. Awasthi and I. M. Lamb. Scale in **a**, **d**=5 mm; in **b**, **c**, **e**, **f**, **g**, **h**, **i**=10 mm

**Thallus:** squamulose, lobes often pruinose; **photobiont:** chlorococcoid; **medulla:** thick, dense white. **Apothecia:** concave to flat or convex; **thalline exciple:** distinct at first, often becoming excluded; **disc:** yellowish brown to red brown; **hamathecium:** of paraphyses; **asci:** 8-spored, *Bacidia* type; **spores:** simple, colourless. **Conidiomata:** pycnidia; **conodia:** filamentous,  $\pm$  curved. Usnic,  $\pm$  psoromic acids, several depsidones and unknown substances.

Out of 28 species known from world, 1 terricolous species is from India.

***Squamarina cartilaginea*** (With.) P. James (Fig. 2.52)

In D. Hawksw. and al. *Lichenologist* 12(1): 107. 1980.

Basionym: *Lichen cartilagineum* With., Bot. Arr. Veg. Gr. Brit.: 708. 1776.

**Thallus:** variable, yellow green to brownish green; **squamules:** irregular to imbricate, concave to strongly convex, thickish, strongly pruinose or not, loosely to firmly attached. **Apothecia:** 3–4 mm in diam., **thalline exciple:** almost entire, becoming excluded; **hymenium:** 65–70 µm high; **disc:** brownish to reddish brown, concave to flat, becoming irregularly convex; **paraphyses:** slightly widened towards apices; **spores:** 10–14 × 4–6 µm, oblong ellipsoid.

**Chemistry:** Thallus P–, K–, KC+ yellowish, C–; medulla P+ yellow or P–. Usnic, ±psoromic acid.

**Ecology and distribution:** *Microhabitat occupied:* Terricolous. In India the species is exclusively terricolous and reported from Srinagar district of Jammu and Kashmir (Sheikh et al. 2006). The sample pertaining to the species is untraceable during study. Outside India, the species is also reported from North Africa, Europe, North America. Specimen pertaining to the species is untraceable in herbarium.

***Stereocaulon*** (Schreb.) Hoffm. (*Stereocaulaceae*)

Deutschl. Fl.: 128. 1796.

**Thallus:** dimorphic; **primary thallus:** horizontal, crustose, granular to squamulose; **secondary thallus:** vertical, fruticose, pseudopodetium; **pseudopodetia:** solid, corticated; surface bearing phyllocladia; **phyllocladia:** granular, verrucose, nodular, squamulose-foliose or cylindrical terete, simple or branched, corticated; **photobiont:** a green alga; **cephalodia:** present on primary thallus and on pseudopodetia, light or dark brown, as protosacculate (solid cored) or sacculate (loose cored), enclosing a cyanobacterium (*Nostoc*, *Scytonema* or *Stigonema*). **Apothecia:** lateral or terminal, rounded, brown to black, up to 4 mm in diam., lecideine; **asci:** with amyloid tholus, 4–8-spored; **spores:** colourless, transversely 2–30-septate, elongate, fusiform to acicular or vermiform.

Out of 137 species known from world, 13 terricolous species known from India.

**Key to the terricolous species of *Stereocaulon*:**

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1.	Pseudopodetia sorediate or pseudosorediate.....	2
1a.	Pseudopodetia lacking soredia and pseudosoredia .....	3
2.	Pseudopodetia sorediate, phyllocladia replaced by dense soredia, cephalodia protosacculate, corticated .....	<i>S. coniophyllum</i>
2a.	Pseudopodetial phyllocladia becoming efflorescent pseudosorediate, cephalodia ecorticate.....	<i>S. austroindicum</i>
3.	Thallus terricolous, on soil, humus or mosses etc .....	4
3a.	Thallus generally growing on soil over rocks.....	5
4.	Phyllocladia present at base, cylindrical to granular, clustered and branched at apices; pseudopodetia white tomentose .....	<i>S. glareosum</i>
4a.	Phyllocladia absent at base of pseudopodetium, appressed, flattened to verruciform in upper part, white .....	<i>S. alpinum</i>
5.	Cephalodia with poorly developed cortex .....	6
5a.	Cephalodia with well-developed cortex, protosacculate or sacculate .....	7

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6.	Pseudopodetia sparingly branched, phyllocladia digitate, lobaric acid present .....	<i>S. sasaki</i>
6a.	Pseudopodetia deeply and intricately branched, forming globular mass in nature, phyllocladia verrucose-squamulose to digitate, stictic acid present.....	<i>S. myriocarpum</i>
7.	Cephalodia protosacculate (solid cored).....	8
7a.	Cephalodia sacculate (loose cored).....	14
8.	Phyllocladia verrucose-squamulose to foliose, lobaric acid present ..	9
8a.	Phyllocladia cylindrical, terete, simple or branched.....	12
9.	Spores 3–4(–5)-septate, phyllocladia granular to subcoralloid.....	<i>S. himalayense</i>
9a.	Spores 6–12-septate, phyllocladia squamulose to foliose.....	10
10.	Phyllocladia turgid to digitate squamulose, not distinctly foliose .....	<i>S. foliolosum</i> var. <i>botryophorum</i>
10a.	Phyllocladia distinctly foliose.....	11
11.	Phyllocladia foliose throughout .....	<i>S. foliolosum</i> var. <i>foliosum</i>
11a.	Phyllocladia foliose below, granular, coralloid above .....	<i>S. foliolosum</i> var. <i>strictum</i>
12.	Pseudopodetia prostrate, tomentose, phyllocladia dense, digitate or coralloid, lobaric acid present.....	<i>S. paradoxum</i>
12a.	Pseudopodetia erect, not tomentose.....	13
13.	Pseudopodetia subcorymbosely branched at apex; apothecia with tessellate hypophysis, norstictic and stictic acids present.....	<i>S. pomiferum</i>
13a.	Pseudopodetia simple to bifurcating at apex, apothecia lacking hypophysis, stictic acid present.....	<i>S. macrocephalum</i>
14.	Apothecia terminal, cephalodia with <i>Nostoc</i> .....	<i>S. piluliferum</i>
14a.	Apothecia on short lateral branches, cephalodia with <i>Scytonema</i> , stictic acid present in phyllocladia.....	<i>S. massartianum</i>

### ***Stereocaulon alpinum*** Laurer (Fig. 2.31b; Fig. 2.52)

In Funck, Cryptog. -Gewächsh. ed. 2, 33: 6. 1927.

**Pseudopodetia:** ± caespitose, 2–3(–4) cm long, 0.5–1(–2) mm thick at base, erect or decumbent, pale brownish or blackish, branched; **phyllocladia:** crowded towards apices, flattened and appressed, to 0.5 mm broad, whitish grey with bluish hue. **Cephalodia:** lacking cortex, with *Nostoc* in surface. **Apothecia:** rare, terminal, to 1.5 mm in diam.; **hymenium:** 40–50 µm high; **spores:** 3-septate, 27–34 × 2.5–3 µm.

**Chemistry:** Atranorin and lobaric acid in phyllocladia.

**Ecology and distribution:** *Microhabitat occupied:* Terricolous; muscicolous-rupicolous; terricolous-rupicolous; detriticolous-terricolous. In India the species is earlier reported from Sikkim and West Bengal. The present study extends its distribution up to Western Himalayas (Uttarakhand) and Arunachal Pradesh too. Outside India, the species is also reported from Nepal, the USA, Northern Europe and South America.

**SPECIMENS EXAMINED: INDIA: ARUNACHAL PRADESH, TAWANG DISTRICT,** Bangajang, alt. 4,146 m, on soil over rock, Rupam Debnath 12-017702 (LWG); **SIKKIM, NORTH SIKKIM,** Llonakh valley, Chhaber lake below Luna La, alt. 4,600 m, Sinha 1594 (BSHC); **UTTARAKHAND, RUDRAPRAYAG DISTRICT,** Tungnath Bugyal, alt. 3,400 m, on soil over rock on moss tuft, Himanshu Rai and Pramod Nag 08-0012202 (LWG); Chandrashila, alt. 3,800 m, on soil over rock with degrading mosses, Himanshu Rai and Pramod Nag 08-0012250 (LWG).

***Stereocaulon austroindicum*** I. M. Lamb (Fig. 2.31c; Fig. 2.52)

Lamb, J. Hattori Bot. Lab. 43: 205. 1977.

**Primary thallus:** persistent, granulose; **pseudopodetia:** erect, to 2 cm tall, aggregated, simple to branched, ca. 1 mm thick at base, to 2 mm at apex, ecorticate and etomentose, yellowish brown, apices white; **phyllocladia:** initially granular coralloid becoming apically efflorescent pseudo-sorediate. **Cephalodia:** yellow-brown, 1 mm in diam., ecorticate, enclosing *Anacystis*, (*Gloeocapsa*) or *Stigonema*. **Apothecia:** terminal, ca. 2 mm in diam.; **hymenium:** 50–75  $\mu\text{m}$  high; **spores:** fusiform, 3(–7)-septate, (23–)30–42  $\times$  2.5–3  $\mu\text{m}$ .

**Chemistry:** Phyllocladia K+ yellow, P+ pale yellow. Atranorin and lobaric acid, rarely only atranorin present.

**Ecology and distribution:** *Microhabitat occupied:* Terricolous. In India the species is widely distributed in Kerala and Tamil Nadu. Outside India, the species is also reported from Sri Lanka.

**SPECIMENS EXAMINED:** **INDIA:** **TAMIL NADU,** DINDIGUL DISTRICT, Kodaikanal, alt. 2,134 m, on ground, O. A. Höeg 2542 (LWG-AWAS); Shenbaganur, near silver cascade, alt. 1,829 m, on hard soil and stones by road surface, exposed to east common forming large patches, D. D. Awasthi and K. P. Singh 70.44 (LWG-AWAS); **NILGIRI HILLS,** Coonoor, alt. 1,829, on hard soil, D. D. Awasthi and K. P. Singh 70.1395 (LWG-LWU); Ootacamund, Bandy shoal, alt. 2,134 m, on red soil ground, D.D. Awasthi and K.P. Singh 70.288 (LWG-LWU); on way to Nilgiri peak, Carriat Shola, alt. 2,286 m, on ground (hard soil), K. P. Singh 72.13 (LWG-LWU); Ootacamund-Kotagiri road, on way to Mayani, 3 miles from Doddabetta, alt. 2,134 m, on hard red soil, K. P. Singh 72.1120 (LWG-LWU); Sholas at 8–9 miles Ootacamund-Mysore road, alt. 2,134 m, on soil, D. D. Awasthi 4457 (LWG-AWAS); Avalanche, on the hill top above power house area, alt. 2,134 m, on hard red soil with pebbles, D. D. Awasthi and K. P. Singh 71.261 (LWG-AWAS); **PALNI HILLS,** near Berijam, alt. 2,438 m, on ground by road surface, D. D. Awasthi and K.P. Singh 70.332 (LWG-LWU).

***Stereocaulon coniophyllum*** I. M. Lamb (Fig. 2.31d; Fig. 2.52)

Lamb, Bot. Not. 114 (3): 266.1961.

**Pseudopodetia:** rarely terricolous, to 5 cm tall, 1–2(2.5) mm thick near base, rigid, irregularly branched or rarely subsimple, brown-black, decorticate, smooth; **phyllocladia:** not developed, replaced by granular, farinose soredia all over the branches of pseudopodetia. **Cephalodia:** 1–2 mm in diam., brown, protosacculate, with palisade-like cortex, enclosing *Nostoc*. **Apothecia:** not present in specimen.

**Chemistry:** Pseudopodetia and soredia K+ yellow, P+ yellow. Atranorin and lobaric acid present.

**Ecology and distribution:** *Microhabitat occupied:* Terricolous. In India the species is rarely distributed in Sikkim and West Bengal (Singh and Sinha 2010). The present study extends its distribution up to Western Himalayas (Uttarakhand). Outside India, the species is also reported from China, Japan, Nepal and arctic and boreal regions of America and Europe. It is only sorediate species known from India.

**SPECIMENS EXAMINED:** **INDIA,** SIKKIM, Tsoka-Phithang trek, alt. 3,500–3,900 m, on soil over rock, G. P. Sinha 216 (BSHC); **UTTARAKHAND,** CHAMOLI DISTRICT, Nanda Devi Biosphere Reserve, N. W. part, on rock over soil, H. R. Negi 29 (LWG).

***Stereocaulon foliolosum* Nyl.**

Nylander, Syn. Lich. 1(2): 240.1860.

var. ***botryophorum*** (Müll. Arg.) I. M. Lamb (Fig. 2.31e; Fig. 2.52)

J. Hattori Bot. Lab. 43: 267. 1977.

Basionym: *Stereocaulon botryophorum* Müll. Arg., Flora 74: 371. 1891.

**Pseudopodetia:** to 9 cm tall, 1–2 mm thick at base; **phyllocladia:** 1–3 mm long, squamulose to digitate squamulose, not distinctly foliose, more abundant towards apical region. **Apothecia:** 2–3 mm in diam.; **hymenium:** 90–120 µm high; **spores:** 6–9-septate, 60–90 × 3 µm.

**Chemistry:** Atranorin and lobaric acid in phyllocladia.

**Ecology and distribution:** *Microhabitat occupied:* Terricolous; terricolous-rupicolous. In India the species is widely distributed in Arunachal Pradesh, Himachal Pradesh, Sikkim, Uttarakhand and West Bengal hills (Singh and Sinha 2010). Outside India, the species is also reported from Nepal and Central Africa.

**SPECIMENS EXAMINED:** **INDIA:** ARUNACHAL PRADESH, WEST KAMENG DISTRICT, Tawang, alt. 4,000 m, on soil, Jaishree Rout s.n. (LWG); UTTARAKHAND, PITHORAGARH DISTRICT, enroute to Milam glacier, alt. 4,000 m, on soil over boulders, B. S. Kholia s.n. (LWG); UTTARAKASHI DISTRICT, Gangotri, alt. 3,123 m, over soil on rock, Himanshu Rai and Pramod Nag 10-0014542 (LWG).

var. ***foliolosum*** (Fig. 2.31f; Fig. 2.52)

**Pseudopodetia:** 3–4.5 cm tall, sparingly branched, decorticated, subglabrous, brownish; **phyllocladia:** flattened, leafy, 1.5–2.5 mm long, evenly distributed throughout up to the apex. **Cephalodia:** 1–2 mm in diam., brown, protosacculate, cortex of elongated or isodiametric cell lumina enclosing *Nostoc*. **Apothecia:** terminal, to 2 mm in diam.; **spores:** vermiform, 6–14-septate, 60–95 × 3–4 µm.

**Chemistry:** Phyllocladia K+ yellow, P+ yellow. Atranorin and lobaric acid present.

**Ecology and distribution:** *Microhabitat occupied:* Terricolous; terricolous-rupicolous. In India the species is widely distributed in Arunachal Pradesh, Himachal Pradesh, Sikkim, Uttarakhand and West Bengal hills. Outside India, the species is also reported from Bhutan and Nepal.

**SPECIMENS EXAMINED:** **INDIA:** ARUNACHAL PRADESH, WEST KAMENG DISTRICT, Tawang, alt. 4,145 m, on soil, Ashish Kar 06-009737 (LWG); HIMACHAL PRADESH, KINNAUR DISTRICT, Chitkul, alt. 3,950 m, on soil, Upreti, Srivastava and Prakash 03-002741 (LWG); KULLU DISTRICT, Great Himalayan National Park, Jiwanala valley, alt. 3,000 m, on soil, Upreti, Srivastava and Prakash 04-003156 C (LWG); on way from Dhela to Lapah, alt. 3,000 m, on soil over rock, D. K. Upreti 99-54076 (LWG); around Soupdhar, alt. 3,900 m, on rock over soil, D. K. Upreti 99-53699, 99-54001 (LWG); around Patal, alt. 2,800 m, on rocks over soil, D. K. Upreti 99-53653, 99-53655 99-53658 (LWG); LAHAUL SPITI DISTRICT, Rohtang Pass area, alt. 3,600 m, on soil, D. K. Upreti 01-26572 (LWG); Lahaul valley, alt. 3,200 m, on soil, D. K. Upreti and P. K. Divakar 02-000049 (LWG); SIKKIM, NORTH SIKKIM DISTRICT, Shingha Rhododendron Sanctuary, alt. 3,300 m, on soil, D. K. Upreti, S. Chatterjee and P. K. Divakar 04-004072 (LWG); Above Lachen, alt. 3,000 m, on soil over rock, D. K. Upreti, S. Chatterjee and P. K. Divakar 04-003825 (LWG); Gangtok, alt. 1,800 m, on soil, K. P. Srivastava 97614 (LWG); UTTARAKHAND, BAGESHWAR DISTRICT, Phurkiya to Mirtoli, alt. 3,505 m, on ground, D. D. Awasthi 7786 (LWG-AWAS); near Pindari glacier, Mirtoli, alt. 3,597 m, on ground, D. D. Awasthi 7726 (LWG-AWAS); near Dhakuri ridge, alt. 2,743 m, on stones and ground, D. D. Awasthi 7606 (LWG-AWAS); Pindari glacier area alt. 3,300 m,



on moraine, P. C. Pandey 81-54344 (LWG); **CHAMOLI DISTRICT**, between Ghangharia and Hemkund, alt. 3,900 m, on soil covered rock, A. Singh 85862 (LWG); Auli below Ghorsu top, alt. 3,300 m, on rocks over soil, D. K. Upreti 202326 (LWG); below Ghorsu top, alt. 3,300 m, on soil, D. K. Upreti 202339 (LWG); Valley of flowers, alt. 3,000 m, on rocks over soil, S. Rawat 06-007138 (LWG); near Badrinath, way from Mana to Vasudhara, alt. 3,340 m, on soil, D. K. Upreti and S. Nayaka 07-010143 (LWG); **PITHORAGARH DISTRICT**, Lilam to Bogudiyar en route to Milam glacier, alt. 2,125 m, on soil over rocks, S. Joshi 07-010363(LWG); **RUDRAPRAYAG DISTRICT**, Kedarnath valley, Rambara area, alt. 1,800 m, on soil, D. K. Upreti, P. K. Divakar, B. Kumar 06-005998 (LWG); Kedarnath valley, around Kedarnath temple, alt. 3,500 m, on soil over rocks, D. K. Upreti, P. K. Divakar, B. Kumar 06-006216, 06-006225 (LWG); **WEST BENGAL, DARJEELING DISTRICT, KURSEONG**, Dow hill, alt. 1,737 m, on soil over rock, D. D. Awasthi and M. R. Agarwal 66.280 (LWG-LWU).

var. *strictum* (C. Bab.) I. M. Lamb (Fig. 32.31g; Fig. 2.52)

Lamb, Canad. J. Bot. 29: 582.1951.

Basionym: *Stereocaulon ramulosum* var. *strictum* C. Bab., Hooker's J. Bot. Kew Gard. Misc. 4: 250. 1852.

**Pseudopodetia:** to 4.5 cm tall, 2 mm thick at base; **phyllocladia:** foliose in lower part of pseudopodetium and a gradual transition to grain-like or shortly coralloid form in upper part. **Apothecia:** to 3 mm in diam.; **spores:** 6–12-septate, 60–90 × 3 µm.

**Chemistry:** Atranorin and lobaric acid present in phyllocladia.

**Ecology and distribution:** *Microhabitat occupied:* Terricolous; terricolous-rupicolous; muscicolous-rupicolous; detriticolous-terricolous. In India the species is widely distributed in Himachal Pradesh, Sikkim, Uttarakhand and West Bengal hills. Outside India, the species is also reported from China and Nepal.

**SPECIMENS EXAMINED: INDIA: SIKKIM, NORTH SIKKIM**, Lachen, along roadside, alt. 2,710 m, on soil over rock, Sinha 1028 (BSHC); **UTTARAKHAND; BAGESHWAR DISTRICT**, near Pindari glacier, Mirtoli, alt. 3,566 m, on ground and stones, D.D. Awasthi 7727 (LWG-AWAS); near Pindari glacier, Mirtoli, alt. 3,597 m, on ground and stone, D.D. Awasthi 7728 B (LWG-AWAS); en route to Pindari Glacier, from Dwali to Phurkiya, alt. 2,972 m, on soil over rock, S. Joshi and Y. Joshi 07-010745 (LWG); en route to Sunderdhunga glacier, before 5 km of Dhakuri, alt. 2,700 m, on soil, Upreti and Tandon 213413 (LWG); en route Dhakuri to Khati, alt. 2,422 m, on soil, S. Joshi and Y. Joshi 07-008856 (LWG); **PITHORAGARH DISTRICT**, Naher Devi to Mapang en route to Milam Glacier, alt. 2,931 m, on soil, S. Joshi 07-010364, 07-010365 (LWG); Rilkot to Burfu en route to Milam glacier, alt. 3,225 m, on soil, S. Joshi 07-010367 (LWG); Bogudiyar to Naherdevi, Milam glacier region, alt. 2,553 m, on soil, S. Joshi 07-010574 (LWG); Rariudiyar (Lilam-Bogudiyar), Milam glacier, alt. 2,400 m, on soil, S. Joshi 07-010362 (LWG); en route to Pindari glacier, Dwali-Phurkiya, alt. 2,972 m, on soil, S. Joshi and Y. Joshi 07-008864 (LWG); **RUDRAPRAYAG DISTRICT**, below Tungnath temple, 6±2 mt. right to road to Chandrashila, alt. 3,400 m, on soil over rock with mosses, Himanshu Rai and Pramod Nag 08-0012212 (LWG); Chopta, alt. 2,900 m, on soil over rock along with mosses, S. Nayaka and D.K.Upreti 09-0012256 (LWG); Chopta, alt. 2,850 m, on soil, Himanshu Rai and Pramod Nag 08-0012215, 08-0012216, 08-0012228 (LWG); Tungnath Bugyal, alt. 3,400 m, on soil over rock on moss tuft, Himanshu Rai and Pramod Nag 08-0012229 (LWG); below Tungnath temple, 10±2 mt. right to road to Chandrashila, alt. 3,400 m, on soil over rock on moss tuft, Himanshu Rai and Pramod Nag 08-0012230 (LWG); Tungnath, alt. 3,400 m, on soil with degrading mosses, Himanshu Rai and Pramod Nag 08-0012235 (LWG); below Tungnath temple, 6±2 mt. right to road to Chandrashila, alt. 3,400 m, on soil over rock on decaying moss, Himanshu Rai and Pramod

Nag 08-0012236 (LWG); Tungnath Bugyal, alt. 3,400 m, on soil over rock on moss tuft, Himanshu Rai and Pramod Nag 08-0012249 (LWG).

***Stereocaulon glareosum*** (Savicz) H. Magn. (Fig. 2.31h; Fig. 2.53)

Magnusson, Goteborgs Kungl. Vetensk. Samhälles. Handl., ser. 4, 30(7): 60. 1926.

Basionym: *Stereocaulon tomentosum* var. *glareosum* Savicz, Bull. Jard. Imp. Bot. Pierre le Grand (Izv. Imp. Bot. Sada Petra Velikago), 14: 121. 1914.

**Primary thallus:** terricolous or on gravelly soil or stones, terete, cylindrical; **pseudopodetia:** to 2 cm tall, 1 mm thick at base, sparingly branched, whitish grey to grey tomentose; **phyllocladia:** cylindrical, 0.5–0.8 mm long, 0.2 mm thick or granular, sparse to abundant near base, clustered and branched at apices. **Cephalodia:** 1 mm in diam., brown-black, cortex poorly developed, enclosing *Nostoc*. **Apothecia:** not present in specimens examined.

