ISSN 0376-5561
Geophytology 45(1): 9-19
May 2015

Altitudinal distribution of cetrarioid lichens in Govind Wildlife Sanctuary, Garhwal Himalaya, Uttarakhand, India

Gaurav K. Mishra and Dalip K. Upreti*

CSIR-National Botanical Research Institute, Rana Pratap Marg, Lucknow-226001, India
E-mail: gmishrak@gmail.com; upretidk@rediffmail.com*
*Corresponding author

Manuscript received: 02 March 2015
Accepted for publication: 30 March 2015

ABSTRACT

Mishra G. K. & Upreti D. K. 2015. Altitudinal distribution of cetrarioid lichens in Govind Wildlife Sanctuary, Garhwal Himalaya, Uttarakhand, India. Geophytology 45(1): 9-19.

The present study records distribution of eight genera and thirteen species of cetrarioid lichens from seven localities, situated at different altitudes, in Govind Wildlife Sanctuary, Uttarkashi district, Uttarakhand. *Cetraria nigricans* Nyl., is a new addition to the lichen flora of Uttarakhand. A key to the genera and species together with short descriptions, synonyms and basionyms of each taxon are also provided. The cetrarioid lichen genus *Cetrelia* is dominant in altitude ranges of 2001-3500 m, whereas *Cetraria* and *Flavocetraria* are dominant in higher altitude range of 3501-4000 m. The altitude range 3501-4000 m exhibits maximum diversity of cetrarioid lichens in the area. The corticolous cetrarioid lichens exhibit dominance at 1501-3500 m altitude whereas terricolous species at 3501-4000 m. Among the different localities situated in lower altitudes, Sankari and Taluka have the poor diversity of cetrarioid lichens, whereas Har-ki-Doon and Morinda Tal areas show their luxuriant growth. The probable reason for poor diversity in the Sankari and Taluka areas may be heavy anthropogenic pressure as the inhabitants of the villages largely depend for their fuel and fodder needs on the nearby forest area which resulted into destruction of forest.

Key-words: Cetrarioid lichen diversity, altitudinal distribution, Govind Wildlife Sanctuary, Garhwal Himalaya, Uttarakhand, India.

INTRODUCTION

Cetrarioid lichens are characterized by an erect foliose or subfruticose growth form of the thallus being loosely attached to the substrate, presence of marginal apothecia and pycnidia (Randlane et al. 2013). The first cetrarioid lichen genus *Cetraria* was described by Acharius (1810). Rassadina (1950) reported 76 species of the genus *Cetraria* from different part of the world. Subsequently, Kärnefelt (1979), Kärnefelt et al. (1992), Lai (1980a, b), Mark et al. (2012), Nelson et al. (2011), Randlane and Saag (1993, 1998a, b), Randlane et al. (1994), Thell et al. (2005, 2009), Culberson and Culberson (1968), Beguinot (1982), Elix (1994) and Lai (2001) described other species of the cetrarioid lichens from different regions of the world.

The first report of cetrarioid lichens from India was made by Babington (1852) based on the collection of Strachey and Winterbottom (in 1947-48) from Central Himalaya and reported three new cetrarioid lichen species [*Allocetraria ambigua* (C. Bab.) Kurok. & M. J. Lai, *Allocetraria stracheyi* (C. Bab.) Kurok. & M. J. Lai and *Nephromopsis stracheyi* (C. Bab.) Müll. Arg.] as new taxa. Awasthi (2000) listed 25 cetrarioid lichen species from the Indian subcontinent. Divakar

and Upreti (2006) reported one new species and three species as new records for the Indian lichen flora.

Geographically, Govind Wildlife Sanctuary is situated between latitudes 35°55'N and 31°17.30'N and longitudes 77°47.30'E and 78°37.30'E and has wide altitudinal gradients between 1300 and 6400 m. The flora and fauna of the sanctuary has rich ecological diversity and includes many unique temperate and alpine plants including lichens. The forests of deep river valleys in the lower altitudinal zone of Naitwar-Sankari, situated between lower altitude of 1501-2000 m, are mostly composed of *Quercus leucotrichophora* and *Pinus roxburghii*, whereas altitudes between 2001 and 3500 m has dominance of *Abies, Cedrus, Juglans, Quercus* and *Rhododendron* trees. The areas with altitudes from 3501 to 4000 m and above exhibit luxuriant growth of *Abies, Betula utilis, Cedrus deodara, Quercus semecarpifolia, Picea* and *Taxus* trees. Different species of lichens together with bryophytes form the major portion of cryptogamic vegetation of the forest in most of the zones.

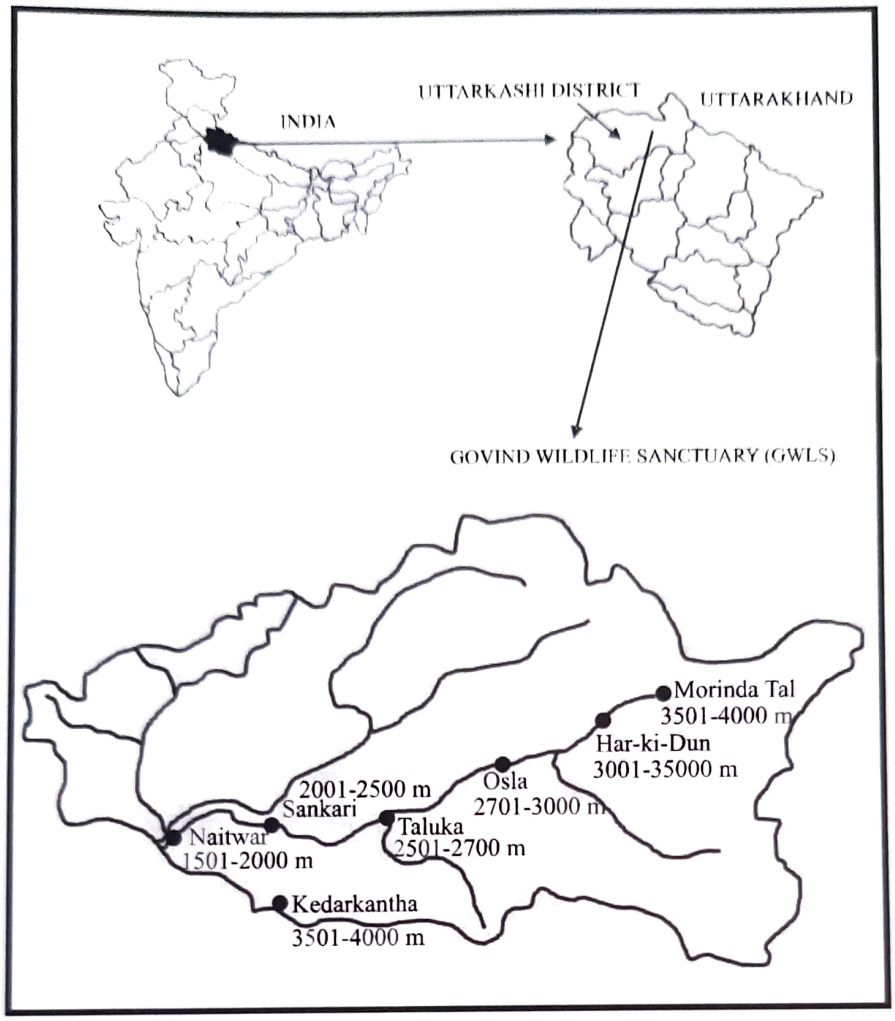
Though, only scattered information is available on cetrarioid lichens from the Indian Himalayan region, their ecology and altitudinal distribution in the region have not been studied so far. The present study therefore aims to know more systematically the distribution and ecology of cetrarioid lichens taxa in the Himalaya.

MATERIAL AND METHODS

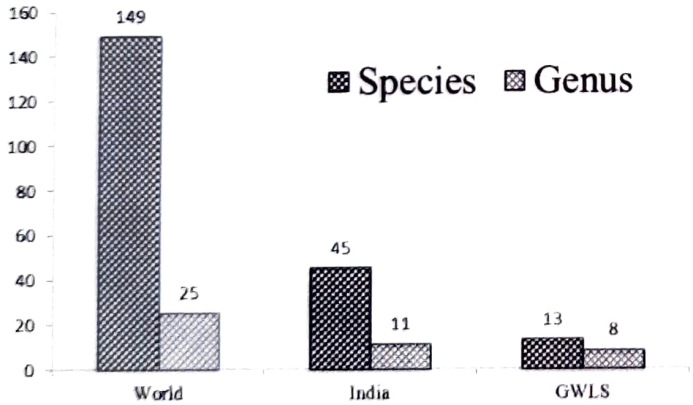
The present study is based on more than 100 cetrarioid lichen specimens collected from different localities of Govind Wildlife Sanctuary in Uttarkashi district, Uttarakhand (Text-figure 1). The collected specimens were investigated morphologically, anatomically and chemically. Thin hand-cut sections of apothecia and thallus were mounted in water and observed under a compound microscope (LEICA S8APO and LEICA DM500). The colour tests were

Table 1. List of sampling sites with name of collected species and genus, GPS coordinates and altitudes.