**Chemistry:** Phyllocladia K+ yellow, P+ yellow. Atranorin and lobaric acid present.

**Ecology and distribution:** *Microhabitat occupied:* Terricolous; terricolous-rupicolous. In India the species is widely distributed in Jammu and Kashmir, Sikkim and Uttarakhand. Outside India, the species is also reported from Nepal; widely distributed in arctic, boreal and circumpolar regions of Asia, Europe, North America and South America.

**SPECIMENS EXAMINED:** **INDIA:** **SIKKIM, NORTH SIKKIM,** Above Lachen, alt. 3,000 m, on soil over rocks, D. K. Upreti, S. Chatterjee, P. K. Divakar 04-003814 (LWG); **UTTARAKHAND, PITHORAGARH DISTRICT,** Rilkot to Burfu en route to Milam glacier, alt. 3,225 m, on soil, S. Joshi 07-010771 (LWG); Mapang to Rilkot en route to Milam glacier, alt. 3,180 m, on soil, S. Joshi 07-010701 (LWG).

***Stereocaulon himalayense*** D. D. Awasthi and I. M. Lamb (Fig. 2.31i; Fig. 2.53)

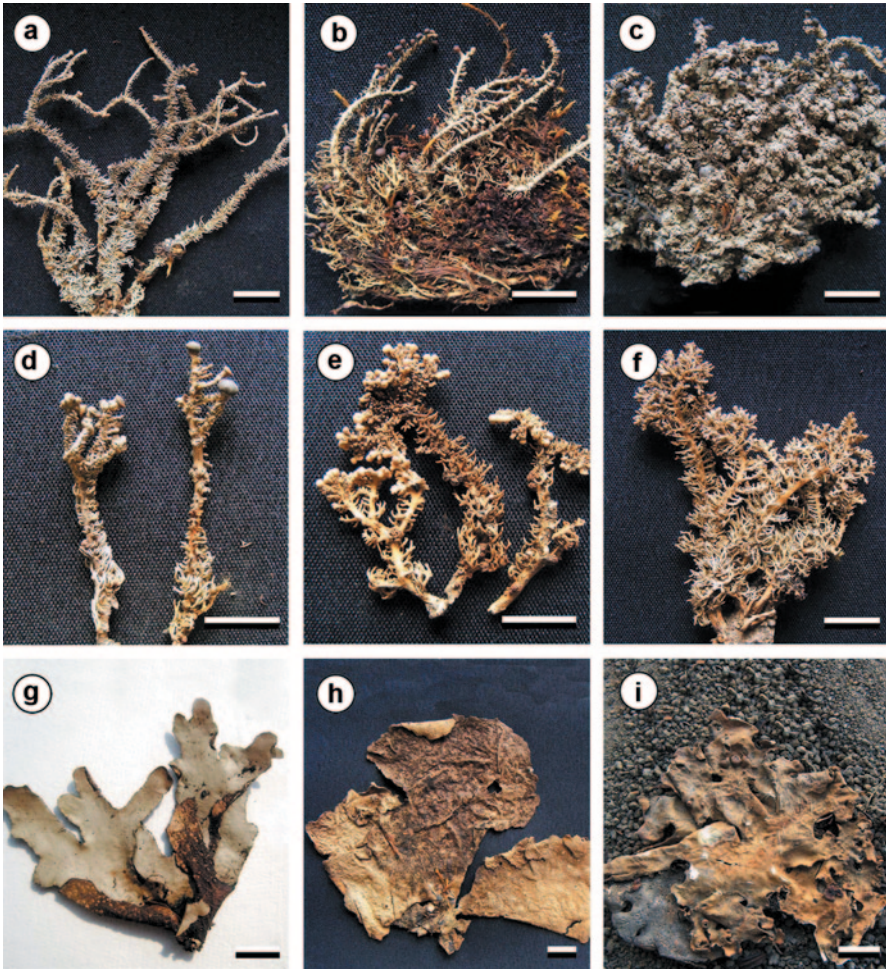
In Lamb, J. Hattori Bot. Lab. 43: 269. 1977.

**Primary thallus:** ±persistent, granular to lobate squamulose; **pseudopodetia:** (1–)2.5 cm tall, 0.8–1.5 mm thick at base, simple to sparingly branched, decorticated, glabrous, whitish to ochraceous; **phyllocladia:** granular to shortly dactyliform, coralloid or rarely lobate subsquamulose, never foliose. **Cephalodia:** 0.8–1.5(4–) mm in diam., brownish to olivaceous, protosacculate, cortex with isodiametric rounded to elongated cell lumina, enclosing *Nostoc*. **Apothecia:** terminal, to 4(–5) mm in diam.; **hymenium:** 70–75(–90) µm high; **spores:** fusiform, (1–)3–4 (rarely 5–7)-septate, (20–)25–40(–45) × 3.5–4.5(–5) µm.

**Chemistry:** Phyllocladia K+ yellow, P+ yellow. Atranorin and lobaric acid present.

**Ecology and distribution:** *Microhabitat occupied:* Terricolous; terricolous-rupicolous. In India the species is widely distributed in Arunachal Pradesh, Himachal Pradesh, Sikkim, Uttarakhand and West Bengal hills and it is endemic to Himalayas. The species is also reported from Bhutan and Nepal.

**SPECIMENS EXAMINED:** **INDIA:** **ARUNACHAL PRADESH, TAWANG DISTRICT,** alt. 4,145 m, on soil, Ashish Kar 04-009731, 04-009738 (LWG); alt. 4,146 m, on soil over rock, Rupam Debnath 12-017702 (LWG); **SIKKIM, NORTH SIKKIM,** Llonakh valley, Chhaber lake below Luna La, alt. 4,600 m, on ground, Sinha 1593 (BSHC).



**Fig. 2.32** **a** *Stereocaulon macrocephalum* Müll. Arg., **b** *S. massartianum* Hue, **c** *S. myriocarpum* Th. Fr., **d** *S. paradoxum* I. M. Lamb, **e** *S. piluliferum* Th. Fr., **f** *S. pomiferum* P. A. Duvign., **g** *Sticta cyphellulata* (Müll. Arg.) Hue, **h** *S. fuliginosa* (Hoffm.) Ach., **i** *S. henryana* Müll. Arg. Scale in **a**, **b**, **c**, **d**, **e**, **f**, **g**, **h**, **i** = 10 mm

***Stereocaulon macrocephalum* Müll. Arg.** (Fig. 2.32a; Fig. 2.53)

Müll. Arg., Flora 74: 371. 1891.

**Pseudopodetia:** to 2.8 cm tall, ca. 2 mm thick at base, simple or bifurcating at apex, brown, partially corticate; **phyllocladia:** cylindrical, terete, to 2 mm long, densely covering pseudopodetia. **Cephalodia:** near base of pseudopodetium, brown, to 1 mm in diam., protosacculate; cortex with rounded to oblong cell lumina, enclosing *Nostoc*. **Apothecia:** terminal, to 3 mm in diam.; **hymenium:** (135–)160–180(–220)  $\mu\text{m}$  high; **spores:** vermiform, 16–26-septate, 105–150(–200)  $\times$  (3–)4–5(–6)  $\mu\text{m}$ .

**Chemistry:** Phyllocladia K+ yellow; P+ yellow-orange. Atranorin and stictic acid present.

**Ecology and distribution:** *Microhabitat occupied:* Terricolous-rupicolous. In India the species is widely distributed in Arunachal Pradesh, Himachal Pradesh, Sikkim and Uttarakhand. The species is also reported from Nepal.

**SPECIMENS EXAMINED:** **INDIA:** ARUNACHAL PRADESH, WEST KAMENG DISTRICT, Tawang, alt. 4,145 m, on soil over rocks, Ashish Kar 04-009732 (LWG); HIMACHAL PRADESH, LAHAUL SPITI DISTRICT, Lahaul Valley, Rohtang pass, alt. 3,950 m, on soil over rock, Upreti and Divakar 02-000025 A (LWG).

***Stereocaulon massartianum*** Hue (Fig. 2.32b; Fig. 2.53)

Hue, *Nouv. Arch. Mus. Hist. Nat.*, ser.3, 10: 252. 1898.

Synonym: *Stereocaulon naesaeum* auct. non Nyl. ex anno 1859.

**Pseudopodetia:** to 7.5 cm tall, 1 mm thick at base, sparingly branched, decorticate, yellow to brownish; **phyllocladia:** cylindrical, to 2–(5) mm long, dense at base, sparse above. **Cephalodia:** to 2.5 mm in diam., brownish, sacculate, centrally loose cored, cortex of round to palisade cell lumina, enclosing *Scytonema* or *Stigonema*. **Apothecia:** terminal, on short lateral branches, to 1 mm in diam., developing on pyriform clavulae; **spores:** vermiform, 7–14-septate, (75–)90–120 × 3 µm.

**Chemistry:** Phyllocladia K+ yellow; P+ yellow. Atranorin and stictic acid present.

**Ecology and distribution:** *Microhabitat occupied:* Terricolous; terricolous-rupicolous. In India the species is widely distributed in Arunachal Pradesh, Sikkim, West Bengal hills and Uttarakhand. Outside India, the species is also reported from Indonesia, Malaya, New Guinea, the Philippines and Taiwan.

**SPECIMENS EXAMINED:** **INDIA:** SIKKIM, EAST SIKKIM, Meimenchu lake surroundings, alt. 3,200–3,500 m, on rock over soil, Sinha 1459, 1490 (BSHC); WEST SIKKIM, on way between Dzungri-Thangsing, alt. 3,900–350 m, on rock over soil, Sinha 794 (BSHC); UTTARAKHAND, PITHORAGARH DISTRICT, Rariudiyar (Lilam-Bogudiyar), Milam glacier, alt. 2,400 m, on soil, S. Joshi 07-010362 B (LWG); Lilam to Bugudiyar en route to Milam glacier, alt. 2,125 m, on soil, S. Joshi 07-010366 (LWG); RUDRAPRAYAG DISTRICT, Chopta, alt. 2,900 m, on soil over rock, Sanjeeva Nayaka and D. K. Upreti 09-0012257(LWG).

***Stereocaulon myriocarpum*** Th. Fr. (Fig. 2.32d; Fig. 2.53)

Th. Fries, *Stereoc. Piloph. Comm.*: 15. 1857.

Synonyms: *Stereocaulon tomentosum*\* *myriocarpum* (Th. Fr.) Nyl., *Syn. Lich.* 1:244. 1860. -*Stereocaulon myriocarpum* var. *orizabae* Th. Fr., *Stereoc. Piloph. Comm.*: 15. 1857. -*Stereocaulon tomentosum*\* *myriocarpoides* Nyl. *Syn. Lich.* 1:245. 1860. -*Stereocaulon myriocarpoides* (Nyl.) Hue, *Nouv. Arch. Mus. Hist. Nat.*, ser. 3, 2: 247. 1890.

**Pseudopodetia:** arising from near the base, densely branched and entangled into an irregular or caespitose convex mass in nature; **phyllocladia:** arising disharmonically, dense, verrucose, lobate-squamulose to digitate-coralloid. **Cephalodia:** 1.5 mm in diam., brownish, cortex poorly developed, enclosing *Nostoc*. **Apothecia:** abundant, lateral and terminal, 0.5–1 mm in diam.; **spores:** spirally wound insurface ascus, 2–3(–4)-septate, 27–30(–36) × 3 µm.

**Chemistry:** Phyllocladia K+ yellow, P+ yellow. Atranorin, stictic, constictic acids, sometimes norstictic acid and an unknown substance present.

**Ecology and distribution:** *Microhabitat occupied:* Terricolous; terricolous-rupicolous; muscicolous-terricolous. In India the species is widely distributed in Arunachal Pradesh, Himachal Pradesh, Sikkim and Uttarakhand. The species is also reported from Bhutan and Nepal; widely distributed in Asia, Central, North and South America.

**SPECIMENS EXAMINED:** **INDIA:** **ARUNACHAL PRADESH, WEST KAMENG DISTRICT,** Sela pass area, alt. 4,221 m, on soil, D. K. Upreti, U. Dubey, R. Khare, G. K. Mishra 08-009425, 08-009246 (LWG); Tawang, alt. 4,145 m, on soil, Ashish Kar 04-009733 (LWG); **HIMACHAL PRADESH, KANGRA DISTRICT,** Ratni Thal, alt. 3,200 m, on ground or stone, O. A. Höeg 1792 (LWG-AWAS); **SIKKIM, NORTH SIKKIM,** Chubuk above Thangu, alt. 4,100 m, on soil over rocks, D. K. Upreti, S. Chatterjee, P. K. Divakar 04-003926 (LWG); Thangu, alt. 4,000 m, on soil, D. K. Upreti, S. Chatterjee, P. K. Divakar 04-003898 (LWG); **UTTARAKHAND, BAGESHWAR DISTRICT,** Dhakuri on ridge, en route to Pindari, alt. 2,896 m, on hard soil among mosses, D. D. Awasthi and A. M. Awasthi 638 (LWG-AWAS); Phurkiya to Pindari glacier, near Mirtoli, alt. 3,566 m, over stone and ground, D. D. Awasthi 7679 (LWG-AWAS); **CHAMOLI DISTRICT,** between Ghangharia and Hemkund, alt. 3,900 m, on rock over soil with mosses, A. Singh 85854 (LWG); between Wan and Bhuna, alt. 3,450 m, on soil covered rock, A. Singh and Party 91598 (LWG); Badrinath between Vasudhara and Bhagirathi Glacier, alt. 4,200 m, on soil, D. K. Upreti 202386, 202397 (LWG); near Badrinath, way from Mana to Vasudhara, alt. 3,350 m, on rock over soil, D. K. Upreti and S. Nayaka 07-010118 (LWG); **UTTARAKASHI DISTRICT,** Gomukh area, right bank second moraine, alt. 3,901 m, on rock soil, D. D. Awasthi and S. R. Singh 8395, 8395 B (LWG-AWAS); Gomukh area, right bank third and fourth moraine, alt. 3,871 m, on soil, D. D. Awasthi and S. R. Singh 8462, 8463, 8463 B, 8464, 8465, 8465 B, 8466, 8467, 8468, 8468 B, 8469, 8470, 8478, 8478 B, 8478 C, 8519, 8524 C, 8525, 8526, 8542 (LWG-AWAS).

*Stereocaulon paradoxum* I. M. Lamb (Fig. 3d; Fig. 2.53)

Lamb, J. Hattori Bot. Lab. 43: 275. 1977.

**Pseudopodetia:** decumbent to prostrate, to 4 cm long, 0.5–1 mm thick at base, simple to branched, yellowish, tomentose; **phyllocladia:** dense, digitate to cylindrical-co-coralloid, 0.5–1.5 mm long, 0.1–0.15 mm thick, white at apices. **Cephalodia:** brownish, protosacculate cortex with isodiametrical to round cell lumina, enclosing *Nostoc*. **Apothecia and pycnidia:** not known.

**Chemistry:** Phyllocladia K+ yellow, P+ yellow. Atranorin and lobaric acid present.

**Ecology and distribution:** *Microhabitat occupied:* Terricolous; terricolous-rupicolous. In India the species is widely distributed in Sikkim and Uttarakhand. The species is also reported from Nepal. The taxon seems to be endemic in Indian Continent. *Stereocaulon paradoxum* is close to *S. myriocarpum*, the latter differs in poorly developed cortex of cephalodia and abundant apothecia.

**SPECIMENS EXAMINED:** **INDIA:** **SIKKIM,** Tsoka-Phithang trek, alt. 3,475 m, on soil, G. P. Sinha 211 (BSHC); **UTTARAKHAND, CHAMOLI DISTRICT,** between Wan and Bhuna, alt. 3,540 m, on soil-covered rocks, A. Singh 91599 (LWG)—dupl. det. I. M. Lamb 1971; **PITHORAGARH DISTRICT,** Lilam to Bugudiyar, en route to Milam glacier, alt. 2,253 m, on soil over rock, S. Joshi 07-010772 (LWG).

***Stereocaulon piluliferum*** Th. Fr. (Fig. 2.32e; Fig. 2.53)

Th. Fries, *Stereoc. Piloph.* Comm.: 21. 1857.

Synonyms: *Stereocaulon sinense* Hue, *Nouv. Arch. Mus. Hist. Nat. Paris*, ser.3, 10: 251. 1898. *S. piluliferum* var. *sinense* (Hue) I. M. Lamb (comb. invalid.) in Asahina 1955.

**Primary thallus:** granular; **pseudopodetia:** 3(–6) cm tall, 0.5–0.8 mm thick at base, simple or sparingly branched in apical region, brownish, corticated, etomentose; **phyllocladia:** cylindrical, simple to branched, to 5 mm long, more dense on one side. **Cephalodia:** 0.5–1 mm in diam., brownish, sacculate, cortex with tubular to round cell lumina, enclosing *Nostoc*. **Apothecia:** terminal, arising on pyriform clavulae, 2(–3) mm in diam.; **hymenium:** 180–225(–240)  $\mu\text{m}$  high; **spores:** vermiform, 10–20(–25)–septate, (75–) 120–150  $\times$  3  $\mu\text{m}$ .

**Chemistry:** Phyllocladia K+ yellow, P+ orange. Atranorin, stictic and norstictic acids and rarely porphyritic acid present.

**Ecology and distribution:** *Microhabitat occupied:* Terricolous; terricolous-rupicolous. In India the species is widely distributed in Arunachal Pradesh, Assam, Meghalaya, Sikkim, Uttarakhand and West Bengal hills. The taxon is also reported from Bhutan, China, Japan and Nepal.

**SPECIMENS EXAMINED:** **INDIA:** **ARUNACHAL PRADESH,** Siang FD, Geling to Kepangla, alt. 1,175 m, on soil over rock, Rolla Sheshagiri Rao 17562 (LWG-BSI); **WEST KAMENG DISTRICT,** Tawang, alt. 4,145 m, on soil, Ashish Kar 04-009736 (LWG); **MEGHALAYA,** on way to Cherrapunji from Shillong, 2 km before Dymfaep, on vertical side of rocks by roadside and on stones, Awasthi 1931 (LWG-AWAS); **UTTARAKHAND, CHAMOLI DISTRICT,** on way from Chopta to Tungnath peak, alt. 3,600–3,900 m, on base of boulders on soil, K. Dange 76.616 (LWG-LWU); **UTTARKASHI DISTRICT,** between Janki Chatti and Yamunotri, alt. 3,000 m, on rocks over soil, Singh and Pher 85615 (LWG); **WEST BENGAL, DARJEELING DISTRICT,** Tiger hill-Senchal lake area, alt. 2,210 m, on soil over rock, D. D. Awsathi 64.110 (LWG-AWAS).

***Stereocaulon pomiferum*** P. A. Duvign. (Fig. 2.32f; Fig. 2.53)

Lejeunia Mem. 14:119. 1956.

**Primary thallus:** granular to squamulose; **pseudopodetia:** 3–5(–9) cm tall, to 3 mm thick at base, subsimple to subcorymbosely branched at apices, grey-brown, decorticate to partially corticate; **phyllocladia:** dense, cylindrical, simple to branched, 1–3(–5) mm long. **Cephalodia:** brownish, 1–2 mm in diam., protosacculate, cortex with tubular to palisade, isodiametric and round cell lumina, enclosing *Nostoc*. **Apothecia:** terminal, arising on pyriform clavulae, 1–3(–5) mm in diam.; **hymenium:** 120–200(–270)  $\mu\text{m}$  high; **spores:** vermiform, 10–22(–30)–septate, (80–)140–180(–220)  $\times$  3.5–4(–4.5)  $\mu\text{m}$ .

**Chemistry:** Phyllocladia K+ yellow, P+ orange-red. Atranorin, stictic and norstictic acids, occasionally porphyritic acid is present.

**Ecology and distribution:** *Microhabitat occupied:* Terricolous; terricolous-rupicolous; muscicolous-terricolous. In India the species is widely distributed in Sikkim, Uttarakhand and West Bengal hills. The species is also reported from Bhutan, China, Hawaii, Japan, Mexico, Nepal, Peru, Taiwan and Venezuela; Africa.

**SPECIMENS EXAMINED:** **INDIA:** SIKKIM, Tsoka-Phithang trek, alt. 3,475 m, on soil, G. P. Sinha 211(BSHC); **UTTARAKHAND, PITHORAGARH DISTRICT,** Lilam to Bugudiyar, en route to Milam glacier, alt. 2,253 m, on soil over rock, S. Joshi 07-010772 (LWG); **RUDRAPRAYAG DISTRICT,** Tungnath Bugyal, alt. 2,850 m, on soil with mosses, Himanshu Rai and Pramod Nag 09-0012219 (LWG); **WEST BENGAL, DARJEELING DISTRICT,** on way from Sandakh-poo to Phalut, alt. 3,600 m, on soil over stones by roadside, Awasthi and Agarwal 67.418, 67.466 (LWG-LWU)-dupl. det. I. M. Lamb 1971.

***Stereocaulon sasaki*** Zahlbr

Zahlbr., Feddes Repert. Spec. Nov. Regni Veg. 33: 48. 1933.

var. *sasaki* (Fig. 2.53)

**Pseudopodetia:** ca. 5 cm tall, 2 mm thick at basal part, sparingly branched, brown, pale tomentose; **phyllocladia:** dense, flattened, digitate-lobate to squamulose, ca. 1 mm long. **Cephalodia:** brown, to 1.5 mm in diam.; cortex poorly developed enclosing *Nostoc*. **Apothecia:** lateral and terminal, 2 mm in diam.; **hymenium:** 70–90 µm high; **spores:** fusiform, 2–3-septate, 12–18 × 3 µm.

**Chemistry:** Phyllocladia K+ yellow, P+ yellow. Atranorin and lobaric acid present.

**Ecology and distribution:** *Microhabitat occupied:* Terricolous. In India the species is reported from Nagaland (Awasthi 2007) and Uttarakhand. Outside India, the species is also reported from China, Indonesia, Japan and Taiwan.

**SPECIMEN EXAMINED:** **INDIA: UTTARAKHAND, ALMORA DISTRICT,** between Bogudiyar and Rilkot, Srivastava 51544 (LWG).

var. *tomentosoides* I. M. Lamb

Lamb, J. Hattori Bot. Lab. 43: 230. 1977.

This variety differs in the subprostrate to dorsiventral habit of **pseudopodetia**, **phyllocladia:** incised and digitate-squamulose; **cephalodia:** subglobose, glaucous grey to brown; apothecia lateral to sublateral, otherwise similar to the type.

**Ecology and distribution:** *Microhabitat occupied:* Terricolous. In India the species is restrictedly distributed to Northern India (Awasthi 2007) and there is no precise locality (Singh and Sinha 2010). The species is also reported from Alaska, Canada, Japan, Nepal, USA and USSR.

**STICTA** Schreb. Ach. (*Lobariaceae*)

Methodus: 275. 1803.

**Thallus:** foliose, dorsiventral, heteromerous, loosely attached, corticated on both surfaces, single to multi-lobed, spreading or stipitate; **lobes:** dichotomously-branched to broad, rounded, irregular; **upper surface:** smooth, wrinkled or ridged, scabrid or tomentose; isidia and soredia present or absent; **cephalodia:** endotrophic present or absent; **photobiont:** green *Trebouxia* or *Myremica* or blue green *Nostoc*; **lower surface:** pale to dark grey, glabrous or tomentose; **cyphellae:** always present. **Apothecia:** hemiangiocarpic, laminal or marginal, sessile to pedicellate; **spores:** colourless, acicular to fusiform, 1–9-septate.

Out of 114 species known from world, 13 species are from India, of which 10 are terricolous.