Sr. No.	Lichen Genus	Lichen Species	Localities	North latitudes	East longitudes	Altitude
1	*Nephromopsis*	*Nephromopsis laii* (A. Thell & Randlane) Saag & A.Thell	Sankari	31°04'30.83"	78°11'08.79"	2800 m
			Talahuti 2 km from Taluka	31°04'40.01"	78°15'04.4"	2155 m
			Judatal to Kedarkantha	31°03'0.833"	78°11'0.261"	3260 m
			Judatal near nursery	31°02' 00.667"	78°10'46.205"	2812 m
			Osla, near potato field	31°07'07.52"	78°21'07.17"	2883 m
		Nephromopsis pallescens (Schaer.) Park	Judatal near nursery	31°02' 00.667"	78°10'46.205"	2312 m
2	*Allocetraria*	*Allocetraria stracheyi* (C. Bab.) Kurok. & M.J.Lai	Har-ki-Dun, enroute to Morinda Tal	31°09'34.22"	78°28'00.15"	3643 m
3	*Cetraria*	*Cetraria muricata* (Ach.) Eckfeldt	Har-ki-Dun, enroute to Morinda Tal	31°09'34.22"	78°28'00.15"	3695 m
		Cetraria nigricans Nyl.	Near Har-ki-Dun guest house	31°08'33.09"	78°25'08.44"	3513 m
4	*Cetrelia*	*Cetrelia braunsiana* (Müll. Arg.) W.L. Culb. & C.F. Culb.	Kedarkantha	31°03'0.833"	78°11'0.261"	2900 m
			In and around Judatal	31°02'00.667"	78°10'46.205"	2820 m
			Judatal near nursery	31°02'00.667"	78°10'46.205"	2812 m
		Cetrelia cetrarioides (Delise ex Duby) W.L. Culb. & C.F. Culb.	Har-Ki-Dun near forest guest house	31°08'33.09"	78°25'08.44"	3513 m
			Enroute to Taluka	31°04'35.45"	78°15'03.51"	2155 m
			Enroute to Jakhol, Dharakhand	31°06'72.8"	78°14'37.5"	2450 m
			Osla	31°07'07.52"	78°21'07.17"	2684 m
			In and around Judatal	31°02'00.667"	78°10'46.205"	2820 m
			Kedarkantha	31°03'0.833"	78°11'0.261"	2900 m
			Judatal to Kedarkantha	31°03'0.833"	78°11'0.261"	3260 m
		Cetrelia pseudolivetorum (Asahina) W.L. Culb. & C.F. Culb.	Judatal to Kedarkantha	31°03'0.833"	78°11'0.261"	3260 m
5	*Cetreliopsis*	*Cetreliopsis rhytidocarpa* (Mont. & Bosch.) M. J. Lai	Kedarkantha to Judatal	31°08'33.09"	78°25'08.44"	3500 m
6	*Flavocetraria*	*Flavocetraria cucullata* (Bellardi) Kärnefelt & A. Thell	Har-ki-Dun, enroute to Morinda Tal	31°09'34.22"	78°28'00.15"	3643 m
		Flavocetraria nivalis (L.) Kärnefelt & A. Thell	Har-ki-Dun, enroute to Morinda Tal	31°09'34.22"	78°28'00.15"	3695 m
7	*Melanelia*	*Melanelia hepatizon* (Ach.) A. Thell.	Har-ki-Dun, enroute to Morinda Tal	31°09'34.22"	78°28'00.15"	3695 m
8	*Parmotrema*	*Parmotrema thomsonii* (Stirt.) A. Crespo, Divakar & Elix	Judatal near nursery	31°02'00.667"	78°10'46.205"	2812 m



Text-figure 1. Map of Govind Wildlife Sanctuary showing localities surveyed for cetrarioid lichen collection.



Text-figure 2. Diversity of cetrarioid lichens in Govind Wildlife Sanctuary

performed with the usual reagents, i.e. K (5% potassium hydroxide), C (Aqueous solution of calcium hypochloride) and P (paraphenylene diamine). Lichen substances were identified with thin layer chromatography (TLC) in solvent system A (toluene: dioxane: acetic acid; 180: 60: 8 ml) using the technique of Orange et al. (2001). The specimens were identified up to species level with the help of publications of Awasthi (2007) and Randlane et al. (2013) and preserved in the herbarium of CSIR-National Botanical Research Institute, Lucknow (LWG) (Table1).

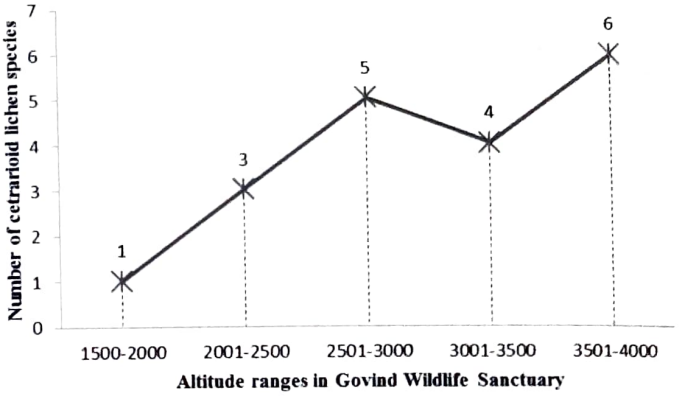
RESULT AND DISCUSSION

Thirteen species of cetrarioid lichens were recognized in the study area. These species are represented in all the seven localities of the sanctuary (Text-figure 2). Among the different cetrarioid lichen genera, *Cetrelia* with three species, showed its dominance followed by the *Cetraria*, *Flavocetraria* and *Nephromopsis* with two species each. Out of 25 genera and 149 species of cetrarioid lichens known from the world, 11 genera and 45 species are known from India (Singh & Sinha 2010) (Text-figure 2). *Cetreliopsis hypotrachyna* (Müll. Arg.) Randlane & Saag, *Nephromopsis isidioidea* (Räsänen) Randlane & Saag, *Parmotrema subthomsonii* (D. D. Awasthi)

A. Crespo et al. and *Nephromopsis sikkimensis* (Divakar & Upreti) Randlane & Saag, are endemic to India.

The localities within altitude range 1501-3500 m, e.g. Naitwar, Sankari, Taluka and Osla, exhibit occurrence of following six foliose cetrarioid lichens: *Cetrelia braunsiana* (Müll. Arg.) W. L. Culb. & C. F. Culb., *C. cetrarioides* (Delise) W. L. Culb. & C. F. Culb., *C. pseudolivetorum* (Asahina) W. L. Culb. & C. F. Culb., *Nephromopsis laii* (A. Thell & Randlane) Saag & A. Thell, *N. pallescens* (Schaer.) Y. S. Park and *Parmotrema thomsonii* (Stirt.) A. Crespo et al.. The Osla and Taluka localities having exposed terrains provide suitable habitat for light loving cetrarioid lichen taxa to grow.