**Key to the terricolous species of *Sticta*:**

1.	Photobiont a green alga.....	2
1a.	Photobiont a blue green alga.....	5
2.	Thallus isidiate, KC+ red.....	<i>S. praetextata</i>
2a.	Thallus lacking isidia and soredia.....	3
3.	Medulla KC+ pink or red.....	<i>S. nylanderiana</i>
3a.	Medulla KC-.....	4
4.	Cyphellae saucer-shaped, pseudocyphellate at margin, thallus smooth at upper surface, dichotomously branched.....	<i>S. henryana</i>
4a.	Cyphellae saucer shaped lacking pseudocyphellae, thallus tomentose granulose on upper surface.....	<i>S. platyphyloides</i>
5.	Thallus attached with a basal holdfast.....	6
5a.	Thallus lacking basal holdfast, attached by a general lower surface.....	8
6.	Thallus isidiate.....	7
6a.	Thallus not isidiate, monophyllous or polyphyllous.....	<i>S. indica</i>
7.	Lobes rounded with crenate margins.....	<i>S. orbicularis</i>
7a.	Lobes narrow canaliculate, sinuous to notched.....	<i>S. cyphellulata</i>
8.	Thallus sorediate marginally or submarginally.....	<i>S. limbata</i>
8a.	Thallus isidiate.....	9
9.	Thallus ± monophyllous, with rounded lobes.....	<i>S. fuliginosa</i>
9a.	Thallus not monophyllous, upper smooth, isidia marginal spreading to submarginal areas.....	<i>S. weigeli</i>

***Sticta cyphellulata* (Müll. Arg.) Hue (Fig. 2.32g; Fig. 2.53)**

Hue, *Nouv. Arch. Mus. Hist. Nat.*, ser. 4, 3: 99. 1901.

Basionym: *Stictina cyphellulata* Müll. Arg., *Flora* 65: 301. 1882.

Synonyms: *Stictina neocaledonica* Müll. Arg., *Flora* 65: 303. 1882. -*Sticta neocaledonica* (Müll. Arg.) Hue, *Nouv. Arch. Mus. Hist. Nat. Paris*, Ser. 4, 3: 101. 1901.

**Thallus:** stipitate, foliose, firmly attached by holdfast, up to 6 cm long and 2–4 mm wide, dichotomously branched, ± palmate; **lobes:** irregularly imbricate, linear, 0.5–2 cm wide; **upper surface:** pale brown to brown, smooth to slightly rugose, scrobiculate, isidiate; **isidia:** marginal to submarginal, granular, styliform, densely clustered, coralloid to squamiform; **maculae:** minute, white, giving a marbled appearance to thallus when moist; **photobiont:** *Nostoc*; **medulla:** white; **lower surface:** darkening to buff brown, tomentose from margins to centre; **cyphellae:** flask shaped, minute, scattered, often crowded, pin-prick-like, 0.1–0.2 mm, margins prominent, white, swollen. **Apothecia:** absent.

**Chemistry:** Thallus K–, C–, KC–, P–; no secondary metabolites in TLC.

**Ecology and distribution:** *Microhabitat occupied:* Terricolous; terricolous-rupicolous. In India the species is distributed in Kerala, Nagaland, Sikkim and Tamil Nadu while species growing on soil is reported from localities of Kerala and Tamil Nadu. Outside India, the species is also reported from Australia, Malaysia, New Caledonia and Tanzania. *Sticta cyphellulata* shows similarity to *S. filicina* and *S. orbicularis* but they have broad lobes and submarginal to laminal isidia.



**SPECIMENS EXAMINED:** **INDIA:** **KERALA, TRIVENDRUM DISTRICT,** Agasthimalai Biosphere reserve, way to Pongalappara, alt. 1,160 m, on soil over rocks, Biju Haridas 06-014614 (LWG); **TAMIL NADU, PALNI HILLS,** on way to Guanji, alt. 1,829 m, on sandy soil, K.P. Singh 73.57 (LWG-LWU); **NILGIRI HILLS,** Avalanche, Hatchery Shola, alt. 2,134 m, in shady and moist place on ground, K. P. Singh 71.579 (LWG-LWU).

***Sticta fuliginosa* (Hoffm.) Ach. (Fig. 2.32h; Fig. 2.53)**

Acharius, Method. Lich.: 280. 1803.

Basionym: *Lobaria fuliginosa* Hoffm., Deutschl. Fl. 2: 109. 1796.

Synonym: *Stictina fuliginosa* (Hoffm) Nyl., Syn. Lich. 1:347. 1860.

**Thallus:** loosely attached by lower surface, horizontally spreading, monophyllous, membranous, to 10 cm across, deeply incised; **lobes:** rounded, to 6 cm wide; margins, often rolled on lower surface; **upper surface:** grey to brown, scrobiculate, isidiate; **isidia:** granular, coralloid branched and rarely subflattened into phyllidia, darker than thallus; **photobiont:** *Nostoc*; **lower surface:** pale creamish to brownish; **cyphellae:** large urceolate, white. **Apothecia:** 1–3 mm in diam.; **exciple:** thalline; **spores:** fusiform, 1–3-septate, 20–51 × 6–8(–10) µm.

**Chemistry:** Thallus K–, C–, KC–, P–; no secondary metabolites in TLC.

**Ecology and distribution:** *Microhabitat occupied:* Terricolous; terricolous-musciculous. In India the species is distributed in Manipur, Nagaland and Tamil Nadu while species growing on soil is reported from localities of Tamil Nadu. The species is also reported from Australia, Sri Lanka, Thailand, Europe and North and South America.

**SPECIMENS EXAMINED:** **INDIA:** **TAMIL NADU, PALNI HILLS,** Berijam, alt. 2,438 m, on ground, D. D. Awasthi and K. P. Singh 70.333 (LWG-LWU); Kodaikanal, Shenbaganur, below silver cascade to Tiger Shola, alt. 1,676 m, on ground by road surface, D. D. Awasthi and K. P. Singh 70.81 (LWG-LWU); Fairy Falls, alt. 1,829 m, on ground, K. P. Singh 70.1226 (LWG-LWU); **NILGIRI HILLS,** Avalanche, Emerald road, near forest rest house, alt. 2,134 m, on moist soft soil, K. P. Singh 70.355, 71.574 (LWG-LWU).

***Sticta henryana* Müll. Arg. (Fig. 2.32i; Fig. 2.53)**

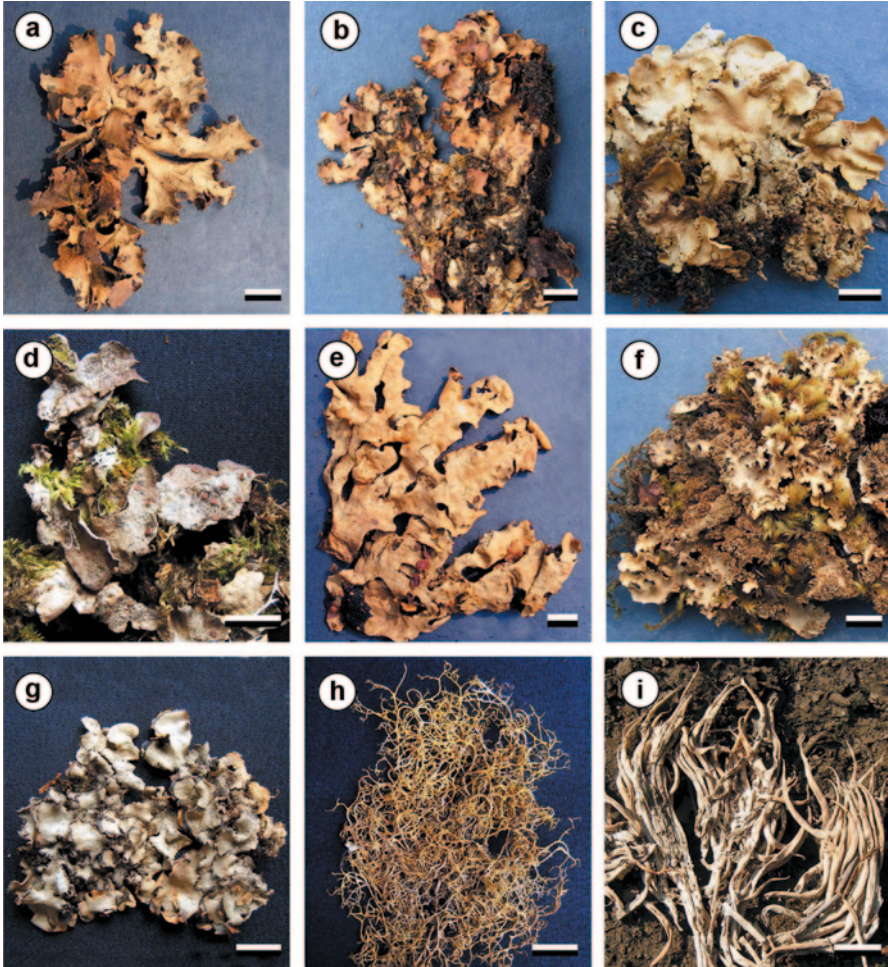
Müll. Arg., Flora 74: 374. 1891.

**Thallus:** horizontally spreading, to 10 cm across, sinuate lobate; **lobes:** 5–17 mm wide; **upper surface:** yellowish-grey to darker, smooth; **lower surface** brownish; **cyphellae:** initially urceolate, 0.5–1.5 mm in diam., becoming saucer shaped, 2–3 mm across with pseudocyphellate-pulverulent margin. **Apothecia:** 6–10 mm in diam.; **spores:** 3–5(–7)-septate, linear fusiform, 40–80 × 5–7 µm.

**Chemistry:** Thallus K–, C–, KC–, P–; no secondary metabolites in TLC.

**Ecology and distribution:** *Microhabitat occupied:* Terricolous. In India the species is distributed in Arunachal Pradesh, Himachal Pradesh, Kerala, Manipur and Uttarakhand while species growing on soil is reported from different localities of Uttarakhand. The taxon is also reported from Bhutan and China.

**SPECIMENS EXAMINED:** **INDIA:** **UTTARAKHAND, CHAMOLI DISTRICT,** Ali Bugyal to Waan, alt. 2,850 m, on soil, Ajay Singh 90320 (LWG); Nanda Devi Biosphere Reserve, NW part, on soil, H. R. Negi L-2504 (LWG); **RUDRAPRAYAG DISTRICT,** between Madmaheshwar to Gondar, alt. 3,000 m, on soil, Ajay Singh 107030 (LWG).



**Fig. 2.33** **a** *Sticta indica* D. Awasthi and Upreti, **b** *S. limbata* (Sm.) Ach., **c** *S. nylanderiana* Zahlbr., **d** *S. orbicularis* (R. Br.) Hue, **e** *S. platyphylloides* Nyl., **f** *S. praetextata* (Räsänen) D. D. Awasthi, **g** *S. weigelii* (Ach.) Vain., **h** *Teloschistes flavicans* (Sw.) Norman, **i** *Thamnolia vermicularis* var. *vermicularis* (Sw.) Ach. ex Schaer. Scale in **a**, **b**, **c**, **d**, **e**, **f**, **g**, **h**, **i** = 10 mm

***Sticta indica*** D. Awasthi and Upreti (Fig. 2.33a; Fig. 2.53)

Nova Hedwigia 90:1–2. 251–255. 2010.

**Thallus:** foliose, palmate, form a basal holdfast, stalked below, 3–7 mm wide; **lobes:** irregularly branched monophyllous to polyphyllous, 1–4 cm wide, broadly rounded to elongate and lacinate; **margins:** entire; **upper surface:** dark brown; **photobiont:** a *Nostoc*; **lower surface:** pale brown to brown black, wrinkled, tomentose; **cyphellae:** frequent, scattered, prominent, rounded to elliptical, up to 1.5 mm

in diam., pale yellow. **Apothecia** common, scattered, solitary, constricted at base, marginal to laminal 1.0–3 mm in diam. **disc:** shining, epruinose, dark brown to black; **asci:** clavate, 65–75 × 15–18 µm; **spores:** broadly ellipsoid with pointed apices, colourless, 1–3-septate, 30–42 × 5.5–8 µm in size.

**Chemistry:** Thallus K–, C–, KC–, P–; no secondary metabolites in TLC.

**Ecology and distribution:** *Microhabitat occupied:* Terricolous-rupicolous. In India the species is distributed in Uttarakhand and West Bengal hills while species growing on soil is reported from single locality of Uttarakhand. The species is endemic to the Himalayas.

**SPECIMEN EXAMINED:** INDIA: UTTARAKHAND, RUDRAPRYAG DISTRICT, Near Chopta, alt. 2,700 m, on soil over rocks in shady place, D. K. Upreti and B. Arya 06-004699 (LWG).

***Sticta limbata* (Sm.) Ach. (Fig. 2.33b; Fig. 2.53)**

Acharius, Method. Lich.: 280. 1803.

**Basionym:** *Lichen limbatus* Sm. in Sm. and Sowerby, Engl. Bot. 16: tab.1104. 1803.

**Thallus:** foliose, monophyllous, reniform to irregularly spreading, loosely attached at one point, occasionally suberect, 1–4(–6) cm in diam.; **lobes:** broadly rounded to sub-irregular with sinuous; **upper surface:** slate gray to gray-brown suffused red-brown when moist, pale gray to dull gray-brown or red-brown when dry, undulate, glossy, erose-soresiate; **soredia:** coarsely granular, gray-blue, in erose, linear marginal soralia or in scattered, rounded, pustular laminal soralia usually close to lobe margins; **photobiont:** *Nostoc*; **lower surface:** brown; **cyphellae:** sparse, widely scattered, rounded to irregular 0.5–1.5(–2) mm in diam., sunken in tomentum.

**Chemistry:** Thallus K–, C–, KC–, P–; no secondary metabolites in TLC.

**Ecology and distribution:** *Microhabitat occupied:* Terricolous; terricolous-rupicolous. In India the species is distributed in Himachal Pradesh, Kerala, Manipur, Meghalaya, Sikkim, Tamil Nadu and Uttarakhand while species growing on soil is reported from different localities of Kerala, Tamil Nadu and Uttarakhand. In world, the species is also reported from Bhutan, Australasia, East Africa and South America.

**SPECIMENS EXAMINED:** INDIA: KERALA, MUNNAR, Mattupetty road, alt. 1,580 m, on soil, Biju Haridas 06-014777 (LWG); TAMIL NADU, NILGIRI HILLS, avalanche, along roadside in moist place, alt. 2,134 m, on ground, K. P. Singh 71.799 (LWG-LWU); UTTARAKHAND, PITHORAGARH DISTRICT, Lilam to Bogudiyar en route to Milam Glacier, on soil over rock, S. Joshi 07-010703 (LWG); Dharchula, Sobhla, opposite in the mountain of village Vatan, alt. 2,000 m, on soil, Upreti and Hariharan 202062 B (LWG); UTTARKASHI DISTRICT, between Bhatwari and Gangrani, on way to Gangotri, alt. 1,860 m, on soil, Ajay Singh 97272 (LWG); between Bhatwari and Gangrani, on soil, Ajay Singh s.n. (LWG).

***Sticta nylanderiana* Zahlbr. (Fig. 2.33c; Fig. 2.53)**

Zahlbruckner, Cat. Lich. Univ. 3: 356. 1925.

**Basionym:** *Sticta damaecornis* \*s. *platyphylla* Nylander, Syn. Lich. 1:357. 1860, non Massalongo ex anno 1853.

**Thallus:** irregularly spreading, ± loosely attached to the substratum, thick coriaceous, up to 14 cm across, lobes 3–30 mm wide, sinuate lobate; **upper surface:** yellowish grey to grey, smooth; **lower surface:** pale brown to brown, cyphellate; **photobiont:** a green alga; **cyphellae:** saucer shaped, 0.3–2(6) mm in diam.; **endotrophic cephalodia:** with *Nostoc* present in lower part of medulla. **Apothecia:** laminal to submarginal, sessile to pedicellate, 2–7 mm in diam., **margin:** entire to crenate, **disc:** brown to dark brown, concave to flat, epruinose; **spores:** colourless, acicular, 3–7-septate,  $42\text{--}81 \times 7\text{--}8 \mu\text{m}$ .

**Chemistry:** Cortex: K<sup>+</sup> yellow; medulla: K<sup>-</sup>, KC<sup>+</sup> pink to reddish, P<sup>-</sup>. Atranorin in cortex, gyrophoric acid and unknown substance in medulla.

**Ecology and distribution:** *Microhabitat occupied:* Terricolous; terricolous-muscicolous. In India the species is distributed in Himachal Pradesh, Manipur, Nagaland, Sikkim, Tamil Nadu and Uttarakhand while species growing on soil is reported from localities of Himachal Pradesh and Uttarakhand. The taxon is also reported from Bhutan, Nepal and China.

**SPECIMENS EXAMINED:** **INDIA:** HIMACHAL PRADESH, KULLU DISTRICT, Greater Himalayan National Park, Jubkutar Thach, alt. 2,900 m, on soil in moist places, D. K. Upreti L65182 B (LWG); UTTARAKHAND, CHAMOLI DISTRICT, Ali Bugyal to Waan, alt. 3,000 m, on soil along with mosses, Ajay Singh 91109 (LWG); PITHORAGARH DISTRICT, Dharchula, Sobhla, in forest above Kartu village, alt. 3,150 m, on ground in humas, Upreti and Hariharan 202218 (LWG).

***Sticta orbicularis*** (R. Br.) Hue (Fig. 2.33d; Fig. 2.53)

Hue, Ann. Jard. Bot. Buitenzorg 17: 193. 1901

Basionym: *Sticta filicina* var. *orbicularis* R. Br. in Meyen and Flot., Actorum Acad. Caes. Leop. Carol. Nat. Cur. 14:215. 1843.

Synonym: *Sticta filicina* sensu Hue, Nouv. Arch. Mus. Hist. Nat. Paris, ser. 4, 3: 150. 1901.

**Thallus:** stipitate to substipitate, to 5 cm across; **lobes:** rounded, to 10 mm wide; **upper surface:** brown to darker, isidiate; **isidia:** marginal to sub-marginal and along cracks in lamina, granular to coralloid or phyllidiate; **photobiont:** *Nostoc*; **medulla:** white; **lower surface:** brown to brown black, thick-veined; **cyphellae:** to 1.5 mm wide, urceolate. **Apothecia:** rare, to 2.5 mm in diam.; **spores:** colourless to pale brown, fusiform, 1–3-septate,  $(21\text{--}) 30\text{--}60 \times 6\text{--}10\text{--}(12) \mu\text{m}$ .

**Chemistry:** Thallus K<sup>-</sup>, C<sup>-</sup>, KC<sup>-</sup>, P<sup>-</sup>; no secondary metabolites in TLC.

**Ecology and distribution:** *Microhabitat occupied:* Terricolous. In India the species is distributed in Arunachal Pradesh, Kerala, Nagaland, Sikkim and Tamil Nadu while species growing on soil is reported from different localities of Tamil Nadu. The taxon is also reported from Taiwan; South East America.

**SPECIMENS EXAMINED:** **INDIA:** TAMIL NADU, PALNI HILLS, Kodaikanal, Shenbaganur, near silver cascade, alt. 1,829 m, on ground, by roadside towards stream, D. D. Awasthi and K. P. Singh 70.79 (LWG-LWU); Tiger Shola, alt. 1,676 m, on ground by roadside, D. D. Awasthi and K. P. Singh 70.136 (LWG-LWU).

*Sticta platyphylloides* Nyl. (Fig. 2.33e; Fig. 2.53)

Nylander, Bull. Soc. Bot. France 34: 22. 1887.

**Thallus:** foliose, adnate, horizontally spreading, 6–15(–20) cm across, loosely attached to the substratum; **margins:** rounded to incised; **upper surface:** yellowish grey to brownish yellow, marginal area tessellate-tomentose; **lower surface:** light to dark, cyphellate; **cyphellae:** saucer-shaped, 2–3 mm in diam.; **medulla:** white; **photobiont:** a green alga; **endotrophic cephalodia:** with *Nostoc* is present in medulla. **Apothecia:** marginal to sub-marginal, pedicellate, up to 7 mm in diam.; **asci:** cylindrical; **spores:** acicular, transversely 1–5-septate,  $35\text{--}73 \times 3\text{--}7 \mu\text{m}$ .

**Chemistry:** Cortex: K+ yellow; medulla: K–, C–, KC–, P–.

**Ecology and distribution:** *Microhabitat occupied:* Terricolous. In India the species is distributed in Arunachal Pradesh, Himachal Pradesh, Manipur, Nagaland, Sikkim, Tamil Nadu, Uttarakhand and West Bengal hills while species growing on soil is reported from different localities of Uttarakhand. Outside India, the species is also reported from Bhutan, China, Nepal and Taiwan.

**SPECIMENS EXAMINED:** **INDIA:** **UTTARAKHAND,** CHAMOLI DISTRICT, between Bagrigad and Waan, alt. 2,850 m, on soil, Ajay Singh 90359 (LWG); **RUDRAPRAYAG DISTRICT,** Madmaheshwar to Gondar, alt. 3,000 m, on soil, Ajay Singh 106996 (LWG).

*Sticta praetextata* (Räsänen) D. D. Awasthi (Fig. 2.33f; Fig. 2.53)

In M. Joshi and D. Awasthi, Biol. Mem. 7(2): 185. 1982.

Basionym: *Sticta platyphylla* var. *praetextata* Räsänen, Arch. Soc. Zool. Bot. Fenn. 'Vanamo' 6(2): 84. 1952.

**Thallus:** adnate, horizontally spreading, to 12 cm across, coriaceous; **lobes:** 7–30 mm wide, margins repeatedly incised lacinulate to squamiform-isidiose (or phyllidiate); **upper surface:** grey to brown; **lower surface:** brownish; **photobiont:** a green alga; **medulla:** white; **lower surface:** bearing **cyphellae:** 0.7–2 mm wide, saucer shaped. **Apothecia:** not known.

**Chemistry:** Upper cortex K+ yellow; medulla K–, C–, KC+ pink-red, P–. Atranorin in cortex and gyrophoric acid, and an unknown substance present in medulla.

**Ecology and distribution:** *Microhabitat occupied:* Terricolous, terricolous-rupicolous. In India the species is distributed in Arunachal Pradesh, Himachal Pradesh, Sikkim and Uttarakhand while species growing on soil is reported from localities of Sikkim and Uttarakhand. Outside India, the species is also reported from Bhutan and Nepal.

**SPECIMENS EXAMINED:** **INDIA:** **SIKKIM,** NORTH **SIKKIM,** above Lachung, Shingring-tang area, alt. 2,900 m, on rocks over soil, D. K. Upreti, S. Chatterjee, P. K. Divakar 04-004300 (LWG); **UTTARAKHAND,** CHAMOLI DISTRICT, Valley of flowers, alt. 3,150 m, on soil, Ajay Singh, 85875 (LWG); Valley of flowers, alt. 3,300 m, on soil, Ajay Singh, 85877 (LWG).

*Sticta weigelii* (Ach.) Vain. (Fig. 2.33g; Fig. 2.53)

Vainio, Acta Soc. Fauna Fl. Fenn. 7:189. 1890.

Basionym: *Sticta damaecornis*  $\beta$  *weigelii* Ach., Lichenogr. Universalis: 446. 1810.

**Thallus:** adnate, to 12 cm across; lobes rounded, incised; margins notched or torn, densely isidiate; **upper surface:** grey to chestnut brown, isidiate submarginal and along cracks in lamina; **isidia:** granular to cylindrical, coralloid, grey-brown; **medulla:** white; **photobiont:** *Nostoc*; **lower surface:** brown to black; **cyphellae:** 0.5–1.5(–3) mm wide, white to fawnish.