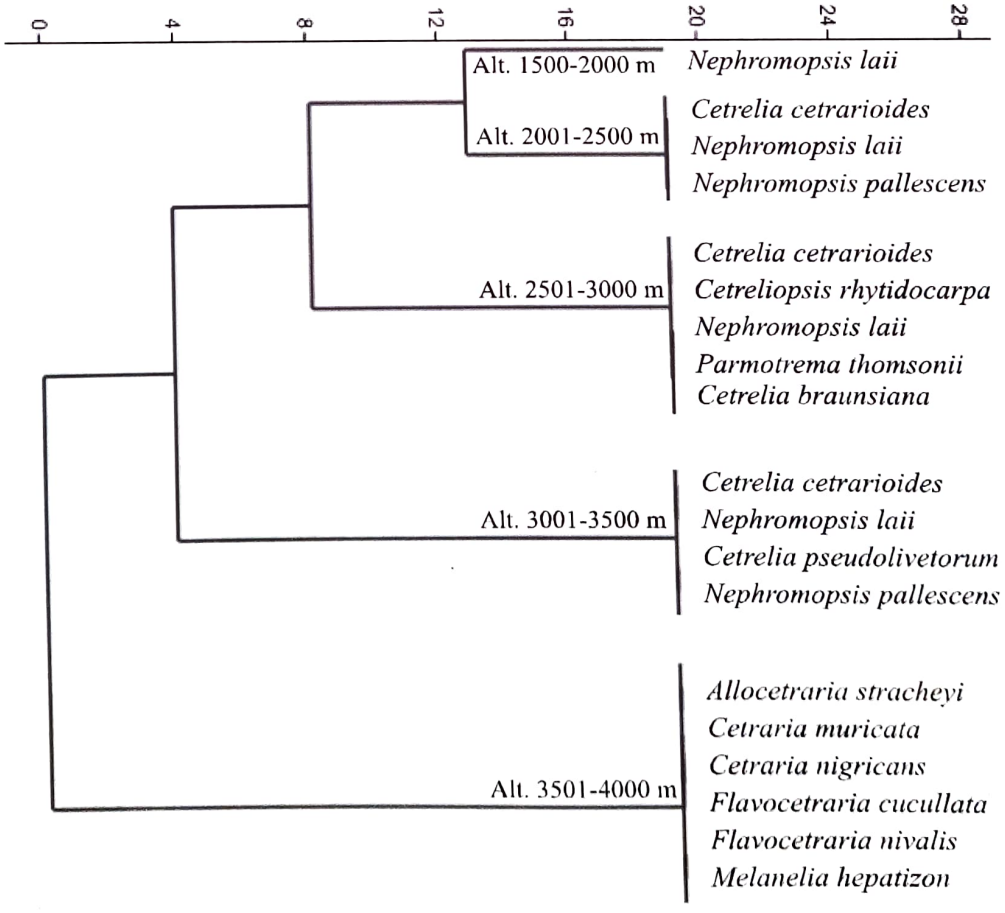
Naitwar and Sankari, situated between altitudes of 1501 and 2000 m, comprise tree vegetation of *Acer oblongum*, *Pinus roxburghii*, *Quercus leucotrichophora* and *Juglanus regia*. En-route localities from Sankari to Taluka, between altitudes of 2001 and 2500 m comprise rich vegetation of coniferous



Text-figure 3. Cetrarioid lichen diversity in different altitudinal ranges of Govind Wildlife Sanctuary.

trees with Oak and *Rhododendron* exhibiting luxuriant growth of *C. cetrarioides, N. laii* and *N. pallescens*.

The localities en-route from Taluka to Osla and Sankari to Judatal, between altitudes of 2501 and 3500 m, show dominance of *Quercus semecarpifolia* trees. These trees show luxuriant growth of cetrarioid lichens on their trunk and twigs. The *Rhododendron* and *Juglans regia* trees, in the forest of Osla, bear *Cetrelia braunsiana, Cetrelia cetrarioides, Cetrelia*



Text-figure 4. Altitudinal distribution pattern of cetrarioid lichens in Govind Wildlife Sanctuary.

pseudolivetorum, together with *Nephromopsis laii* and *N. pallescens.* The altitude range of 3001-3500 m, en-route from Judatal to Kedarkantha and Osla to Har-ki-Dun, exhibits varied altitudinal gradient with luxuriance of coniferous trees (*Cedrus deodara, Picea* and *Abies*). The species of *Nephromopsis* grow luxuriantly on conifer trees.

The higher altitude localities of the sanctuary (3501 to 4000 m), en-route Har-ki-Dun to Morinda Tal and Kedarkantha, are mostly devoid of trees and have small bushes and large exposed grassland. Due to non availability of trees, the cetrarioid lichens in the region mostly grow on rock, soil and branches of shrubs. The common saxicolous (rock inhabiting) cetrarioid lichens (*Melanelia* sp.) grow on exposed boulders. The flat top of the boulders, covered with small bushes, provides shade where cetrarioid lichens grow in association with grasses and other herbaceous plants.

Cetraria muricata (Ach.) Eckfeldt, *C. nigricans* Nyl., *Flavocetraria cucullata* (Bellardi) Kärnefelt & A. Thell and *F. nivalis* (L.) Kärnefelt & A. Thell grow on soil along the boulders together with grasses and other herbs. The small shrubs bear luxuriant growth of *Cetreliopsis hypotrachyna* (Müll. Arg.) Randlane & Saag. The alpine region of the study area showed restricted occurrence of seven species of fruticose, subfruticose and foliose cetrarioid lichens. Har-ki-Dun, Kedarkantha and Osla localities have many sites having rich diversity of cetrarioid lichens.

Some of the cetrarioid lichen species, e.g. *Nephromopsis laii* (A. Thell & Randlane) Saag & A. Thell, *Cetrelia cetrarioides* (Delise ex Duby) W. L. Culb. & C. F. Culb., *Nephromopsis pallescens* (Schaer.) Park, *Cetrelia braunsiana* (Müll. Arg.) W. L. Culb. & C. F. Culb. and *Cetrelia pseudolivetorum* (Asahina) W. L. Culb. & C. F. Culb, exhibit their restricted distribution in lower altitudes between 1501 and 3500 m whereas some cetrarioid lichen species are restricted to higher altitudes, e.g. *Allocetraria stracheyi* (C. Bab.) Kurok. & M. J. Lai, *Cetraria muricata* (Ach.) Eckfeldt., *Cetraria nigricans* Nyl., *Flavocetraria cucullata* (Bellardi) Kärnefelt & A. Thell, *Flavocetraria nivalis* (L.) Kärnefelt & A. Thell and *Melanelia hepatizon* (Ach.) A. Thell. The forest type also influences the occurrence of species up to a greater extent (Text-figures 3, 4).

The recorded taxa represent both corticolous and terricolous species of the cetrarioid genera, which make it possible to compare the worldwide distribution patterns and available distribution records of the lichen taxa. This plays vital role in carrying various long term environmental studies in the area

Key to the cetrarioid genera in Govind Wildlife Sanctuary

1. Thallus fruticose or subfruticose.....2
   1a. Thallus foliose.....4
2. Cortex double layered, exciple 3-layered ....*Cetraria*
   2a. Cortex single layered, exciple 2-layered.....3
3. Asci with broad axial body, ascospores globose to subglobose.....*Allocetraria*
   3a. Asci with narrow axial body, ascospores ellipsoid.....*flavocetraria*
4. Thallus upper surface olive-brown to brown black.....*Melanelia*
   4a. Thallus upper surface otherwise.....5
5. Apothecia nephromoid, except small size.....*Nephromopsis*
   5a. Apothecia non nephromoid.....6
6. Thallus upper side white maculate, lacking pseudocyphellae.....*Parmotrema*
   6a. Thallus upper side emaculate, pseudocyphellae present.....7
7. Thallus foliose to subfruticose, pseudocyphellae black rimmed with or without black fibrils.....*Cetreliopsis*
   7a.Thallus foliose, pseudocyphellae without black rimmed and fibrils.....*Cetrelia*

Genus: *Allocetraria* Kurok. & M. J. Lai

A total of nine species are reported from the world (Randlane et al. 2013). Five species are reported from the Himalayan region of India (Singh & Sinha 2010) and a single terricolous species is known from Govind Wildlife Sanctuary.

Allocetraria stracheyi (C. Bab.) Kurok. & M. J. Lai

Bull. Natl. Sci. Mus. Tokyo, B, 17: 62. 1991; D. D. Awasthi, Comp. Macrolich. India, Nepal and Sri Lanka: 31. 2007.

Description: Thallus fruticose, terricolous, prostrate to erect, caespitose, up to 2.5 cm tall, branched; lobes up to 2 mm wide, sometimes apically almost radially symmetrical; upper surface yellowish grey to brownish, convex; lower side also yellow to brownish, concave, lacunose to scrobiculate; medulla white to ochraceous. Apothecia rare, marginal to submarginal, up to 6 mm in diameter , ascospores 7 × 4.5 µm.

Chemistry: Medulla K–, C–, P–, KC–; usnic acid in cortex, lichesterinic, protolichesterinic, secalonic acid present in TLC.

Distribution in India: Jammu & Kashmir, Sikkim and Uttarakhand; usually in shady places, on the boulders and rocks of soil.

Specimens examined: Uttarakhand, Uttarkashi district, Govind Wildlife Sanctuary, Har-ki-Dun, en-route to Morinda Tal, alt.3643 m, on rock, 12.06.2012, D. K. Upreti and R. Bajpai 12-016184, 12-018553(LWG)

Genus: *Cetraria* Ach.