**Chemistry:** Thallus K–, C–, KC–, P–; no secondary metabolites in TLC.

**Ecology and distribution:** *Microhabitat occupied:* Terricolous. In India the species is distributed in Arunachal Pradesh, Assam, Kerala, Manipur, Meghalaya, Nagaland, Sikkim, Tamil Nadu and Uttarakhand while species growing on soil is reported from localities of Kerala and Tamil Nadu. Outside India, the species is also reported from Australia, Bhutan, Nepal and Sri Lanka; tropical and subtropical regions of the Africa and America.

**SPECIMENS EXAMINED: INDIA: KERALA, IDUKKI DISTRICT,** Kallar Munnar Hills, alt. 8,400 m, on soil, Ajay Singh and M. Ranjan 103061 (LWG); **TAMIL NADU, NILGIRI HILLS,** Avalanche, Emerald road, along roadside, near forest rest house, alt. 2,134 m, on red soil in moist place, K. P. Singh 71.354, 71.356, 71.572 (LWG-LWU); **MADURAI,** below SH College, Shenbaganur along Old Ghat road, alt. 1,783 m, on ground, D. D. Awasthi 4366, 4369 A (LWG-AWAS); **PALNI HILLS,** Kodaikanal, Pambampuram, alt. 2,286 m, on ground, K. P. Singh 70.567 (LWG-LWU); Berijam, alt. 2,438 m, on ground, D. D. Awasthi and K. P. Singh 70.328 (LWG-LWU); **TIRUNELVELI DISTRICT,** Pothigaimalai Hills, Courtallam, alt. 1,200 m, on soil, A. Singh and M. Ranjan 103002, 103013 (LWG).

### **TELOSCHISTES** Norm. (*Teloschistaceae*)

Norman, *Nyt. Mag. Naturvidensk.* 7:228. 1853.

**Thallus:** subfruticose to fruticose, flattened dorsiventral to ± cylindrical, terete, branched, often with marginal fibrils or cilia; **upper surface:** yellow to orange (K+ purple). Thallus heteromerous, corticated on both or on all surfaces; cortex composed of longitudinally oriented hyphae; **photobiont:** a green alga (*Trebouxia*); **medulla:** white. **Apothecia:** sessile or pedicellate, lecanorine; **disc:** yellow or orange; **hypothecium:** colourless; **paraphyses:** simple, capitate; **asci:** 8-spored; **spores:** colourless, polaribilocular.

Out of the 33 species known from the world, 1 terricolous species is known from India.

### *Teloschistes flavicans* (Sw.) Norman (Fig. 2.33h; Fig. 2.54)

Norman, *Nyt. Mag. Naturvidensk.* 7: 229.1853.

Basionym: *Lichen flavicans* Sw., *Nov. Gen. Sp. Pl.*: 147. 1788.

**Thallus:** fruticose, erect to pendent; irregularly branched, forming entangled clumps; **branches:** terete, to 0.5 mm thick; **surface:** yellow to orange-red, smooth to scabrid; soralia orbicular to elongate; **soredia:** white, granular; **fibrils:** black tipped, scattered. **Apothecia:** absent.

**Chemistry:** Thallus K+ purple-violet. Parietin present.

**Ecology and distribution:** *Microhabitat occupied:* Terricolous. In India the species is distributed in the regions of Karnataka, Kerala and Tamil Nadu while the species growing on soil is reported from single locality of Tamil Nadu and rarely ter-

ricolous. Earlier it was reported from Sri Lanka and widely distributed in warm subtropical to temperate regions of the world. The species is cosmopolitan in distribution.

**SPECIMEN EXAMINED:** **INDIA: TAMIL NADU, PALNI HILLS,** Kodaikanal, Shenbaganur, near silver cascade, alt. 1,829 m, on ground by road surface, D. D. Awasthi and K. P. Singh 70.54 (LWG-LWU).

**THAMNOLIA** Ach. ex Schaer. (*Icmadophilaceae*)

Enum. Crit. Lich. Eur.: 243. 1850..

**Thallus:** fruticose, podetoid, erect or prostrate, attached to substratum by few rhizines; **podetia:** cylindrical or vermiform with apically tapering ends, simple or furcate; **surface:** whitish; **photobiont:** a green alga. **Apothecia:** not known.

Out of 4 species known from world, 1 terricolous species is known from India

***Thamnolia vermicularis*** (Sw.) Ach. ex Schaer.

The following two varieties are identical in morphology but different chemically. Schaerer, Enum. Critic. Lich. Europ.: 243. 1850.

Basionym: *Lichen vermicularis* Sw., Meth. Musc.: 37.1784.

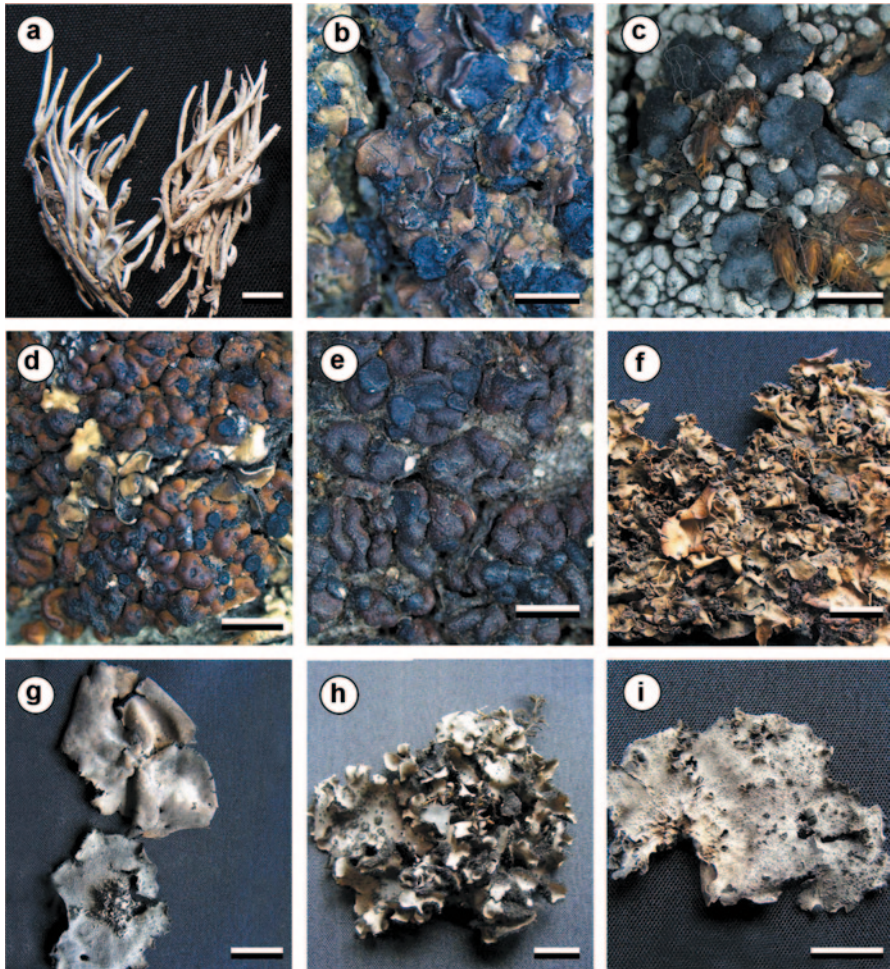
var. ***vermicularis*** (Fig. 2.33i; Fig. 2.54)

**Thallus:** fruticose, podetia like, attached basally, cylindrical, to 5 cm tall, 2 mm thick at base, tapering, and centrally hollow; **surface:** milky white to greyish, smooth.

**Chemistry:** Thallus: K+ deep yellow, P+ deep orange, to reddish-orange later. Thamnic and decarboxythamnic acids present.

**Ecology and distribution:** *Microhabitat occupied:* Terricolous, terricolous-rupicolous; terricolous-muscicolous. In India the species is exclusively terricolous and widely distributed in Arunachal Pradesh, Sikkim and Uttarakhand. Outside India, the species is also reported from Nepal; throughout alpine regions of the world.

**SPECIMENS EXAMINED:** **INDIA: ARUNACHAL PRADESH, WEST KAMENG DISTRICT,** Tawang, alt. 4,000 m, on soil with mosses, Jaishree Rout s.n. (LWG); Sela Pass, alt. 4,221 m, on soil, D. K. Upreti, U. Dubey, R. Khare and G. K. Mishra 08-009398 (LWG); **SIKKIM, EAST SIKKIM,** alt. 3,962 m, on ground with mosses, D. D. Awasthi 87 (LWG-AWAS); **NORTH SIKKIM,** Sebula base camp, east surface, alt. 4,960 m, on soil, G. P. Sinha 1246 (LWG); Chubuk, above Thangu, alt. 4,100 m, on soil, D. K. Upreti, S. Chatterjee, P. K. Divakar 04-003938 (LWG); **UTTARAKHAND, BAGESHWAR DISTRICT,** zero mile to Pindari glacier, on the ridge of moraine, alt. 3,658 m, on ground, D. D. Awasthi 7692 (LWG-AWAS); above Phurkiya towards Pindari glacier, alt. 3,581 m, on hard ground among mosses, D. D. Awasthi and A. M. Awasthi 789 (LWG-AWAS); above Phurkiya to Mirtoli, alt. 3,505 m, on ground in association of *Stereocaulon*, D. D. Awasthi 7791 (LWG-AWAS); **CHAMOLI DISTRICT,** near Roopkund, alt. 4, 572 m, on ground, Swami Parwanand 4023 (LWG-AWAS); Kedar-nath east of Kalbhairav, alt. 3,600 m, on soil in crevices of rocks, S. L. Kapoor and party 70588 (LWG); Badrinath, Mana village, towards Vasudhara glacier, on soil, S. M. Singh 03-001856 (LWG); on way of Nanda Devi Biosphere reserve, Srenikhal, alt. 3,700 m, on soil, S. Rawat 08-011270 (LWG); **UTTARKASHI DISTRICT,** Gomukh area, right bank, third and fourth moraine, alt. 3,871 m, on soil, D. D. Awasthi and S. R. Singh 8443 (LWG-AWAS); Tapovan, 5 km away from Gomukh, alt. 4,350 m, on soil, B. Dutt and Brij s.n. (LWG); Gangotri to Chirwasa, alt. 3,500 m, on soil over rocks, S. Chatterjee and P. K. Divakar 02-000241 (LWG).



**Fig. 2.34** **a** *Thamnolia vermicularis* var. *subuliformis* (Ehrh.) Schaer., **b** *Toninia cinereovirens* (Schaer.) Massal., **c** *T. sedifolia* (Scop.) Timdal, **d** *T. tristis* ssp. *asiae-centralis* (Magn.) Timdal, **e** *T. tristis* ssp. *scholanderi* (Lyng.) Timdal, **f** *Tuckneraria laureri* (Kremp.) Randle and A. Thell, **g** *Umbilicaria decussata* (Vill.) Zahlbr., **h** *U. indica* Frey, **i** *U. leiocarpa* DC. Scale in **b**, **c**, **d**, **e**=2 mm; in **a**=5 mm; in **f**, **g**, **h**, **i**=10 mm

var. *subuliformis* (Ehrh.) Schaer. (Fig. 2.34a; Fig. 2.54)

Schaerer, Enum. Critic. Lich. Eur.: 243.1850.

Basionym: *Lichen subuliformis* Ehrh., Beitr. Natur Kunde 3: 82. 1788.

Synonym: *Thamnolia subvermicularis* Asahina, J. Jap. Bot. 13:317. 1937.

**Chemistry:** Thallus K<sup>+</sup> pale yellow; P<sup>+</sup> persistently yellow, UV<sup>+</sup>. Baeomycesic and squamatic acids present.



**Ecology and distribution:** *Microhabitat occupied:* Terricolous, terricolous-rupicolous. In India the species is exclusively terricolous and distributed in Sikkim (Awasthi 2007) and Uttarakhand. Outside India, the species is also reported from Bhutan and Nepal; throughout alpine regions of the world.

**SPECIMENS EXAMINED: INDIA: UTTARAKHAND, CHAMOLI DISTRICT,** Badrinath, between Vasudhara and Bhagirathi glacier, alt. 4,200 m, on soil, D. K. Upreti 202393 (LWG); **UTTARKASHI DISTRICT,** Gomukh area, right bank, second moraine, alt. 3,901 m, on rocky soil, D. D. Awasthi and S. R. Singh 8407 (LWG-AWAS); Gomukh area, right bank, fifth moraine, alt. 3,840 m, on soil, D. D. Awasthi and S. R. Singh 8535 (LWG-AWAS); Gomukh area, right bank, third and fourth moraine, alt. 3,840 m, on soil, D. D. Awasthi and S. R. Singh 8444, 8446 (LWG-AWAS).

**TONINIA** Massal. (*Catillariaceae*)

Ric. Auton. Lich. Crost.: 107. 1852.

**Thallus:** squamulose, warty, globulose-blistered to subsquamulose; **lower surface:** attached by rhizinae or hyphae; **photobiont:** a green alga (*Protococcus* or *Trentepohlia*). **Apothecia:** round, sessile, dark to black, leciadiene; **asci:** 8-spored, thin walled; **paraphyses:** simple, capitate, thickened; **spores:** colourless, 1-7-septate, thin walled, elongate, ellipsoid to bacillar, cells cylindrical.

Out of 82 species known from world, 3 species are from India, of them 3 are terricolous.

**Key to the terricolous species of *Toninia*:**

- 
- 1. Epithecium grey, K+ violet and N+, squamules weakly convex to bullate, but not vertically flattened or imbricate..... *T. sedifolia*
  - 1a. Epithecium green or brown, K- and/or N- ..... 2
  - 2. Thallus with punctiform impressions and pores, squamulose, dark brown, epruinose,..... *T. tristis*
  - 2a. Thallus without punctiform impressions and pores, brown to dark brown ..... *T. cinereovirens*
- 

***Toninia cinereovirens*** (Schaer.) Massal. (Fig. 2.34b; Fig. 2.54)

Massalongo, Ric. auton. lich. crost.: 107. 1852.

Basionym: *Lecidea cinereovirens* Schaer., Lich. helv. spicil. 3: 109.1828.

**Thallus:** squamulose, indeterminate, squamules upto 3 mm in diam., orbicular to elongated, often deeply lobed, weakly concave to weakly convex; **upper surface:** medium brown to dark brown, epruinose, dull to slightly shiny; margin: usually dark grey; **upper cortex:** 60–100 µm thick; **lower cortex:** poorly developed. **Apothecia:** up to 1 mm in diam., plane to weakly convex, indistinctly marginate, epruinose to faintly pruinose; **epihymenium:** 10–20 µm high, olivaceous brown to bright green; **hymenium:** 60–70 µm high, hyaline; **paraphyses:** straight, sparingly branched, thin walled; **asci:** 8-spored; **spores:** hyaline, ellipsoid to bacilliform, 1–3-septate, 13–30 × 3–4.5 µm.

**Chemistry:** Thallus K-, C-, P-. Epihymenium K-, N+ violet, proper exciple K-, N-. TLC: No chemicals.

**Ecology and distribution:** *Microhabitat occupied:* Terricolous-rupicolous. The species is distributed in Sikkim and Jammu and Kashmir while species growing on

soil is reported from single locality of Jammu and Kashmir. Outside India, the species is also reported from Nepal, Kenya, North America, Central Europe.

**SPECIMEN EXAMINED: INDIA: JAMMU AND KASHMIR, SRINAGAR**, Baltal, alt. 2,700 m, on rocks over soil, A. Singh and D. K. Upreti 13914 (LWG).

***Toninia sedifolia*** (Scop.) Timdal (Fig. 2.34c; Fig. 2.54)

Opera Bot. 110: 93. 1991. [1992]

Basionym: *Lichen sedifolius* Scop., Fl. carniol., ed. 2, 2: 395. 1772.

Synonym: *Toninia coeruleonigricans* auct., non (Leightf.) Th. Fr.: sensu D. D. Awasthi, Beih. Nova Hedwigia 17: 123. 1965.

**Thallus:** squamulose; **squamules:** up to 3 mm diam., scattered to adjacent or irregularly imbricate, rounded or elongated, weakly convex to bullate; **upper surface:** olivaceous green to grayish green or olivaceous brown to grayish brown, thinly pruinose, dull or faintly shiny, smooth or sometimes with a few shallow fissures, lacking pores and pseudocyphellae; **upper cortex:** up to 60  $\mu\text{m}$  high, containing calcium oxalate crystals; **margin:** concolorous with upper surface or white. **Apothecia:** up to 3 mm diam., plane and marginate when young, later convex and immarginate, epruinose or faintly pruinose or densely pruinose; **asci:** clavate, 8-spored; **spores:** colourless, 2-celled, elongate-fusiform, 14–18  $\times$  3–4  $\mu\text{m}$ .

**Chemistry:** Thallus K<sup>-</sup>, C<sup>-</sup>, KC<sup>-</sup>, P<sup>-</sup>; no secondary metabolites in TLC.

**Ecology and distribution:** *Microhabitat occupied:* Terricolous-rupicolous; terricolous-muscicolous. The species is distributed in Himachal Pradesh and Jammu and Kashmir while species growing on soil is reported from different localities of Jammu and Kashmir. Widespread in all continents except Antarctica. Cosmopolitan in distribution.

**SPECIMENS EXAMINED: INDIA: JAMMU AND KASHMIR, ANANTNAG DISTRICT**, Baltal, alt. 2,700 m, on rock over soil, A. Singh and D. K. Upreti 13914 (LWG); **SRINAGAR**, Shankaracharya Hill near the temple, alt. 1,828.8 m, on ground among mosses, D. D. Awasthi 2652, 13914 (LWG-AWAS).

***Toninia tristis*** (Th. Fr.) Th. Fr.

Lich. Scand. (Uppsala) 1: 341. 1874.

Basionym: *Lecanora tristicolor* Th. Fr., Lich. Scand. (Uppsala) 1: 269.1871.

**subsp. *asiae-centralis*** (Magn.) Timdal (Fig. 2.34d; Fig. 2.54)

Opera Botanica 110: 112. 1991.

Basionym: *Lecidea asiae-centralis* Magnusson, Lich. cent. Asia: 55.1940.

**Thallus:** squamulose, indeterminate, squamules upto 2(–3) mm in diam., scattered to contiguous, usually bullate; **upper surface:** castanaceous brown to dark brown, dull or shiny, smooth or with deep fissures in the cortex; **margins:** concolorous with upper surface. **Apothecia:** up to 1.5(–4 mm) in diam., plane to weakly convex, marginate to immarginate; **asci:** 8-spored; **spores:** hyaline, narrowly ellipsoid to fusiform, 1-septate, 12.5–19  $\times$  3.5–5.5  $\mu\text{m}$ .

**Chemistry:** Thallus K<sup>-</sup>, C<sup>-</sup>, P<sup>-</sup>. Epithymenium K<sup>-</sup>, N<sup>+</sup> violet. Hypothecium K<sup>+</sup> red or K<sup>-</sup>. Proper exciple K<sup>-</sup>, N<sup>-</sup> or N<sup>+</sup> violet. Triterpenes at R<sub>f</sub> class 5 (similar to Chemotype 4 of Timdal 1991).

**Ecology and distribution:** *Microhabitat occupied:* Terricolous; terricolous-muscicolous. In India the species is exclusively terricolous and distributed in Jammu and Kashmir and Uttarakhand. Outside India, the species is also reported from Northern Hemisphere, Peru, China, Nepal.

**SPECIMENS EXAMINED:** **INDIA:** JAMMU AND KASHMIR, LEH DISTRICT, Ladak Yeru, alt. 3,600 m, on soil among mosses, D. K. Upreti and S. Chatterjee 03-001792 B (LWG); UTTARAKHAND, CHAMOLI DISTRICT, Badrinath, alt. 3,900 m, on soil, D. K. Upreti 202365 (LWG); way to Vashundhara from Mana, alt. 3,340 m, on soil, D. K. Upreti and S. Nayaka 07-010159 (LWG).

**subsp. *scholanderi*** (Lynge) Timdal (Fig. 2.34e; Fig. 2.54)

Opera Botanica 110: 115. 1991.

Basionym: *Lecidea scholanderi* Lynge, Skr. Svalbard Ishavet 81: 47. 1940.

**Thallus:** squamulose, indeterminate, squamules up to 2(–3) mm in diam., scattered to contiguous, bullate horizontally flattened; **upper surface:** castaneous brown to dark brown. **Apothecia:** up to 1.5(–4) mm in diam., plane to weakly convex, distinctly marginate to immarginate; **paraphyses:** straight, sparingly branched, thin walled; **asci:** 8-spored; **spores:** hyaline, simple, narrowly ellipsoid, 9–1 5.5 × 3.5–5 μm.

**Chemistry:** Thallus K–, C–, P–. Epithemium K–, N+ violet. Hypothecium K–. Proper exciple K–, N– or N+ violet. Triterpenes at R<sub>f</sub> class 4 and 4–5 (similar to Chemotype 3 of Timdal 1991).

**Ecology and distribution:** *Microhabitat occupied:* Terricolous. In India the species is exclusively terricolous and restrictedly distributed in the Western Himalayas, Uttarakhand. Outside India, the species is also reported from Greenland, the Rocky Mountains and Nepal.

**SPECIMENS EXAMINED:** **INDIA:** UTTARAKHAND, CHAMOLI DISTRICT, Badrinath, between Vasudhara and Bhagirathi glacier, alt. 4,000 m, on soil, D. K. Upreti L13201 (LWG); alt. 3,900 m, on soil, D. K. Upreti 202365 (LWG).

**TUCKNERARIA** Randl. and Thell (*Parmeliaceae*)

Randlane and al., Acta Bot. Fenn. 150:144. 1994.

**Thallus:** foliose, large, loosely adnate; **lobes:** ciliate at margins; **upper surface:** yellow, yellow-green to grey, with or without soredia and isidia; **photobiont:** a green alga (*Trebouxia*); **medulla:** white; **lower surface:** rhizinate and pseudocyphellate. **Apothecia:** marginal, rounded or reniform, nephromoid; **disc:** brown; **asci:** with small tholus, broad ocular chamber and axial body, 8-spored; **spores:** colourless, simple, globose to subglobose. **Pycnidia:** usually marginal; **pycnoconidia:** bifusiform (dumbell shaped). Usnic acid present or absent in upper cortex.

Out of 6 species known from world, 2 species are known from India, of which 1 is terricolous.

***Tuckneraria laureri*** (Kremp.) Randlane and A. Thell (Fig. 2.34f; Fig. 2.54)

In Randlane, Saag, Thell and Kärnefelt, Acta Bot. Fenn. 150: 149. 1994.

Basionym: *Cetraria laureri* Kremp., Flora 34: 673. 1851.

Synonym: *Nephromopsis laureri* (Kremp.) Kurok., J. Jap. Bot. 66: 156. 1991.

**Thallus:** adnate, to 5 cm across, deeply lobed; **lobes:** to 4 mm wide; **upper surface:** yellowish-brown; margins soraliolate and minute, black fibrils present in non-soraliolate parts; **soredia:** farinose to granular; **lower surface:** pale brown, rhizinate, pseudocyphellate; **pseudocyphellae:** white. **Apothecia:** absent.

**Chemistry:** Medulla K<sup>-</sup>, C<sup>-</sup>, KC<sup>-</sup>, P<sup>-</sup>. Lichesterinic and protolichesterinic acids present.

**Ecology and distribution:** *Microhabitat occupied:* Terricolous. In India the species is distributed in Himachal Pradesh, Sikkim and Uttarakhand while species growing on soil is reported from single locality of Sikkim. Outside India, the species is also reported from Bhutan, China, Japan, Mongolia, Nepal and Russia; Central Europe; South America.

**SPECIMEN EXAMINED:** **INDIA:** SIKKIM, NORTH SIKKIM, Yangdi, above Thangu, alt. 4,250 m, on soil, D. K. Upreti, S. Chatterjee and P. K. Divakar 04-003967 B (LWG).