About 30 species of the genus are reported from the world (Randlane et al. 2013). Six species are reported from India (Singh & Sinha 2010) and two species are known from the study area.

Key to the species

1. Pseudocyphellae indistinct, marginal cilia long, upper surface dark brown to black.....*C. nigricans*

   1a. Pseudocyphellae district, marginal cilia rare or short, upper surface brown .....*C. muricata*

Cetraria muricata (Ach.) Eckfeldt.

Bull. Torrey Bot. Club 22: 240. 1895; G.P. Sinha & Kr. P. Singh, Macrolich. Sikkim: 84. 2005; D. D. Awasthi, Comp. Macrolich. India, Nepal and Sri Lanka: 70. 2007.

Description: Thallus fruticose, terricolous, densely branched, terete, up to 1.5 mm thick; upper surface brown, with oval-elliptic, plane, white pseudocyphellae; medulla white solid. Apothecia not seen.

Chemistry: Medulla K–, C–, P–, KC–; protolichesterinic and rangiformic acid present in TLC.

Distribution in India: Karnataka, Sikkim, Tamil Nadu and Uttarakhand; usually in shady places, on the boulders and rocks.

Specimens examined: Uttarakhand, Uttarkashi district, Govind Wildlife Sanctuary, Har-ki-Dun, Morinda Tal, alt. 3695 m, on rock, D. K. Upreti & R. Bajpai 12-011475 (LWG)

Cetraria nigricans Nyl.

Herb. Musci Fenn.: 109. 1859; Kärnefelt, Opera Bot. 46: 117. 1979; D. D. Awasthi, Bull. Bot. Surv. India 24(1-4): 25. 1982; G. P. Sinha & Kr. P. Singh, Macrolich. Sikkim: 84. 2005.

Description: Thallus fruticose, terricolous, up to 3 cm tall, branched, lobes to up to 2 mm wide, rarely canaliculated, marginal projections sparse; upper side dark brown to black, rarely sorediate, lower side pale brown to brown; marginal pseudocyphellae very narrow to indistinct, medulla white. Apothecia to 10 mm in diameter, ascospores 5 × 2.5 µm.

Chemistry: Medulla K–, C–, P–, KC–; lichesterinic and protolichesterinic acid present in TLC.

Distribution in India: Sikkim; usually in shady places, on the boulders and rocks.

Specimens examined: Uttarakhand, Uttarkashi district, Govind Wildlife Sanctuary, near Har-ki-Dun guest house, alt. 3513 m, on rock, 12.06.2012, D. K. Upreti and R. Bajpai 12-018544 (LWG)

Genus: *Cetrelia* W. L. Culb. & C. F. Culb.

Cetrelia is a cosmopolitan genus of about 18 species reported from the world (Randlane et al. 2013). Nine species of this genus are known from Indian (Singh & Sinha 2010) and three species occur in the study area.

Key to the species

1. Thallus sorediate, lacking isidia....*C. cetrarioides*

   1a. Thallus isidiate, lacking soredia.....2

2. Thallus containing alectoronic and α-collatolic acids, medulla C-, KC+ pink.....*C. braunsiana*

2a. Thallus containing olivetoric acid, medulla C+ pink and KC+ red ..... *C. pseudolivetorum*

***Cetrelia braunsiana* (Müll. Arg.) W. L. Culb. & C. F. Culb.**

Contr. U.S. Natl. Herb. 34: 493. 1968; D. D. Awasthi, Geophytology 5(2): 184. 1975 & Comp. Macrolich. India, Nepal and Sri Lanka: 73. 2007. *Parmelia braunsiana* Müll. Arg., Flora 64: 506. 1881.

Description: Thallus foliose, corticolous, medium to large, 8-12 cm across; lobes 0.5-1.7 cm broad; upper surface gray or ashy-white and commonly isidiate, lower surface black, the margins brown or grayish like the color of the upper surface, rhizines black, sparse; upper cortex 19-25 µm thick; medulla 109–264 µm thick; lower cortex 16–22 µm thick. Apothecia rare, submarginal, perforate, about 0.5 mm broad; hymenium 93–109 µm thick; subhymenial layers 40–53 µm thick, underlain by a dense layer of algae, asci 8 spored, ascospores ovoid, 12–15 × 8–9 µm. Pycnidia rare, marginal, black, pruinose; conidia 1 × 4-6 µm, rod-shaped, ends slightly enlarged.