### UMBILICARIA Hoffm. (*Umbilicariaceae*)

Descr. Pl. Cl. Crypt. 1(1): 8. 1789.

**Thallus:** foliose, umbilicate, monophyllous or polyphyllous; **upper surface:** pale grey, brown to brown-black, areolate; **margins:** entire or incised; with or without isidia, soredia, phyllidia, fibrils or lobules; **lower surface:** pinkish, pale brown, brown to black, smooth to areolate, lacunose-verrucose; **rhizinomorphs:** branched and often with simple to multicelled thallospores; **photobiont:** a green alga (Protococoid); **medulla:** narrow, white. **Apothecia:** laminal, lecideine; **margin:** carbonaceous; **disc:** non gyrose with central protruding sterile tissue (leiodisc), irregularly scattered gyrose (omphalodisc), radially gyrose (actinodisc) or concentrically gyrose (gyrodisc); **asci:** 8-spored; **spores** colourless, becoming brown when mature, simple or muriform. **Pycnidia:** laminal; **pycnocnidia:** short, cylindrical.

Out of 97 species known from the world, 12 are from India, 4 of them are terricolous.

#### Key to the terricolous species of *Umbilicaria*:

1.	Lower surface with rhizinomorphs .....	2
1a.	Lower surface lacking rhizinomorphs .....	3
2.	Upper surface brown, smooth, epruinose, lower surface with simple to irregularly branched rhizinomorphs; apothecia initially omphalodiscus, later gyrodiscus .....	<i>U. indica</i>
2a.	Upper surface greyish to whitish pruinose, finely fissured, lower surface grey brown to black, with cylindrical and club-shaped, lumpy rhizinomorphs, apothecia rare, gyrodiscus.....	<i>U. vellea</i>
3.	Upper surface plane to undulate, weakly reticulate-ribbed near margins, lower surface brown, apothecia leiodiscus .....	<i>U. leiocarpa</i>
3a.	Upper surface reticulately folded and ridged, grey to brown-black, lower surface black up to the margin, apothecia rare, gyrodiscus .....	<i>U. decussata</i>

***Umbilicaria decussata*** (Vill.) Zahlbr. (Fig. 2.34g; Fig. 2.54)

Zahlbruckner, Cat. Lich. Univ. 8: 490. 1932.

Basionym: *Lichen decussatus* Villars, Hist. Pl. Dauphine 3: 964. 1789.

Synonyms: *Gyrophora decussata* (Vill.) Zahlbruckner, Cat. Lich. Univ. 4: 678. 1927. -*Omphalodiscus decussatus* (Vill.) Schol., Llano 1950: 78.

**Thallus:** generally monophyllous, umbilicate, to 3.5(-5) cm across, orbicular, central umbo part elevated peak-like, reticulately ribbed; **ribs:** decreasing towards periphery; **margins:** entire to incised; **upper surface:** ochraceous buff to greyish brown-black, granulose pruinose; **lower surface:** blackish, smooth, lacking rhizomorphs.

**Chemistry:** Thallus K-, C-, KC-, P-; no secondary metabolites in TLC.

**Ecology and distribution:** *Microhabitat occupied:* Terricolous. It is rarely occurring terricolous species of India and known only from Sikkim. Outside India, the species is also reported from Nepal; Antarctica, Asia, Arctic Europe, North and South America.

**SPECIMEN EXAMINED:** **INDIA: SIKKIM, NORTH SIKKIM,** Yangdi, above Thangu, alt. 4,100 m, on soil, D. K. Upreti, S. Chatterjee and P. K. Divakar 04-003991 B (LWG).

***Umbilicaria indica*** Frey (Fig. 2.34h; Fig. 2.54)

Frey, Ber. Schweiz, Bot. Ges. 59:456. 1949.

Basionym: *Umbilicaria papillosa* Nylander, Syn. Lich. 2:11. 1885, non DC. ex anno 1805.

Synonym: *Gyrophora himalayensis* Räsänen, Arch. Soc. Zool. Bot. Fenn. 'Vanamo' 5(1): 25.1950.

**Thallus:** foliose, monophyllous or mostly polyphyllous, umbilicate, (2-3) 6 (-9) cm across; **margins:** incised, weakly to strongly undulating and wrinkled; **upper surface:** grey to brownish, smooth to tumid, often with holes with protruding rhizomorphs; **lower surface:** brown-black, smooth, lacking trabeculae; **rhizomorphs:** cylindrical, simple or irregularly branched. **Apothecia:** to 2 mm in diam., irregularly gyrose; **spores** simple or muriform when mature, 16-27 × 7-15 µm.

**Chemistry:** K-, C+ red, Gyrophoric acid present

**Ecology and distribution:** *Microhabitat occupied:* Terricolous, terricolous-rupicolous. In India the species is distributed in Arunachal Pradesh, Himachal Pradesh, Nagaland, Sikkim, Uttarakhand and West Bengal -hills while species growing on soil is reported from localities of Himachal Pradesh and Uttarakhand. Outside India, the species is also reported from Bhutan, China and Nepal.

**SPECIMENS EXAMINED:** **INDIA: HIMACHAL PRADESH, KULLU DISTRICT,** Great Himalayan National Park, on way from Shilt-Gumtaro, alt. 3,600 m, on soil over rocks, D. K. Upreti 99-53630 (LWG); on way from Dhela to Lapah, alt. 3,000 m, on ground, D. K. Upreti 99-54079 (LWG); **UTTARAKHAND, CHAMOLI DISTRICT,** Srenikhal, alt. 3,700 m, on soil, S. Rawat, s.n. (LWG).

***Umbilicaria leiocarpa*** DC. (Fig. 2.34i; Fig. 2.54)

In Lamarck and De Candolle. Fl. Franc. ed. 3, 2: 410. 1805.

Synonym: *Agyrophora leiocarpa* (DC.) Gyelnik. Ann. Mycol. 30: 444. 1932.

**Thallus:** monophyllous to polyphyllous, umbilicate, to 8 cm across; **margins:** incised; **upper surface:** buff to brown-black, uneven to folded, centrally rugose-rimulose, peripherally areolate; **lower surface:** grey-brown, folded, lacking rhizinomorphs. **Apothecia:** to 2 mm in diam., leiodiscus; **spores:** simple, hyaline, 12–14 × 4.8 μm.

**Chemistry:** Thallus K–, C–, KC–, P–; no secondary metabolites in TLC.

**Ecology and distribution:** *Microhabitat occupied:* Terricolous. Earlier the species was only known from Nepal and for the first time it is reported from Sikkim. It is a new record for Indian lichen flora. The species growing on soil is reported from single locality of Sikkim. Outside India, the species is also reported from Northern arctic regions of Europe and North America.

**SPECIMEN EXAMINED:** INDIA: SIKKIM, NORTH SIKKIM DISTRICT, Yangdi, above Thangu, alt. 4,250 m, on soil, D. K. Upreti, S. Chatterjee and P. K. Divakar 04-003972 (LWG).

*Umbilicaria vellea* (L.) Ach. (Fig. 2.35a; Fig. 2.54)

Acharius, Kongl. Vetensk. Akad. Nya Handl. 15:101. 1794.

Basionym: *Lichen velleus* L., Sp. Pl.: 1150. 1753.

**Thallus:** monophyllous, umbilicate, 2.5–12 cm across, rigid; **margin:** entire to incised; **upper surface:** grey to blackish grey, smooth, areolate, pruinose; **lower surface:** black, to brownish black; **rhizinomorphs:** dimorphic, long, cylindrical and thick, club shaped. **Apothecia:** rare, to 3 mm in diam., black, gyrodiscus; **spores:** simple, colourless 8.5–13 × 6.8–10 μm.

**Chemistry:** Thallus K–, C–, KC–, P–; no secondary metabolites in TLC.

**Ecology and distribution:** *Microhabitat occupied:* Terricolous, terricolous-rupicolous. In India the species is distributed in Jammu and Kashmir, Sikkim and Uttarakhand while species growing on soil is reported from different localities of Sikkim. Outside India, the species is also reported from Bhutan, Nepal and Sri Lanka; Africa, Europe, North America. Cosmopolitan in distribution.

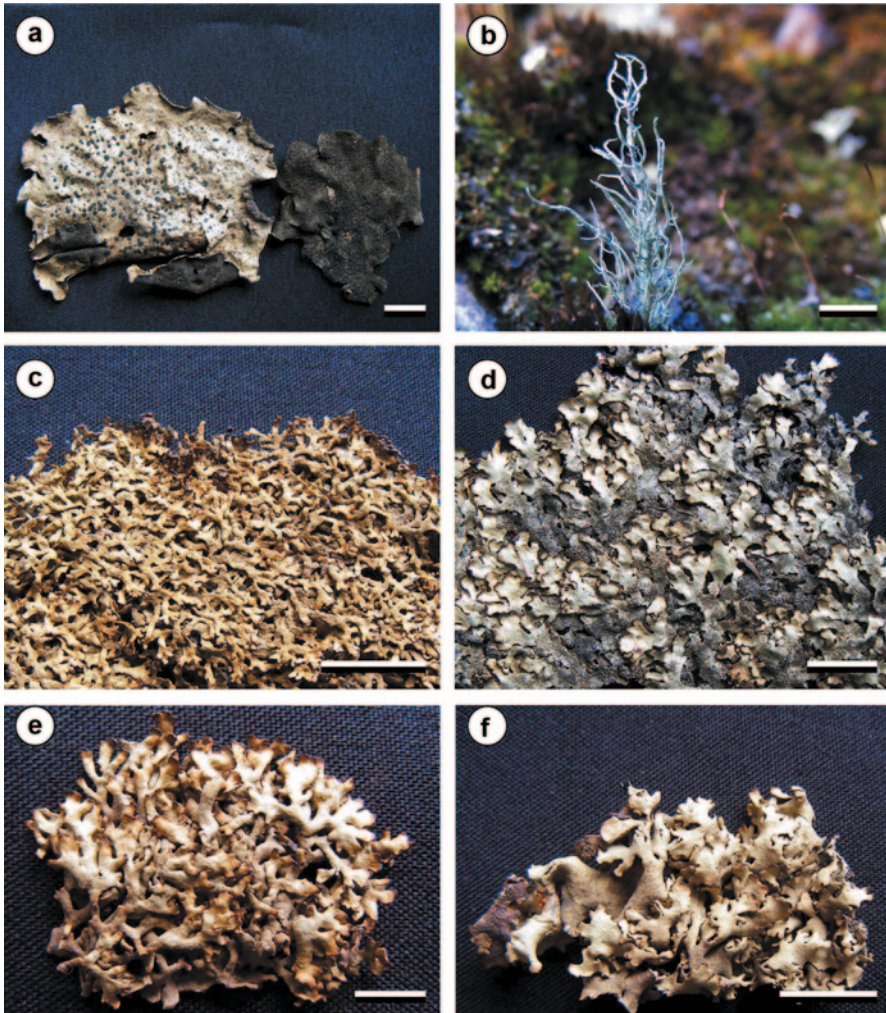
**SPECIMENS EXAMINED:** INDIA: SIKKIM, NORTH SIKKIM DISTRICT, Giagaon, after Thangu, alt. 4,600 m, on rock over soil, D. K. Upreti, S. Chatterjee and P. K. Divakar 04-004024 (LWG); Chubuk, above Thangu, alt. 4,100 m, on soil, D. K. Upreti, S. Chatterjee and P. K. Divakar 04-003933 (LWG); 2 km before Shingbo Rhododendron Sanctuary, near Yumthang alt. 3,800 m, on rock over soil, D. K. Upreti, S. Chatterjee and P. K. Divakar 04-004088 (LWG).

USNEA Dill. ex Adans. (*Parmeliaceae*)

Adanson, Fam. Pl.: 2:7. 1763.

**Thallus:** fruticose, erect, shrubby, procumbent to pendulous, attached by a blackish discoid holdfast; dichotomous to sympodially branched or filamentous; **upper surface:** greenish grey, yellowish grey or reddish, with or without papillae, tubercles, pseudocyphephae, soredia, and isidia; **photobiont:** a green alga (*Trebouxia*); **medulla:** arachnoid or dense, white or red pigmented; **central axis:** composed of longitudinally oriented, thick walled, conglutinate hyphae, generally solid, sometimes centrally lacerated. **Apothecia:** lateral, terminal, geniculate, lecanorine, generally ciliate; **asci:** 8-spored; **spores:** simple, colourless, ellipsoid. Usnic acid present in cortex of all species.

Out of 330 species known from world, 60 are from India, of which one is terricolous.



**Fig. 2.35** **a** *Umbilicaria vellea* (L.) Ach., **b** *Usnea longissima* Ach., **c** *Xanthoparmelia bellatula* (Kurok. and Filson) Elix. and al., **d** *X. mexicana* (Gyeln.) Hale, **e** *X. stenophylla* (Ach.) Ahti and D. Hawksw., **f** *X. terricola* Hale, Nash and Elix. Scale in **b**=5 mm; in **a, b, c, d, e, f**=10 mm

*Usnea longissima* Ach. (Fig. 2.35b; Fig. 2.54)

Acharius. Lichenogr. Universalis.: 626.1810.

Synonym: *Usnea longissima* var. *himalayensis* Räsänen, Arch. Soc. Zool. Bot. 'Vanamo' 6(2): 81. 1952.

**Thallus:** pendulous, filamentose branches several meters long in nature, pale yellow, greyish green to light brownish; 0.5-1 mm in diam.; **lateral branchlets:** dense, perpendicular, 2–5 cm long; surface of filamentose branches usually decorticated,

rarely pulverulent to powdery, cortex of lateral branchlets persistent, cracked near base, with soredia or isidia; **central axis:** solid, colourless, I+ blue. **Apothecia:** absent.

**Chemistry:** Medulla with barbatic, squamatic diffractaic, evernic and fumarprotocetraric acids resulting in 6–7 chemical strains. Asahina had made nomenclatural entities on the basis of the presence of different lichen substances, which have been merged into 7 chemical strains (Awasthi 1986).

**Ecology and distribution:** *Microhabitat occupied:* Terricolous. In India the species is widely distributed in Arunachal Pradesh, Himachal Pradesh, Jammu and Kashmir, Sikkim, Uttarakhand and West Bengal-hills while species growing on soil is reported from different localities of Sikkim and Uttarakhand. The species is rarely terricolous. Outside India, the species is also reported from Bhutan, China, Nepal and Japan; Europe, North America.

**SPECIMENS EXAMINED:** **INDIA:** SIKKIM, NORTH SIKKIM, above Lachen, alt. 3,000 m, on soil, D. K. Upreti, S. Chatterjee and P. K. Divakar 04-003779 (LWG); **UTTARAKHAND, UTTARKASHI DISTRICT,** Gangotri, alt. 3,133 m, on soil, Himanshu Rai and Pramod Nag 10-0014538 (LWG); Gangotri, alt. 3,128 m, on soil, Himanshu Rai and Pramod Nag 10-0014546 (LWG).

### XANTHOPARMELIA (Vain.) Hale (*Parmeliaceae*)

Phytologia 28: 485. 1974.

**Thallus:** foliose to subfoliose, unattached; **lobes:** branched, marginally eciliate; **upper surface:** pale yellow, yellow-green to grey-green or brown, olive-brown to black; **lower surface:** whitish, yellow-brown or blackish. **Apothecia:** laminal, lecanorine, disc red-brown to brown-black; **asci:** 8-spored; **spores:** colourless, simple and ellipsoidal.

Out of 500 species known from world, 16 are from India, of which 4 are terricolous.

#### Key to the terricolous species of *Xanthoparmelia*:

1.	Thallus isidiate, isidia subglobose to cylindrical, coralloid branched, black tipped .....	<i>X. mexicana</i>
1a.	Thallus lacking isidia .....	2
2.	Lobes 2–5 mm wide .....	<i>X. stenophylla</i>
2a.	Lobes 0.5–2 mm wide .....	3
3.	Lobes canaliculate .....	<i>X. bellatula</i>
3a.	Lobes not canaliculate .....	<i>X. terricola</i>

### *Xanthoparmelia bellatula* (Kurok. and Filson) Elix. and al. (Fig. 2.35c; Fig. 2.54)

Elix. and al., Bull. Brit. Mus. (Nat. Hist.), Bot. 15(3): 203. 1986.

Basionym: *Parmelia bellatula* Kurok. and Filson in Filson, Austral. J. Bot. 30: 521. 1982.

**Thallus:** foliose, loosely attached to the substratum, forming rosettes, 2–4 cm across; **lobes:** separate near the margins of the thallus, sub linear, elongate, dichotomously branched, contiguous, separate, 0.5–2 mm wide, margin black rimmed;



**upper surface:** pale yellow to yellowish green, emaculate, shiny, slightly convex, smooth, lacking isidia and soredia; **medulla:** white; **lower surface:** pale brown to brown in the centre, canaliculated, sparsely rhizinate; **rhizines:** present in the centre of thallus, concolorous with the lower surface, short, simple. **Apothecia:** not observed.

**Chemistry:** Medulla K+ yellow then red, C-, KC-, P+ yellow to orange. Salazinic and consalazinic acids present.

**Ecology and distribution:** *Microhabitat occupied:* Terricolous; terricolous-rupicolous. In India the species is restrictedly distributed to Western Himalaya and reported only from Uttarakhand growing on soil. Outside India, the species was only known from Australia. It is close to *X. terricola*, in terricolous habitat and presence of salazinic acid in medulla but differs in lower canaliculated surface.

**SPECIMENS EXAMINED: INDIA: UTTARAKHAND, CHAMOLI DISTRICT,** Badrinath, north surface of temple, on way to Mana village, alt. 3,150–3,250, on soil, Dange 76.928 (LWG-LWU); on way to Niti, 10 kms before Niti, alt. 3,100 m, on soil over rocks, D. K. Upreti and S. Nayaka 07-010298 (LWG).

***Xanthoparmelia mexicana* (Gyeln.) Hale (Fig. 2.35d; Fig. 2.54)**

Hale. Phytologia 28: 488.1974.

Basionym: *Parmelia mexicana* Gyeln., Repert. Spec. Nov. Regni Veg. 29: 281. 1931.

**Thallus:** foliose, adnate to loosely attached to the substratum, to 4 cm across; **lobes:** imbricate, flat, 1.5–3.0 mm wide, margins blackening, apices rotund; **upper surface:** yellow green, emaculate, shiny near apices and dull in centre, smooth at margins but rugose and cracked in centre; **isidia:** dense in thallus centre, subglobose to cylindrical, simple to coralloid branched, brownish to black; **medulla:** white; **lower surface:** pale brown to brown, smooth, sparsely rhizinate; **rhizines:** simple, short, concolorous with the lower surface. **Apothecia:** not present.

**Chemistry:** Medulla K+ yellow turning red, C-, KC-, P+ orange. Salazinic, consalazinic and traces of norstictic acids present.

**Ecology and distribution:** *Microhabitat occupied:* Terricolous. In India earlier it was known from Uttarakhand (Divakar 2005). The present study extends its distribution up to Eastern Himalayas and known from Sikkim, growing on soil at alpine region. Outside India, the species was also reported from Western USA, Mexico, Dominican Republic, Argentina, Kenya, Australia, New Zealand, Japan, Korea, China and Nepal. The species may be confused with *X. coreana*, which has globose, pale isidia and relatively branched lobes.

**SPECIMEN EXAMINED: INDIA: SIKKIM, NORTH SIKKIM DISTRICT,** Kalep, before Thangu, alt. 3,900 m, on soil, D. K. Upreti, S. Chatterjee and P. K. Divakar 04-003837(LWG).

***Xanthoparmelia stenophylla* (Ach.) Ahti and D. Hawksw. (Fig. 2.35e; Fig. 2.54)**

Ahti and Hawksworth, Lichenologist 37: 363. 2005. 531

Basionym: *Parmelia conspersa* [β] *stenophylla* Acharius, Meth. Lich.: 206. 1803.

Synonyms: *Parmelia stenophylla* (Ach.) Du Rietz, Svensk. Bot. Tidskr. 15:176. 1921. *Parmelia conspersa* var. *imitans* Müller Argoviensis, Flora 74:378.1891. *Xanthoparmelia somloensis* (Gyeln.) Hale, Mycotaxon 28: 96. 1987; Divakar and Upreti, Parmelioid Lichens in India: 422. 2005.

**Thallus:** foliose, loosely attached to the substratum, 4–18 cm across; **lobes:** variable, sub linear to linear elongate, flat, sometimes forming dense mat in the centre, dichotomously branched, contiguous, separate, 0.5–2 mm wide, margin black rimmed; **upper surface:** pale yellow to yellowish green, emaculate, shiny, slightly convex, smooth, lacking isidia and soredia; **medulla:** white; **lower surface:** pale brown to brown in the centre, canaliculated, sparsely rhizinate or sometimes rhizines absent. **Apothecia:** absent.

**Chemistry:** Medulla K+ yellow then red, C–, KC–, P+ yellow to orange. Salazinic and consalazinic acids present.

**Ecology and distribution:** *Microhabitat occupied:* Terricolous. In India the species is distributed in Himachal Pradesh, Jammu and Kashmir, Sikkim and Uttarakhand while species growing on soil is reported from localities of Jammu and Kashmir and Sikkim. Outside India, the species is also reported from China, Japan, Korea, Mongolia, Nepal and Pakistan; Europe, North America.

**SPECIMENS EXAMINED:** **INDIA: JAMMU AND KASHMIR, SRINAGAR DISTRICT,** Shankaracharya Hills, on soil, G. C. Rath s.n. (LWG); **SIKKIM, NORTH SIKKIM,** Giagaon, above Thangu, alt. 4,600 m, on soil, D. K. Upreti, S. Chatterjee and P. K. Divakar 04-004017 (LWG).

*Xanthoparmelia terricola* Hale, Nash and Elix (Fig. 2.35f; Fig. 2.54)

In Hale, Mycotaxon 27: 603.1986.

**Thallus:** foliose, loosely attached to the substratum, to 5 cm across; **lobes:** sub linear, dichotomously branched, contiguous, separate, 0.8–2 mm wide, margin black-rimmed; **upper surface:** yellowish green, but darkening or black at the centre with age, emaculate, shiny near periphery, irregularly cracked, lacking isidia and soredia; **medulla:** white; **lower surface:** brown, sparsely rhizinate; **rhizines:** present in the centre of thallus, concolorous with the lower surface, at tips white, simple to furcated. **Apothecia:** not present.

**Chemistry:** Medulla K+ yellow turning red, C–, KC–, P+ orange. Salazinic, consalazinic and traces of norstictic acids present.

**Ecology and distribution:** *Microhabitat occupied:* Terricolous, terricolous-rupicolous. In India the species is known to be terricolous and distributed in Himachal Pradesh and Uttarakhand. Outside India, the species is also reported from South Africa.

**SPECIMENS EXAMINED:** **INDIA: HIMACHAL PRADESH, LAHAUL SPITI DISTRICT,** Darcha, alt. 3,200 m, on soil, D. K. Upreti and S. Chatterjee 03-001717 (LWG); **UTTARAKHAND, CHAMOLI DISTRICT,** Badrinath, between Vasudhara and Bhagirathi glacier, alt. 3,900–4,500 m, on soil, Upreti L-13209, 2023769 (LWG); **UTTARKASHI DISTRICT,** Gangotri, alt. 3,204 m, on soil over rocks, Himanshu Rai and Pramod Nag 10-0014501 (LWG).

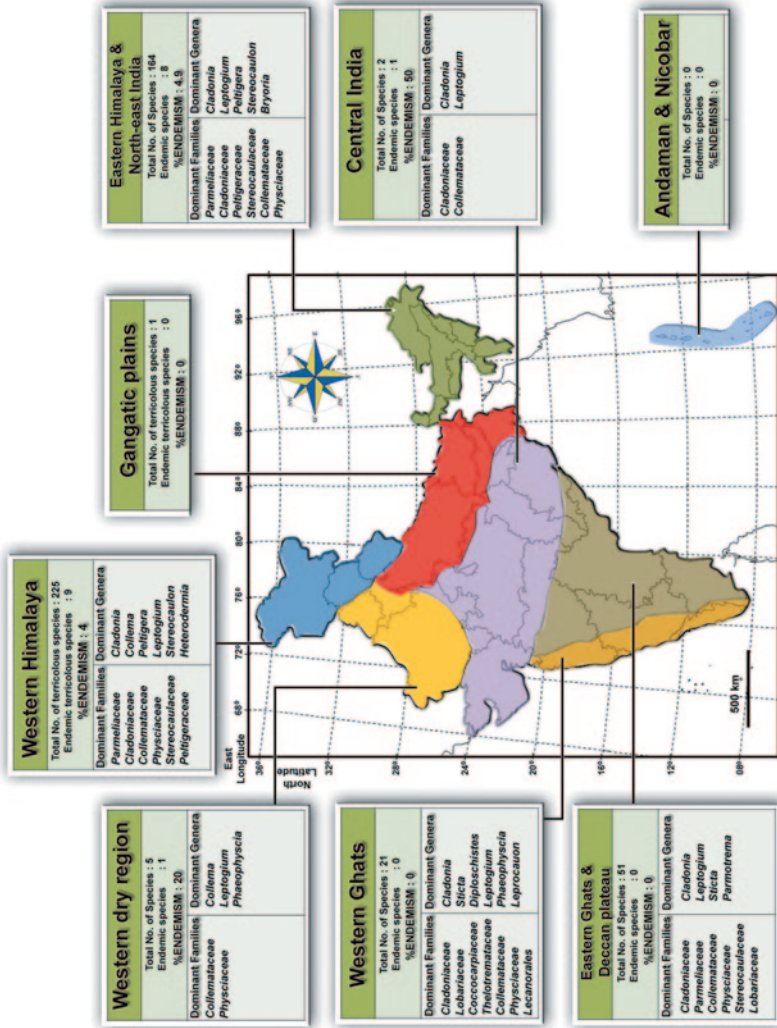


Fig. 2.36 Diversity of terricolous lichens in different lichenogeographic regions of India

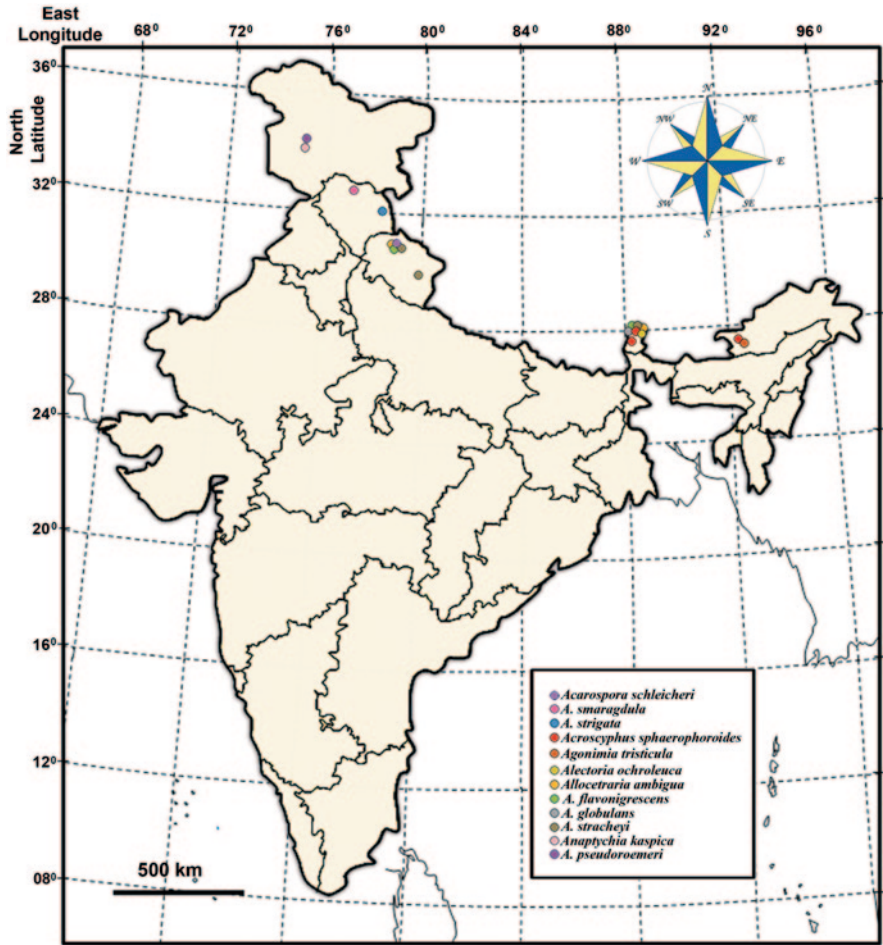
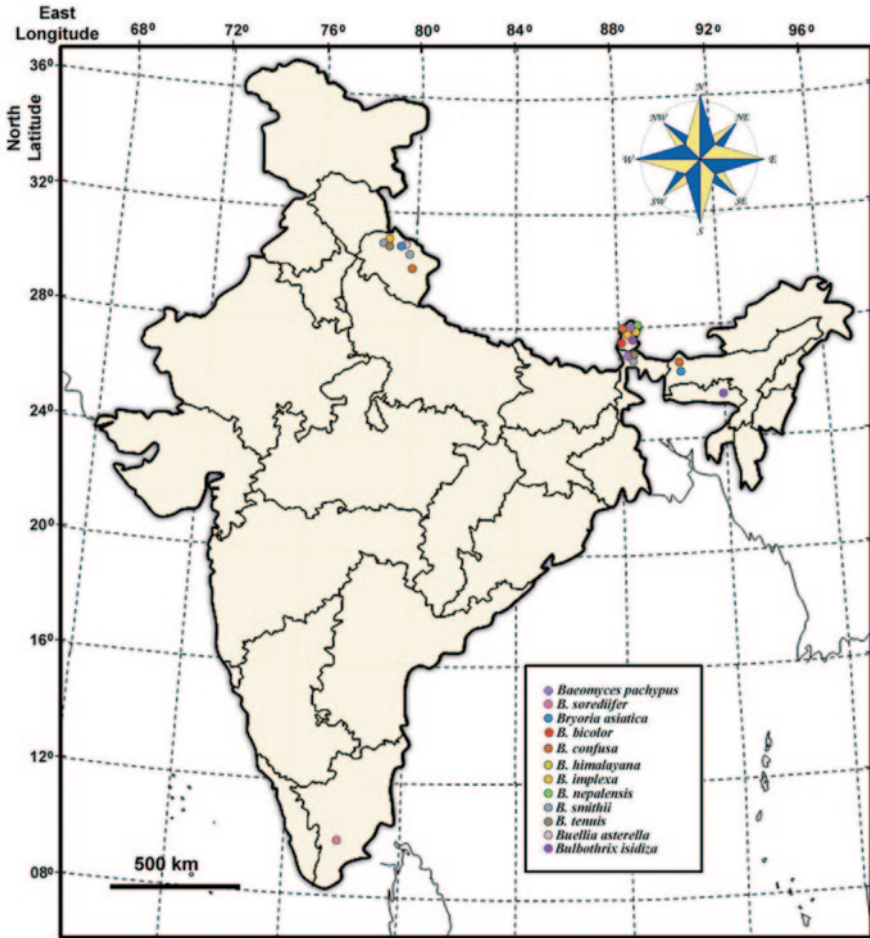
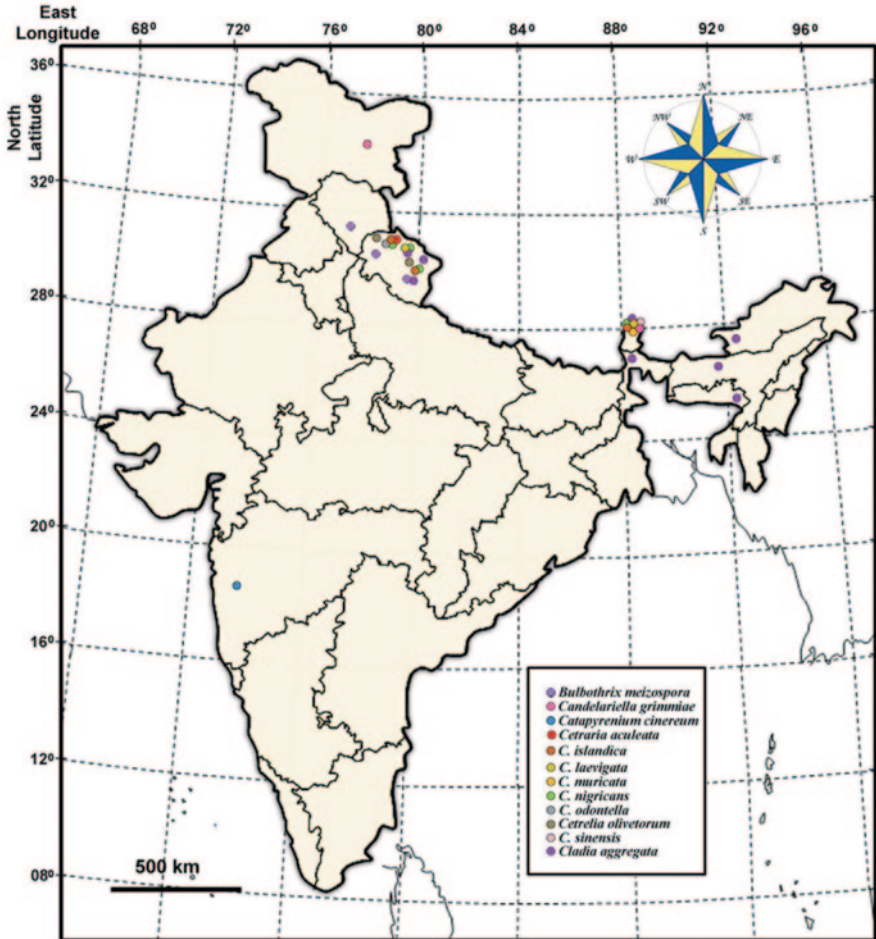


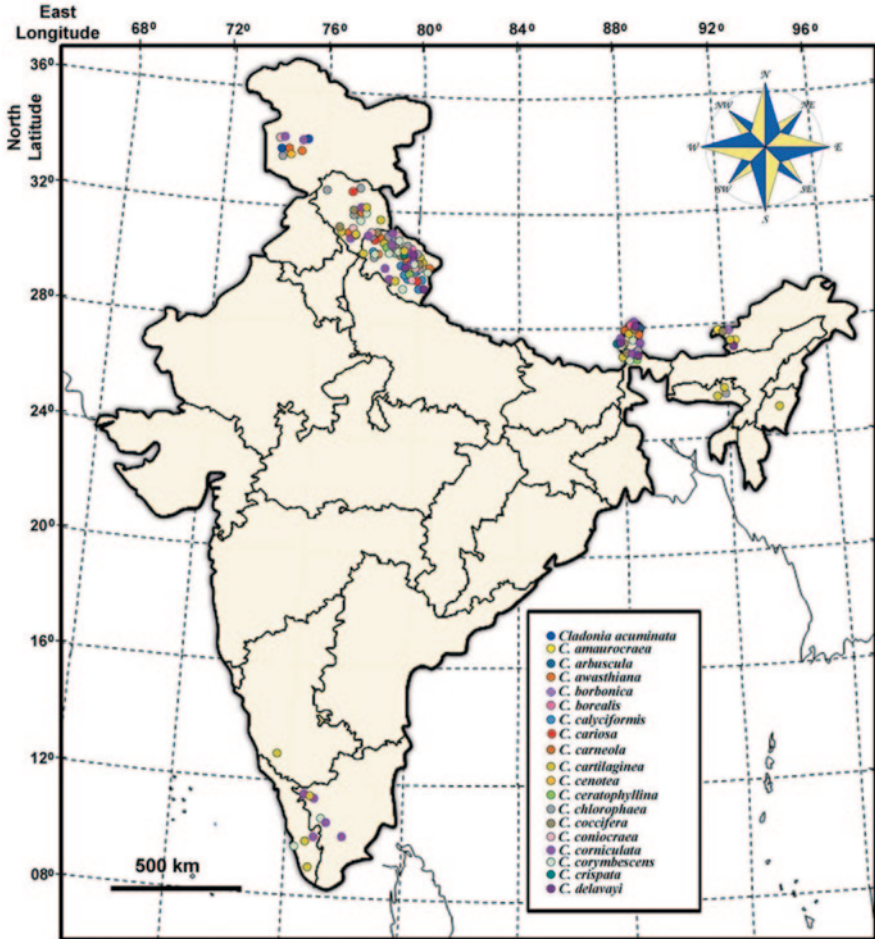
Fig. 2.37 Species distribution map of terricolous lichens—*Acarospora schleicheri* (Ach.) A. Massal., *A. smaragdula* (Wahlenb.) A. Massal., *A. strigata* (Nyl.) Jatta, *Acrosyphus sphaerophoroides* Lév., *Agonimia tristicula* (Nyl.) Zahlbr., F. *Alectoria ochroleuca* (Hoffm.) A. Massal., *Allocetraria ambigua* (C. Bab.) Kurok. and M. J. Lai, *A. flavinigrescens* A. Thell and Randlane, *A. globulans* (Nyl.) A. Thell and Randlane, D. *A. stracheyi* (C. Bab.) Kurok. and M. J. Lai, *Anaptychia kaspica* Gyeln. and *A. pseudoermeri* D. D. Awasthi and S. R. Singh—in India



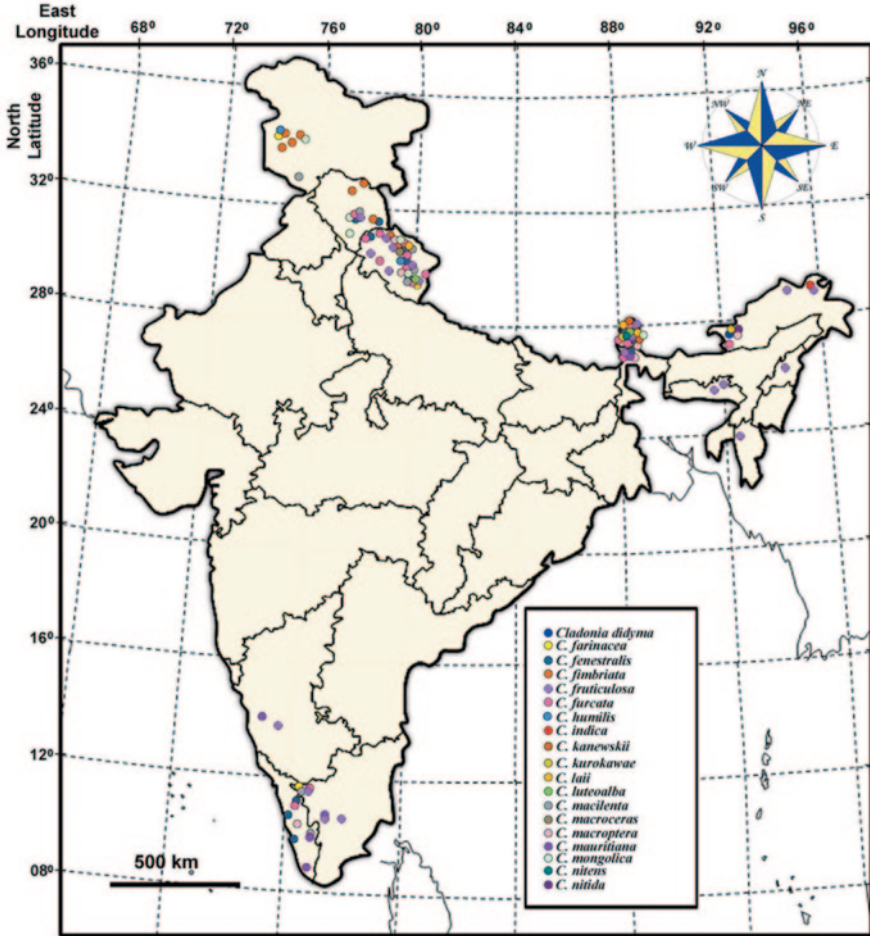
**Fig. 2.38** Species distribution map of terricolous lichens—*Baeomyces pachypus* Nyl., *B. soreidifer* Nyl., *Bryoria asiatica* (Du Rietz) Brodo and D. Hawksw., *B. bicolor* (Ehrh.) Brodo and D. Hawksw., *B. confusa* (D. D. Awasthi) Brodo and D. Hawksw., *B. himalayana* (Mot.) Brodo and D. Hawksw., *B. implexa* (Hoffm.) Brodo and D. Hawksw., *B. nepalensis* D. D. Awasthi, *B. smithii* (Du Rietz) Brodo and D. Hawksw., *B. tenuis* (A. E. Dahl) Brodo and D. Hawksw., *Buellia asterella* Poelt and Sulzer and, *Bulbothrix isidiza* (Nyl.) Hale—in India



**Fig. 2.39** Species distribution map of terricolous lichens—*Bulbothrix meizospora* (Nyl.) Hale, *Candeleriella grimmiae* Poelt and Reddi, *Catapyrenium cinereum* (Pers.) Körb., *Cetraria aculeata* (Schreb.) Fr., *C. islandica* (L.) Ach., *C. laevigata* Rass.; *C. muricata* (Ach.) Eckfeldt, *C. nigricans* Nyl., *C. odontella* (Ach.) Ach., *Cetraria olivetorum* (Nyl.) W. L. Culb. and C. F. Culb., *C. sinensis* W. L. Culb. and C. F. Culb. and *Cladia aggregata* (Sw.) Nyl.—in India

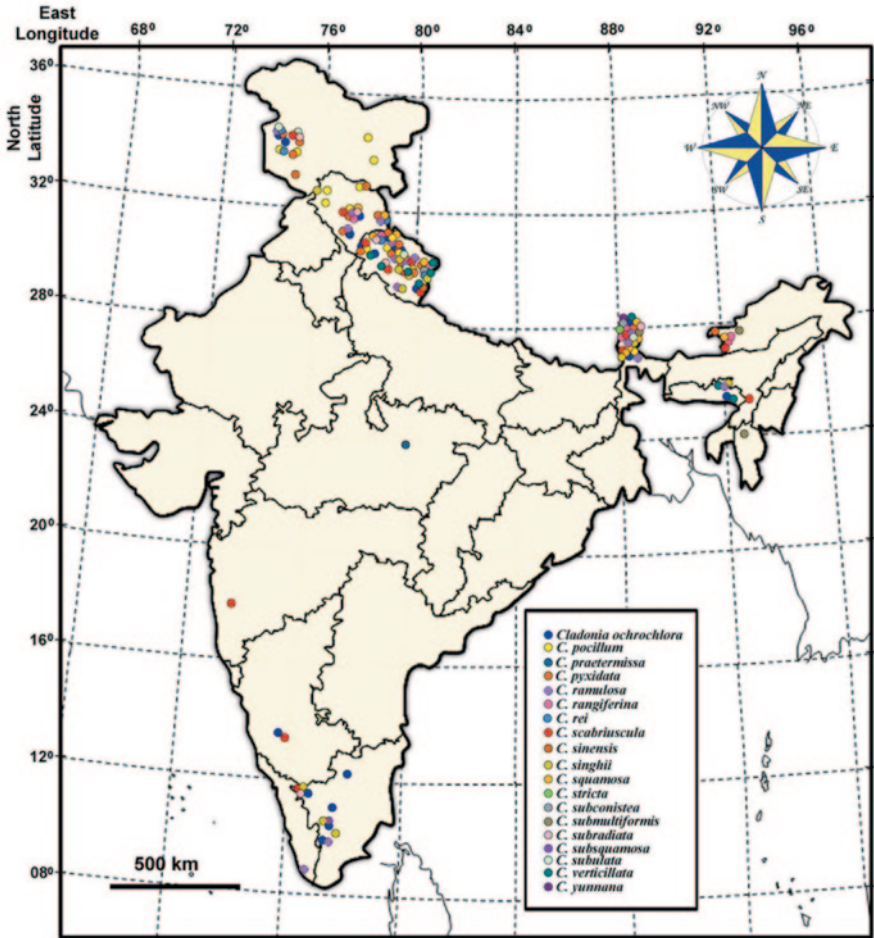


**Fig. 2.40** Species distribution map of terricolous lichens—*Cladonia acuminata* (Ach.) Norrl., *C. amaurocraea* (Flörke) Schaer., *C. arbuscula* (Wallr.) Flot., *C. awasthiana* Ahti and Upreti, *C. borbonica* Nyl., *C. borealis* S. Stenroos, *C. calyciformis* Nuno, *C. cariosa* (Ach.) Spreng., *C. carneola* (Fr.) Fr., *C. cartilaginea* Müll. Arg., *C. ceratophyllina* (Nyl.) Vain., *C. chlorophaea* (Flörke ex Sommerf.) Spreng., *C. coccifera* (L.) Willd., *C. coniocraea* (Flörke) Spreng., *C. corniculata* Ahti and Kashiw., *C. corymbescens* Nyl. ex Leight., *C. crispata* (Ach.) Flot., *C. delavayi* Abbayes—in India



**Fig. 2.41** Species distribution map of terricolous lichens—*Cladonia didyma* (Fée) Vain., *C. farinacea* (Vain.) A. Evans, *C. fenestralis* Nuno, *C. fenestrata* (L.) Fr., *C. fimbriata* (L.) Fr., *C. fruticulosa* Kremp., *C. furcata* (Huds.), *C. humilis* (With.) J. R. Laundon, *C. indica* Ahti and Upreti, *C. kanewskii* Oksner, *C. kurokawae* Ahti and S. Stenroos, *C. laii* S. Stenroos Schrad., *C. luteoalba* Wheldon and A. Wilson, *C. macilenta* Hoffm., *C. macroceras* (Delise) Hav., *C. macroptera* Räs., *C. mauritiana* Ahti and J. C. David, *C. mongolica* Ahti, *C. nitens* Ahti (isotype, University of Helsinki-H), *C. nitida* Ahti—in India





**Fig. 2.42** Species distribution map of terricolous lichens—*C. ochrochlora* Flörke, *C. pocillum* (Ach.) Grognot, *C. praetermissa* A. W. Archer, *C. pyxidata* (L.) Hoffm., *C. ramulosa* (With.) J. R. Laundon, *C. rangiferina* (L.) F. H. Wigg., *C. rei* Schaer., *C. scabriuscula* (Delise) Nyl., *C. sinensis* S. Stenroos and J. B. Chen, *C. singhii* Ahti and P. K. Dixit, *C. squamosa* Hoffm., *C. stricta* (Nyl.) Nyl., *C. subconistea* Asahina, *C. submultiformis* Asahina, *C. subradiata* (Vain.) Sandst., *C. subsquamosa* Kremp., *C. subulata* (L.) F. H. Web. ex Wigg., *C. verticillata* (Hoffm.) Schaer., *C. yunnana* (Vain.) Abbayes ex J. C. Wei and Y. M. Jiang—in India



**Fig. 2.43** Species distribution map of terricolous lichens—*Coccocarpia erythroxyli* (Spreng.) Swinsc. and Krog., *C. palmicola* (Spreng.) Arv. and D. J. Galloway, *C. pellita* (Ach.) Müll. Arg. em. R. Sant., *Collema auriculiforme* (With.) Coppins and J. R. Laundon, *C. coccophorum* Tuck., *C. crispum* (Huds.) G. H. Web., *C. cristatum* (L.) G. H. Web., *C. furfuraceum* (Arn.) Du Rietz, *C. furfureolum* Müll. Arg., *C. fuscovirens* (With.) J. R. Laundon, *C. japonicum* (Müll. Arg.) Hue., *C. polycarpon* Hoffm., *C. pulcellum* var. *subnigrescens* (Müll. Arg.) Degel., *C. rugosum* Krep., *C. ryssoleum* (Tuck.) Schneid., *C. subconveniens* Nyl., *C. subflaccidum* Degel., *C. tenax* var. *tenax* (Sw.) Ach.—in India



**Fig. 2.44** Species distribution map of terricolous lichens—*Collema tenax* var. *corallinum* (A. Massal.), *C. tenax* var. *vulgare* (Schaer.) Degel., *C. texanum* Tuck., *C. thamnodes* Tuck. ex Riddle, *Dermatocarpon vellereum* Zschacke, *Dibaeis baeomyces* (L.f.) Rambold and Hertel, *D. pulogenis* (Vain.) Kalb and Gierl, *Diploschistes cinereocaesius* (Sw. ex Ach.) Vain., *D. dicapsis* (Ach.) Lumbsch, *D. muscorum* subsp. *bartlettii* Lumbsch, *D. muscorum* subsp. *muscorum* (Scop.) R. Sant., *D. scruposus* (Schreb.) Norman., *Endocarpon subrosetum* Ajay Singh and Upreti, *Evernia mesomorpha* Nyl., *Everniastrum cirrhatum* (Fr.) Hale ex Sipman, *E. nepalense* (Taylor) Hale ex Sipman, *E. vexans* (Zahlbr.) Hale ex Sipman, *Flavocetraria cucullata* (Bellardi) Kärnefelt and A. Thell, *F. nivalis* (L.) Kärnefelt and A. Thell—in India

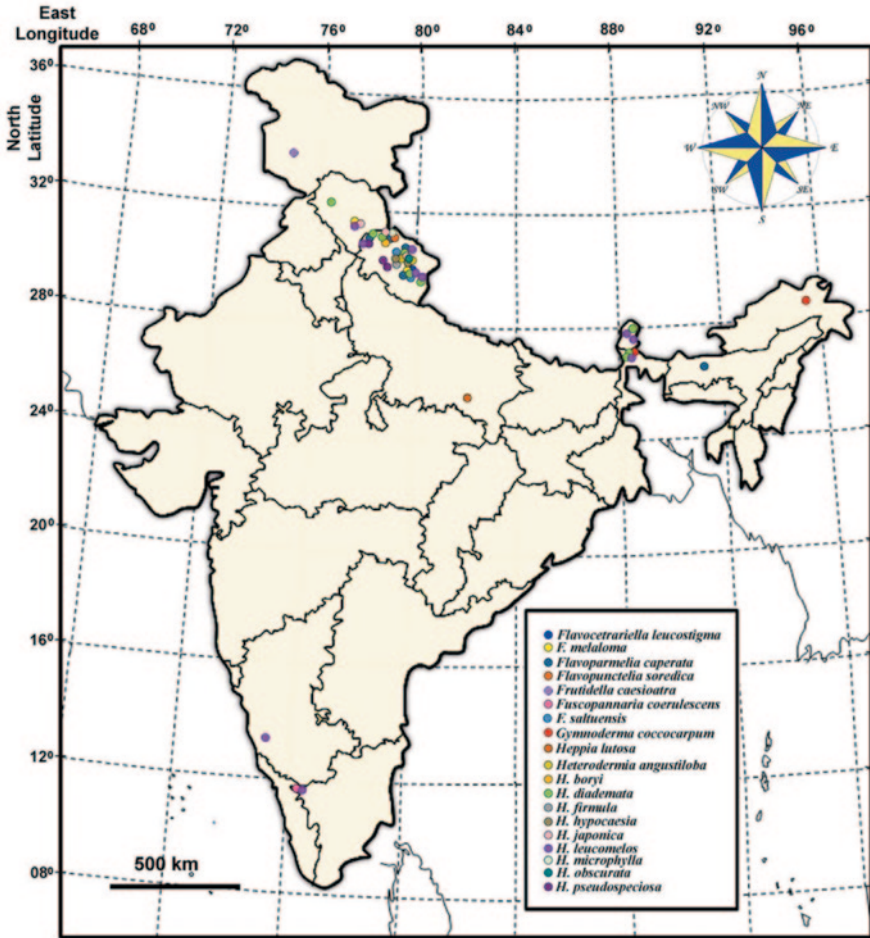


Fig. 2.45 Species distribution map of terricolous lichens—*Flavocetrariella leucostigma* (Lév.) D. D. Awasthi, *F. melaloma* (Nyl.) D. D. Awasthi, *Flavoparmelia caperata* (L.) Hale, *Flavopunctelia soredica* (Nyl.) Hale, *Fuscopannaria coerulescens* P. M. Jørg., *F. saltuensis* P. M. Jørg., *Gymnoderma coccocarpum* Nyl., *Heppia lutos* (Ach.) Nyl., *Heterodermia angustiloba* (Müll. Arg.) D. D. Awasthi, *H. boryi* (Fée) Kr. P. Singh and S. R. Singh, *H. diademata* (Taylor) D. D. Awasthi, *H. firmata* (Nyl.) Trevis., *H. hypoaesia* (Yasuda) D. D. Awasthi, *H. japonica* (M. Satō) Swinscow and Krog, *H. leucomelos* (L.) Poelt, *H. microphylla* (Kurok.) Skorepa, *H. obscurata* (Nyl.) Trevis., *H. pseudospeciosa* (Kurok.) W. L. Culb.—in India



Fig. 2.46 Species distribution map of terricolous lichens—*Heterodermia rubescens* (Räsänen) D. D. Awasthi, *Hypogymnia alpina* D. D. Awasthi, *H. bitteri* (Lyngé) Ahti., *H. hypotrypa* (Nyl.) Ras-sad., *H. vittata* (Ach.) Gasilien., *Hypotrachyna adducta* (Nyl.) Hale, *H. crenata* (Kurok.) Hale, *H. exsecta* (Taylor) Hale, *H. scytophylla* (Kurok.) Hale, *Icmadophila ericetorum* (L.) Zahlbr., *Lecanora chondroderma* Zahlbr., *L. himalayae* Poelt, *Lecidoma demissum* (Rutström) G. Schneider and Hertel., *Lempholemma chalazanum* (Ach.) de Lesd., *Lepraria caesiaalba* var. *groenlandica* L. Saag, *L. lobificans* Nyl., *L. neglecta* (Nyl.) Erichsen, *L. vouauxii* (Hue) R. C. Harris—in India

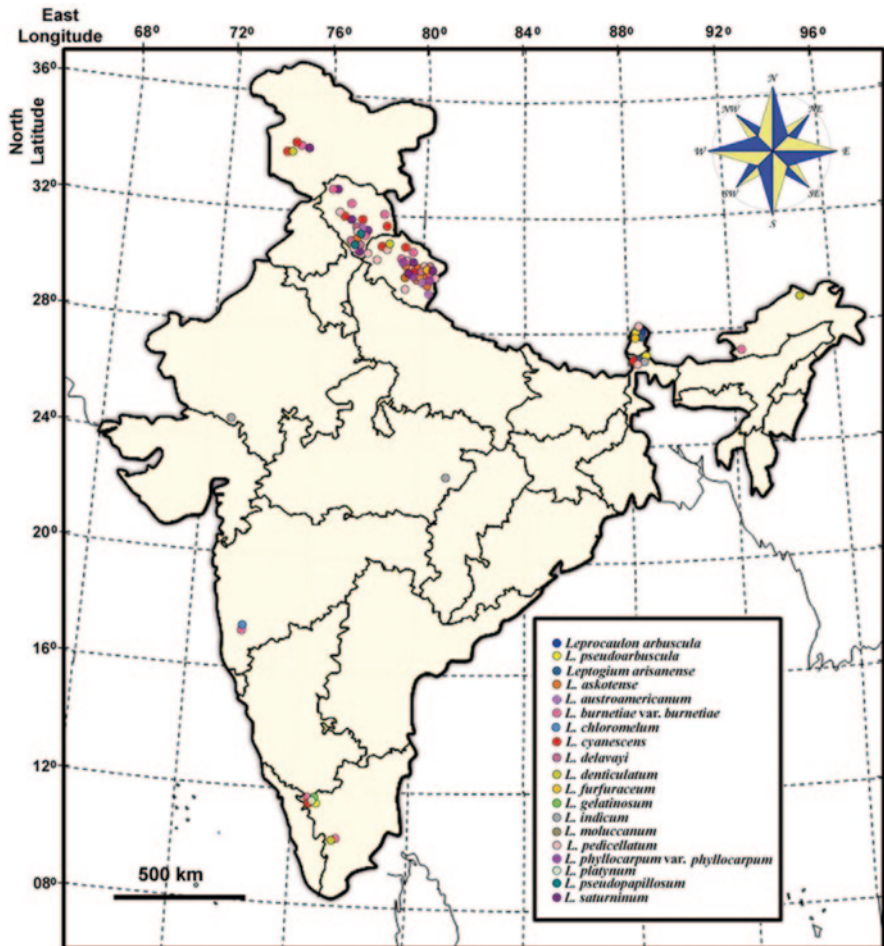
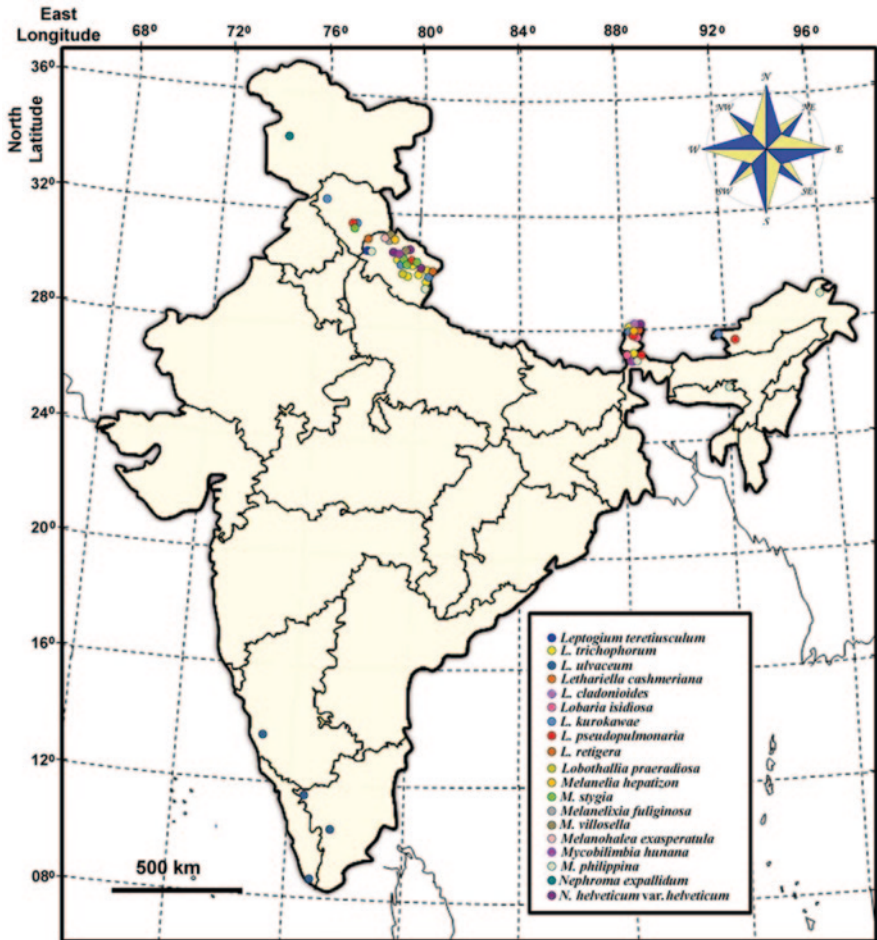
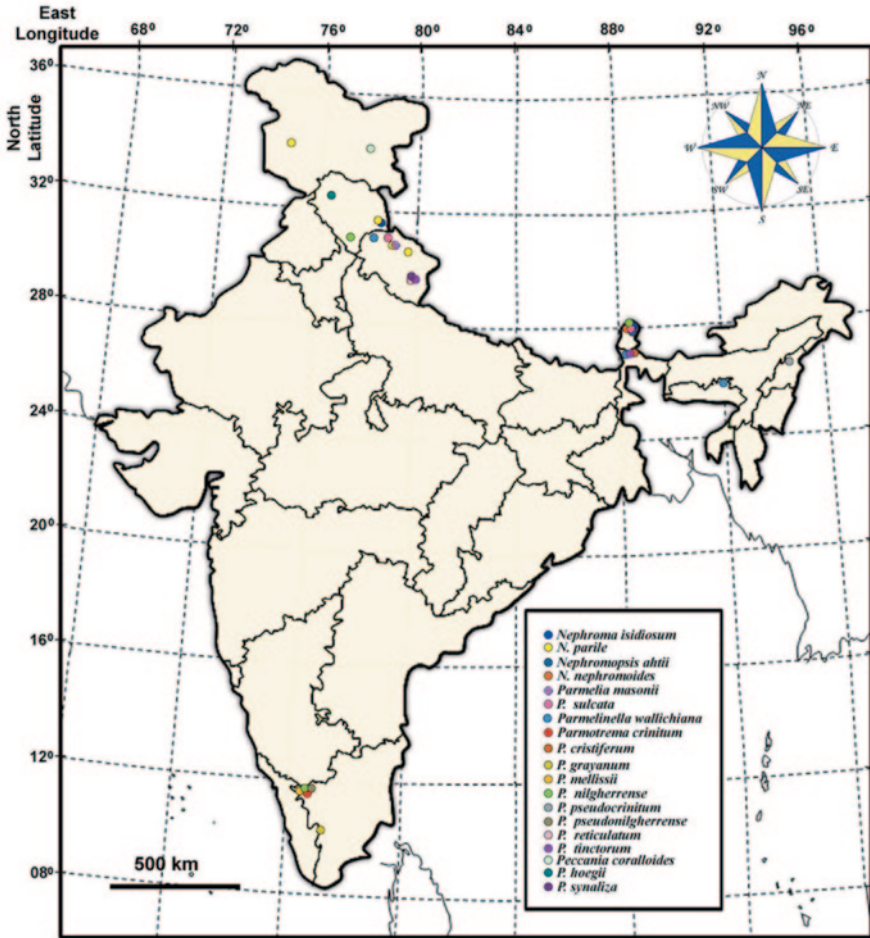


Fig. 2.47 Species distribution map of terricolous lichens—*Leprocaulon arbuscula* (Nyl.) Nyl., *L. pseudoarbuscula* (Asahina) I. M. Lamb and Ward, *Leptogium arisanense* Asahina, *L. askotense* D. D. Awasthi, *L. austroamericanum* (Malme) C. W. Dodge, *L. burnetiae* var. *burnetiae* C. W. Dodge, *L. chloromelum* (Sw.) Nyl., B. *L. cyanescens* (Rabenh.) Körb., *L. delavayi* Hue, *L. denticulatum* Nyl., *L. furfuraceum* (Harm.) Sierk, *L. gelatinosum* (With.) J. R. Laundon, *L. indicum* D. D. Awasthi and Akhtar, *L. moluccanum* (Pers.) Vain., *L. pedicellatum* P. M. Jørg., *L. phyllocarpum* var. *phyllocarpum* (Pers.) Mont., *L. platynum* (Tuck.) Herre, *L. pseudopapillosum* P. M. Jørg., *L. saturninum* (Dicks.) Nyl.—in India

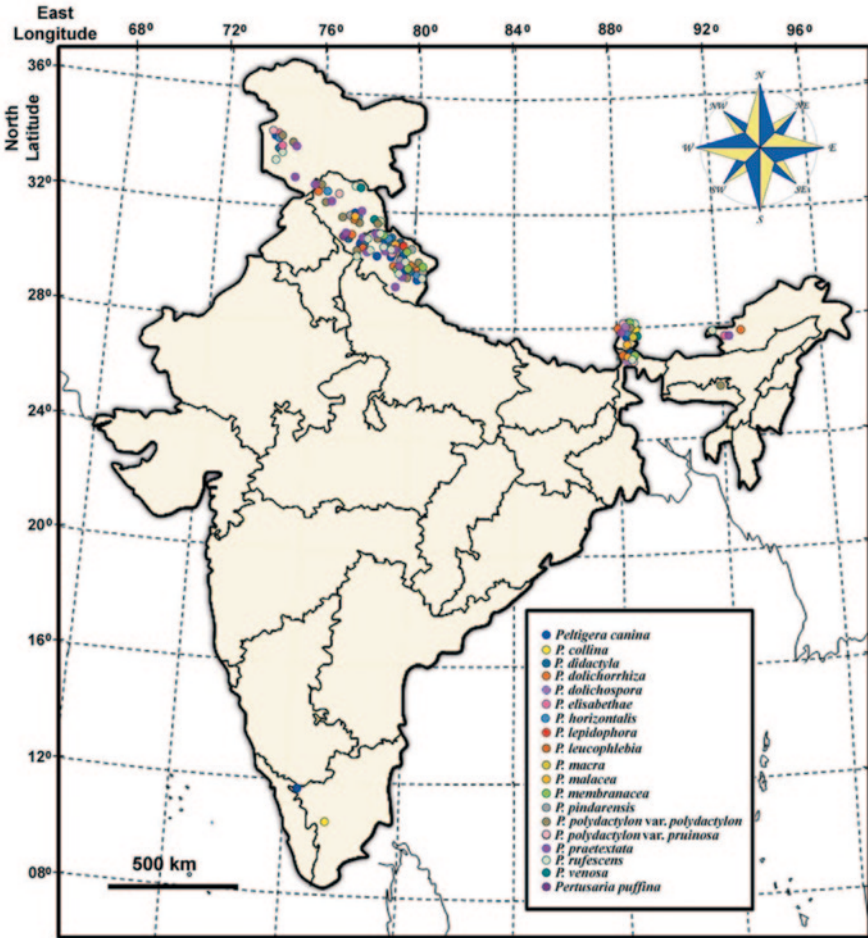


**Fig. 2.48** Species distribution map of terricolous lichens—*Leptogium teretiusculum* (Flörke in Wallr.) Arnold, *L. trichophorum* Müll. Arg., *L. ulvaceum* (Pers.) Vain., *Lethariella cashmeriana* Krog, *L. cladonioides* (Nyl.) Krog, *Lobaria isidiosa* (Müll Arg.) Vain., *L. kurokawae* Yoshim., *L. pseudopulmonaria* Gyeln., *L. retigera* (Bory) Trevis., *Lobothallia praeradiosa* (Nyl.) Hafellner, *Melanelia hepatizon* (Ach.) A. Thell, *M. stygia* (L.) Essl., *Melanelixia fuliginosa* (Fr. ex Duby) O. Blanco and al., *M. villosella* (Essl.) O. Blanco and al., *Melanohalea exasperatula* (Nyl.) O. Blanco and al., *Mycobilimbia hunana* (Zahlbr.) D. D. Awasthi, *M. philippina* (Vain.) D. D. Awasthi, *Nephroma expallidum* (Nyl.) Nyl., *N. helveticum* var. *helveticum* Ach.—in India



**Fig. 2.49** Species distribution map of terricolous lichens—*Nephroma isidiosum* (Nyl.) Gyeln., *N. parile* (Ach.) Ach., *Nephromopsis ahtii* (Randlane and Saag) Randlane and Saag, *N. nephromoides* (Nyl.) Ahti and Randlane, *Parmelia masonii* Essl. and Poelt, *P. sulcata* Taylor in J. Mackay, *Parmelinella wallichiana* (Taylor) Elix and Hale, *Parmotrema crinitum* (Ach.) M. Choisy, *P. cristiferum* (Taylor) Hale, *P. grayanum* (Hue) Hale, *P. mellissii* (C. W. Dodge) Hale, *P. nilgherrense* (Nyl.) Hale, *P. pseudonilgherrense* (Asahina) Hale, *P. reticulatum* (Taylor) M. Choisy, *P. tinctorum* (Despr. ex Nyl.) Hale, *Peccania coralloides* (Massal.) Massal., *P. hoegii* D. D. Awasthi, *P. synaliza* (Ach.) Forssell—in India

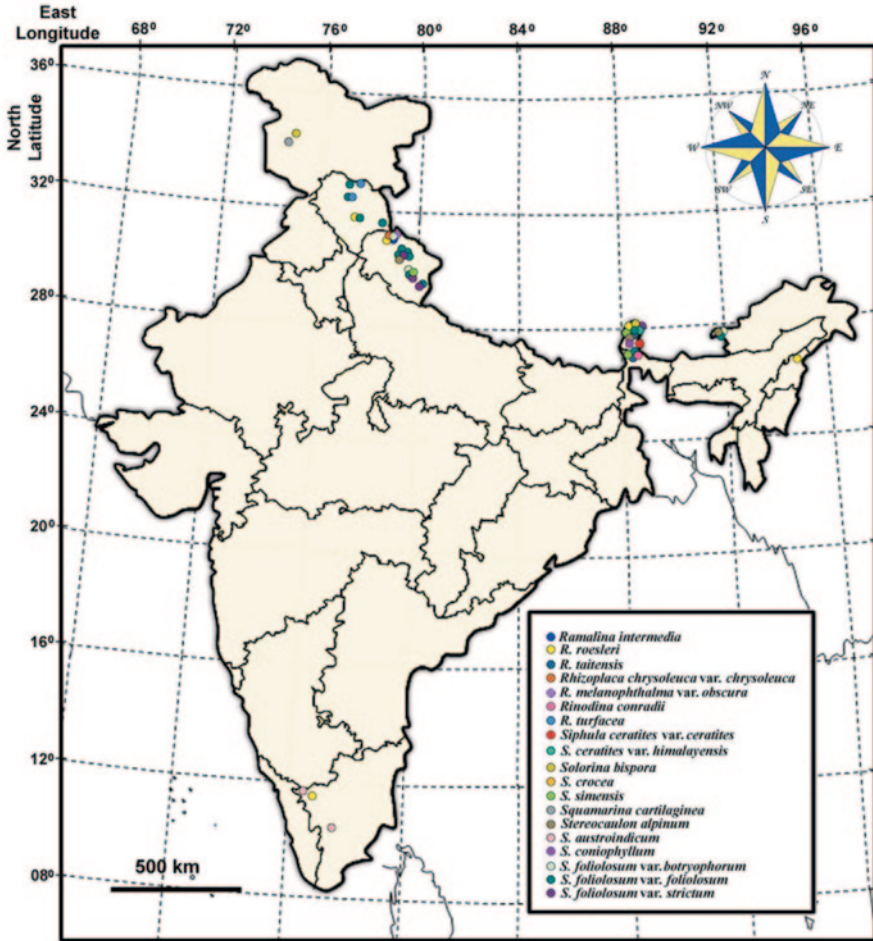




**Fig. 2.50** Species distribution map of terricolous lichens—*Peltigera canina* (L.) Willd., *P. collina* (Ach.) Schrad., *P. didactyla* (With.) J. R. Laundon, *P. dolichorrhiza* (Nyl.) Nyl., *P. dolichospora* (Lu) Vitik., *P. elisabethae* Gyeln., *P. horizontalis* (Huds.) Baumg., *P. lepidophora* (Nyl.) Bitter, *P. leucophlebia* (Nyl.) Gyeln., *P. macra* Vain., *P. malacea* (Ach.) Funck., *P. membranacea* (Ach.) Nyl., *P. pindarensis* D. D. Awasthi and M. Joshi, *P. polydactylon* var. *polydactylon* (Neck.) Hoffm., *P. polydactylon* var. *pruinosa* Gyeln., *P. praetextata* (Flörke) Zopf, *P. rufescens* (Weiss.) Humb., *P. venosa* (L.) Hoffm., *Pertusaria puffina* A. W. Archer and Elix—in India



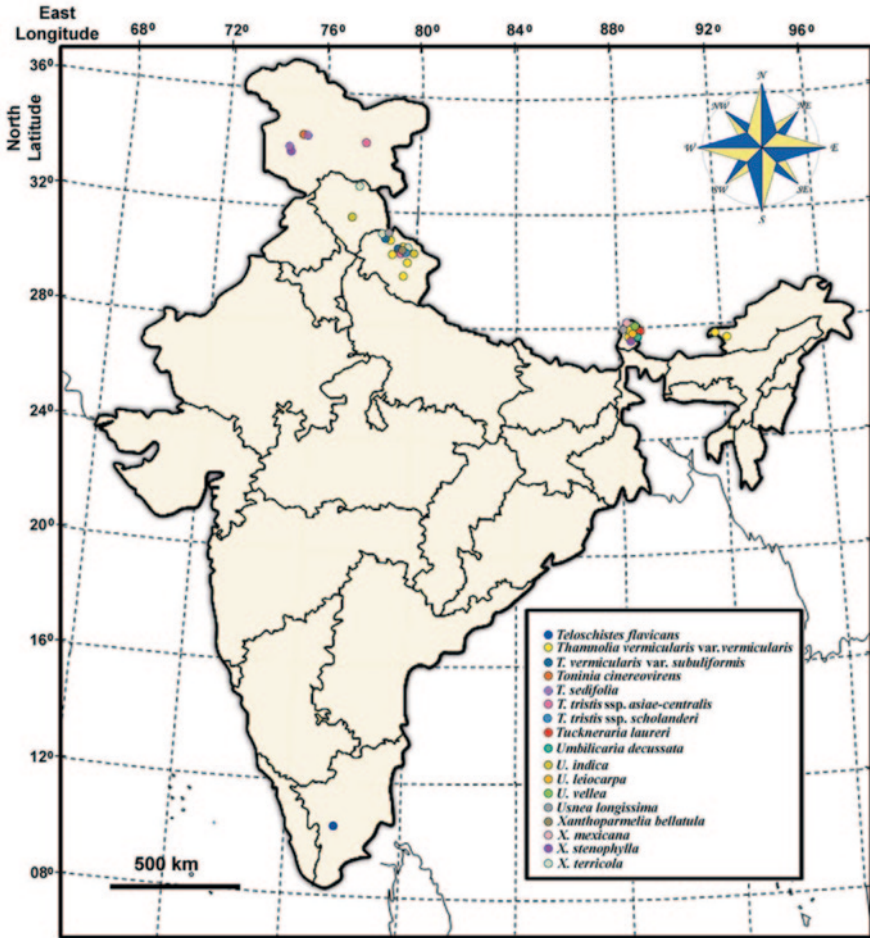
**Fig. 2.51** Species distribution map of terricolous lichens—*Phaeophyscia ciliata* (Hoffm.) Moberg, *P. constipata* (Norrl. and Nyl.) Moberg, *P. decolor* (Kashiw.) Essl., *P. hispidula* (Ach.) Moberg, *Physcia adscendens* (Fr.) H. Olivier, *P. caesia* (Hoffm.) Fűrnr., *P. dilatata* Nyl., *P. tribacoides* Nyl., *Physconia deterosa* (Nyl.) Poelt, *P. grisea* (Lam.) Poelt, *P. muscigena* (Ach.) Poelt, *Placidium lachneum* (Ach.) de Lesd., *P. squamulosum* (Ach.) Breuss, *Pseudocyphellaria ceylonensis* H. Magn., *Psora decipiens* (Hedw.) Hoffm., *P. himalayana* (C. Bab.) Timdal, *Punctelia borrieri* (Sm.) Krog, *P. rudecta* (Ach.) Krog, *Ramalina hossei* Vain.—in India



**Fig. 2.52** Species distribution map of terricolous lichens—*Ramalina intermedia* (Delise ex Nyl.) Nyl., *R. roesleri* (Hochst.) Hue, *R. taitensis* Nyl., *Rhizoplaca chrysoleuca* var. *chrysoleuca* (Sm.) Zopf, *R. melanophthalma* var. *obscura* (J. Steiner) D. D. Awasthi, *Rinodina conradii* Körb., *R. turfacea* (Wahlenb.) Körb., *Siphula ceratites* var. *ceratites* (Wahlenb.) Fr., *S. ceratites* var. *himalayensis* Räsänen, *Solorina bispora* Nyl., *S. crocea* (L.) Ach., *S. simensis* Hochst., *Stereocaulon alpinum* Laurer, *S. austroindicum* I. M. Lamb, *S. coniophyllum* I. M. Lamb, *S. foliosum* var. *botryophorum* (Müll. Arg.) I. M. Lamb, *S. foliosum* var. *foliosum* Nyl., *S. foliosum* var. *strictum* (Bab.) I. M. Lamb—in India



Fig. 2.53 Species distribution map of terricolous lichens—*Stereocaulon glareosum* (Savicz) H. Magn., *S. himalayense* D. D. Awasthi and I. M. Lamb., *S. macrocephalum* Müll. Arg., *S. massartianum* Hue, *S. myriocarpum* Th. Fr., *S. paradoxum* I. M. Lamb, *S. piluliferum* Th. Fr., *S. pomiferum* P. A. Duvign., *S. sasaki* var. *sasaki* Zahlbr., *Sticta cyphellulata* (Müll. Arg.) Hue, *S. fuliginosa* (Hoffm.) Ach., *S. henryana* Müll. Arg., *S. indica* D. Awasthi and Upreti, *S. limbata* (Sm.) Ach., *S. nylanderiana* Zahlbr., *S. orbicularis* (R. Br.) Hue, *S. platyphylloides* Nyl., *S. praetextata* (Räsänen) D. D. Awasthi, *S. weigellii* (Ach.) Vain.—in India



**Fig. 2.54** Species distribution map of terricolous lichens—*Teloschistes flavicans* (Sw.) Norman, *Thamnolia vermicularis* var. *vermicularis* (Sw.) Ach. ex Schaer., *T. vermicularis* var. *subuliformis* (Ehrh.) Schaer., *Toninia cinereovirens* (Schaer.) Massal., *T. sedifolia* (Scop.) Timdal, *T. tristis* ssp. *asiae-centralis* (Magn.) Timdal, *T. tristis* ssp. *scholanderi* (Lyngé) Timdal, *Tuckneraria laureri* (Kremp.) Randle and A. Thell, *Umbilicaria decussata* (Vill.) Zahlbr., *U. indica* Frey, *U. leiocarpa* DC., *U. vellea* (L.) Ach., *Usnea longissima* Ach., *Xanthoparmelia bellatula* (Kurok. and Filson) Elix. and al., *X. mexicana* (Gyeln.) Hale, *X. stenophylla* (Ach.) Ahti and D. Hawksw., *X. terricola* Hale, Nash and Elix.—in India

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# Erratum

## **Terricolous Lichens of India: Taxonomic Keys and Description**

Himanshu Rai, Roshni Khare, Dalip Kumar Upreti and Teuvo Ahti

H. Rai, D. K. Upreti (eds.), *Terricolous Lichens in India*,

DOI 10.1007/978-1-4939-0360-3,

© Springer Science+Business Media New York 2014

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DOI 10.1007/978-1-4939-0360-3\_3

The publisher regrets the error published in the print and online versions of this book for the “Key to the terricolous lichen genera of India” in Chapter 2, pages 21–26. See the following page for the corrections.

The online version of the original chapter can be found at

[http://dx.doi.org/10.1007/978-1-4939-0360-3\\_2](http://dx.doi.org/10.1007/978-1-4939-0360-3_2)



**Key to the terricolous lichen genera of India:**

- |      |  |                          |
|------|--|--------------------------|
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- 89a. Apothecia lecanorine, thallus greenish to yellowish grey ..... *Squamarina*
90. Squamules free and upright, white, pink, tan, gray or brown, often white below, margins sometimes white or pruinose; apothecia usually black, globose, hypothecium usually brown ..... *Psora*
- 90a. Squamules brown-grey to ashy white, apothecia red-brown to black, flat to convex, adnate, 0.4–1 mm diameter, hypothecium hyaline, spores 10–18 × 5–8 μm .... *Lecidoma*
91. Thallus possessing prothallus, subcrustose to squamulose, heteromerous, photobiont *Nostoc*, spores colourless, simple ..... *Fuscopannaria*
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# Glossary

**Acicular** Needle-shaped

**Acuminate** Gradually narrowing to a point, like a spade on a playing card

**Acute** Sharply pointed at the apex

**Adnate** Tightly adherent to surface

**Aggregated** Clustered

**Amyloid** Staining blue, blue-purple, blue-black or reddish in iodine

**Anastomosing** A joining together to form a vein-like network

**Anisotomic** Unequal branching, with a distinct main axis and smaller side branches

**Alga (pl. Algae)** A simple plant composed of a single cell or a string of cells

**Apical** Situated at the tip

**Apothecia** A disk- or cup-shaped spore-producing organ

**Appressed** Lying flat or pressed closely against the substrate

**Arachnoid** Cobweb-like in texture or pattern

**Areolate** Sharply divided into tile-like areolae

**Areole (pl. Areolae)** A small, irregular, often angular patch of thallus delimited by cracks or chinks in the thallus surface

**Ascending** Directed upwards at a rather narrow angle, curving upwards

**Ascus (pl. Asci)** The sac-like structure in which the spores are formed

**Aseptate** Simple without cross walls

**Bacilliform** Rod-like, usually more than three times as long as wide (cf. cylindrical)

**Biatorine** Apothecia lacking a true exciple when mature and generally strongly convex

- Biseriate** In two rows
- Bitunicate** With two functional wall layers
- Bullate** Of a surface, blistered or puckered
- Bullate-areolate** With convex (blister-like) areolae
- Canaliculated** Channelled
- Capitate** Having a well-formed head
- Cephalodium (pl. Cephalodia)** Delimited region within, or a warty, squamulose or shrubby structure on the surface of a lichen thallus containing a photobiont (cyanobacterium) different to that characteristic of the rest of the thallus
- Clavate** Club-like
- Concave** Hollowed out, basin-like
- Concolorous** Of the same colour throughout
- Confluent** Coming together; running into one another
- Conglutinate** Glued together
- Conidioma (pl. Conidiomata)** Multihyphal, conidium-containing structure
- Constricted** Of lobes, of varying width
- Contiguous** Touching but not fused
- Convex** Equally rounded, broadly obtuse
- Convolute** Of lobes, the upper surface strongly convex and the lower surface strongly concave
- Coralloid** Usually of isidia, coral-like, often brittle
- Coriaceous** Leathery
- Cortex** The outermost layer of the thallus, which if present, consists of hyphae which may appear either cellular or fibrous
- Corymbose** Arranged in clusters
- Crateriform** Crater-like
- Crenate** Having the edge toothed with rounded teeth
- Crenulate** Delicately crenate
- Crisped** Of a margin, crumpled or thrown into waves
- Crustose** Crust-like lichens that are closely attached to their substrate and lack a lower cortex
- Cryptolecanorine** Of an ascoma, with a reduced or inapparent thalline margin

- Cuneate** Wedge-shaped, thinner at one end than the other
- Cylindrical** Rod-like, usually 2–3 times as long as wide (cf. bacilliform)
- Cyphella (pl. Cyphellae)** A pore recessed into the lower thallus surface where medullary hyphae protrude
- Dactyl** A hollow, nodular to cylindrical protuberance, somewhat resembling a swollen isidium, bounded by a cortex, often opening at the apex to expose the medulla
- Decorticate** Lacking a cortex
- Decumbent** Resting on a substratum, with the end turned up
- Deflexed** Bent sharply downwards
- Delimited** Having a distinct restricting edge or margin
- Dendroid** Irregularly branched, tree-like in form but not in size
- Dichotomous** Branching, frequently successively into two more or less equal arms (cf. anisotomic, isotomic)
- Diffract** Cracked into small areas, areolate
- Diffuse** Widely or loosely spreading, with no distinct margin
- Digitate** Finger-like
- Dimorphic** Having two forms, e.g. both a crustose and fruticose thallus as in *Cladonia*
- Disc** The upper surface of a lichen apothecium enclosed by, but not including, the margin
- Dorsiventral** Flattened, with upper and lower surfaces
- Ecorticate** Without a cortex
- Effigurate** Obscurely lobed
- Effuse** Stretched out flat, especially as a spreading growth without a distinct margin
- Ellipsoidal** Oval in outline and three-dimensional
- Endemic** Occurring naturally only in a single geographic area
- Entire** Without teeth; more or less smooth on the margin
- Epicortex** A thin homogeneous polysaccharide-like layer over the surface of the cellular cortex which may have regular pores when viewed with the scanning electron microscope
- Epispore** The fundamental and often outer wall of a spore which determines its shape (cf. perispore)

- Epihyemenium** Uppermost (often pigmented) layer of hymenium, above asci
- Epithecium** The uppermost portion of the hymenium formed by the tips of the paraphyses, which are frequently expanded or branched, often pigmented and sometimes containing tiny granules
- Epruinose** Lacking pruina
- Erose** Eroded
- Erumpent** Bursting through the surface
- Evanescent** Short-lived
- Exciple** The margin around the apothecial disc
- Fasciculate** Of branching or growth form, many branches arising from one point like a bundle of sticks; of rhizines, many simple rhizines arising from one point or region
- Farinose** Of soredia, like grains of flour (use  $\times 10$  lens)
- Fenestrate** With open areas or slits
- Filamentous** Thread-like
- Filiform** Very narrow in section
- Fissured** Cracked, split
- Flabellate** Fan-shaped
- Flexuose** Having a wavy or zigzag form
- Foliose** Having leaf-like lobes with distinct upper and lower surfaces
- Foveolate** Honey-combed
- Fruticose** A shrubby or hair-like growth form attached only at the base or free growing and normally with no clearly distinguishable upper and lower surfaces
- Furcate** Forked, as in rhizines with two long, terminal branches
- Fusiform** Spindle-like, narrower at the ends than in the middle
- Glabrous** Without an indumentum
- Glaucous** Having a bluish grey bloom
- Globose** Globe-shaped
- Granular** Like grains of sugar
- Gyrose** Circularly folded or brain-like
- Halonate** Of the outer layer of spores, surrounded by a transparent coat
- Hemiangiocarpic** Of a sporocarp, opening before quite mature

**Heteromerous** Having mycobiont and photobiont components in well-defined layers, with the photobiont in a more or less distinct zone between the upper cortex and the medulla

**Holdfast** A process from the base of the thallus for attachment, often disc-like

**Homoiomorous** Having mycobiont and photobiont components intermixed throughout thallus, not layered

**Hyaline** Colourless, translucent

**Hymenium** The spore-bearing layer of fungal reproductive structures (ascoma)

**Hyphae** Fungal filaments, often modified and resembling round or angular cells

**Hypothallus** The first and purely fungal (without photobiont) layer upon which an alga-containing thallus may develop often projecting beyond the thallus onto substrate

**Hypothecium** The tissue just below the hymenium (and subhymenium) but above the exciple, often with a distinctive colour or texture but sometimes merging with the exciple

**Imbricate** With overlapping layers

**Immarginate** Without a margin

**Immersed** Embedded in the substratum

**Indeterminate** Effuse

**Innate** Immersed

**Involute** With margins rolled in

**Isidia** Small, asexual reproductive structures on lichens that are minute and finger-like, covered with a cortex and contain the photobiont

**Isidiate** Having isidia

**Isidioid** Resembling isidia

**K** Medullary reaction to potassium hydroxide (of chemical reactions)

**KC** Medullary reaction to potassium hydroxide followed by calcium hypochlorite

**Labriform** Lip-shaped

**Lacerate** With irregularly cut or torn margins

**Laciniate** Deeply, usually irregularly divided into narrow, more or less pointed segments; of lobes, developing laciniae or being lacinia-shaped; of margins, deeply, usually irregularly, divided into narrow, more or less pointed segments

**Laminal** In the middle, or main part, of the thallus surface, rather than on the margins

- Lateral** At or near edge, especially side or secondary branches
- Lax** Loosely arranged
- Lecanorine** An apothecial margin which usually contains a photobiont and often resembles the thallus, but not the disk, in colour and texture
- Lecideine** An apothecial margin with no photobiont cells that often resembles the disk, but not the thallus, in colour and texture
- Leptose** Having the surface dissolved into soredia, loose, powdery, without any cortex
- Lichen** Composite organism made up of a fungus and an alga, a cyanobacterium, or all three
- Linear** Very narrow, with parallel margins
- Lobate** Bearing lobes
- Lobe** A flattened branch or projection
- Lobulate** Having lobules
- Lobule** Tiny, lobe-like, dorsiventral asexual reproductive outgrowths
- Maculate** Spotted or blotched
- Margin** Referring either to the outer edge of foliose or crustose lichen thalli or the outer boundary of apothecia
- Marginate** With a well-defined edge or margin
- Matt** With a dull surface
- Medulla** A loosely arranged layer of hyphae below the upper cortex and photobiont zone
- Membranaceous** Parchment-like
- Monophyllous** Consisting of a single lobe, often undulate or folded
- Multiseptate** With many septa
- Muriform** Like a wall, having many transverse and longitudinal septa (cf. submuriform)
- Mycobiont** The fungal component of a lichen
- Oblong** Proportioned about 1:3–6 with the margins more or less parallel; rectangular but ends not necessarily squared off
- Oblique** With sides unequal
- Obtuse** Rounded or blunt at the apex
- Ochraceous** Of a dull, yellow colour

- Ocular chamber** A cavity lying on the longitudinal axis of an ascus and penetrating into the thickened apical dome of the ascus from the ascus sac
- Opaque** Dull, not translucent
- Orbicular** Circular or nearly so, more or less flat
- Oriented** Turned in one direction
- Ostiole** A small opening or pore, in fungi and lichens, a pore at the apex of a perithecium through which spores are extruded, adj. ostiolar
- Oval** Broadly elliptic, narrowing somewhat from middle to rounded ends
- Ovoid** Egg-shaped, three-dimensional
- P** Medullary reaction to a fresh alcoholic solution of paraphenylene diamine (of chemical reactions)
- Palmate** Radiately lobed or divided
- Papilla (pl. Papillae)** Minute protuberance on the surface of a cell
- Paraphyses** A sterile filament (sometimes branched, attached at the base and free at the summit) found amongst the asci in the hymenium
- Parathecium** Of apothecia, the outside hyphal layer
- Pedicellate** Stalked
- Peltate** Shield-like
- Pendulous** Hanging down from a support
- Periclinal** Curved in the direction of, or parallel to, the surface or the circumference
- Perithecia** A globose or flask-shaped fruiting body (ascoma) completely enclosed with protective sterile tissue and with an opening pore at the tip
- Photobiont** The photosynthetic component in a lichen, either algae in the strict sense (e.g. green algae) or cyanobacteria (blue-green algae), or both
- Podetium (pl. Podetia)** The upright, hollow stalk formed by an elongated apothecium
- Polyphyllous** Of a foliose thallus, divided into many lobes
- Proper exciple** Tissue at the margin of an apothecium adjacent to the hymenium and hypothecium and inside the thalline exciple when present, without photobiont cells
- Prosoplectenchyma** Tissue consisting of cells with thickened walls and longish lumina and in which hyphal elements are recognisable as hyphae

**Prothallus** A web of fungal hyphae (white, reddish or blue-black) at the margin of the thallus, lacking photobiont, often projecting beyond the thallus onto the substratum

**Pruina** Powdery frost-like deposit, typically composed of calcium oxalate

**Pruinose** Having a frosted appearance caused by a deposit of pruina

**Pseudocyphella (pl. Pseudocyphellae)** A break or opening in the cortex where medullary hyphae protrude; it may be round, irregular, angular, or a minuscule pore

**Pubescent** Having a somewhat dense cover of short, weak, soft hairs

**Pulvinate** In cushions

**Punctiform** Dot-like

**Pustule** A pimple or blister-like swelling, hollow within, often eroding, adj. pustulate

**Pycnidium (pl. Pycnidia)** Minute, flask-shaped, fungal fruiting body

**Pyriform** Pear-shaped

**Radiating** Spreading from a central point

**Recurved** Curved downward or backward

**Reniform** Kidney-shaped

**Reticulum** A network, adj. reticulate

**Revolvute** Of a margin, rolled downwards; of lobes, weakly convolute, the upper surface weakly convex, the lower surface canaliculated

**Rhizine** Root-like hyphae on the lower side of a foliose lichen thallus

**Rimose** Cracked

**Rosette** A flower-like pattern arrayed around a common point of attachment; a circular cluster, e.g. of lobes

**Rugose** Wrinkled

**Rugulose** Delicately or minutely wrinkled

**Scabrous** Rough to touch with short, hard emergences or hairs

**Schizidia** Propagule formed from upper layers of thallus splitting off as scale-like segments from main lobes

**Scrobiculate** Coarsely pitted, foveolate

**Scyphus** An expanded, cup-like structure often terminating a podetium



- Secondary metabolite** Natural product of restricted taxonomic distribution with no obvious metabolic function
- Septate** Divided by cross walls
- Septum (pl. Septa)** A cross wall
- Seriate** Arranged in rows
- Sessile** Attached directly to the thallus surface without a stalk of any kind
- Simple** Not divided; unbranched
- Soralium (pl. Soralia)** An area of the thallus in which the cortex has broken down or cracked and soredia are produced
- Sorediate** Having soredia
- Soredium (pl. Soredia)** Asexual reproductive structure that is powdery to granular, not covered with a well-defined cortex, and contains both algal (photobiont) and fungal (mycobiont) components
- Spores** Microscopic reproductive bodies released from the apothecia of a lichen
- Sporoblastidia** Small subsidiary locules in a thick-walled spore, especially in *Physciaceae*
- Spot test** Tests for colour reactions obtained by applying a liquid chemical reagent to lichen
- Squamiform** Scale-like
- Squamule** Small flakes or scales of a lichen, lifting from the substrate, at least at the edges, often rounded, ear-like, or lobed
- Squamulose** Composed of or characterized by having squamules—an intermediate growth form between crustose and foliose
- Squarrose** Branching at right angles from a single main axis, like a bottlebrush
- Sterile** Without sexual reproductive structures
- Subfoliose** Almost foliose, pertaining to the overall growth form of a crustose thallus that has marginal lobes showing some tendency to curve upwards
- Submuriform** Of spores, having both transverse and longitudinal septa, but in which not more than 15 cells may be seen (cf. muriform)
- Substratum** The underlying layer, or base to which a lichen is fixed
- Subulate** Tapering from a wide base to a sharp apex, more or less circular in cross section, awl-shaped
- Superficial** On the surface

**Terete** Circular in cross section—cylindrical and smooth

**Terminal** Borne at the end

**Thalline exciple** Tissue at the margin of an apothecium external to proper exciple and having a structure similar to that of the vegetative thallus with photobiont cells included in it

**Thallus (pl. Thalli)** The vegetative part of a lichen consisting of both algal and fungal components, a more or less undifferentiated plant body

**Tholus** A thickened inner part of the ascus wall in the ascus apex

**TLC** Thin layer chromatography—a technique used to separate chemical compounds

**Tomentose** Densely covered with matted short hairs

**Tomentum** A layer of hair-like structures other than discrete rhizines

**Translucent** More or less transparent

**Transverse** Across the width

**Trichotomous** Branching almost equally in three parts

**Truncate** With an abruptly transverse end, as if cut off

**Tufted** Of rhizines, a simple rhizine densely fasciculate at the tip

**UV** Response of cortex to UV light

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