Chemistry: Medulla K–, C–, KC + pink, PD–; alectoronic and α-collatolic acids and atranorin present in TLC.

Distribution in India: Himachal Pradesh, Jammu & Kashmir, Sikkim, Nagaland, Uttarakhand in the Himalayas; on tree trunks and over boulders.

Specimens examined: Uttarakhand, Uttarkashi district, Govind Wildlife Sanctuary, Kedarkantha, alt. 2900 m, on bark, Oct 2013, R. Bajpai 13-021907, 13-020023/B (LWG) in and around Judatal, alt. 2820 m, on bark, 5.10.2013, R. Bajpai 13-019885/B, 13-020147, 13-020033 13-19885, 13-21907, 13-21903, 13-020147 (LWG) en-route to Judatal near nursery, alt. 2812 m, on bark, 05.10.2013, R. Bajpai 13-19832, 13-023909 (LWG).

***Cetrelia cetrarioides* (Delise ex Duby) W. L. Culb. & C. F. Culb.**

Contr. U. S. Natl. Herb. 34: 498. 1968; D. D. Awasthi, Comp. Macrolich. India, Nepal and Sri Lanka: 73. 2007.

Description: Thallus foliose, corticolous, medium to large, 7-15 cm across, lobes (0.5-) 1-1.5 cm broad, upper surface uniformly tan or pale, lower surface jet-black, the margins brown, usually punctate with many small pores; rhizines few, black, rarely pale. Apothecia extremely rare, 1-2 mm broad, ascospores ovoid, 12–14 × 19–24 µm. Pycnidia unknown.

Chemistry: Medulla K–, C–, KC– or KC+ pinkish, P–; perlatolic or imbricaric acid and atranorin present in TLC.

Distribution in India: Arunachal Pradesh, Himachal Pradesh, Jammu & Kashmir, Manipur, Nagaland, Sikkim, Uttarakhand and West Bengal-hills; usually in shady places, on the bark of trees, rock faces, and over boulders.

Specimens examined: Uttarakhand, Uttarkashi district, Govind Wildlife Sanctuary, Har-Ki-Dun near forest guest house, alt. 2700-3300 m, on bark, 22.09.2013, G. K. Mishra (LWG); 10.06.2012, D. K. Upreti & R. Bajpai 12-016113 (LWG), en-route to Taluka, alt. 2155 m, on bark, 05.04.2013, R. Bajpai 13-023409 (LWG); en-route to Jakhol, Dharakhand, alt. 2450 m, on bark, R. Bajpai 12-018345 (LWG); Osla, back side of forest guest house, alt. 2684 m, on bark, 10.06.2012, D.K. Upreti & R. Bajpai 12-016117, 12-1017432, 12-017475, 12-018520 (LWG), in and around Judatal, alt. 2820 m, on bark, 5.10.2013, R. Bajpai 13-019886, 13-020023/A, 13-21908 (LWG), Kedarkantha, alt. 2900 m, on bark, Oct 2013, R. Bajpai 13-021916, 13-021903, 13-021908 (LWG), Judatal to Kedarkantha, alt. 3400 m, on bark, 06.10.2013, R. Bajpai 13-020098 (LWG), before Har-ki-Dun forest guest house, alt.3222mt, on rock, 11.06.2012, D. K. Upreti and R. Bajpai 12-016144/B, 12-017488(LWG).

***Cetrelia pseudolivetorum* (Asahina) W.L. Culb. & C.F. Culb.**

Contr. U.S. Natl. Herb. 34: 519. 1968; D. D. Awasthi, Comp. Macrolich. India, Nepal and Sri Lanka: 74. 2007.

Description: Thallus foliose, corticolous, small to large, lobes 0.5-1.5 cm broad; upper surface grayish or grayish-white or uniformly light, simple or coralloid isidia; lower surface black, the margins brown or colored like the upper surface, not punctate; rhizines few, black, upper cortex 16-30 µm thick; medulla 150–

200 µm thick. Apothecia very rare, 0.4–1.7 cm broad, mostly perforate; hymenium 53–78 µm thick, hyaline; subhymenial layers 40-53 µm thick, asci 8 spored, ascospores, ellipsoid, (11–) 16–22 × 9–12 µm. Pycnidia unknown.

Chemistry: Medulla K–, C+ pink or red, KC+ pink to red, P–; contains atranorin, olivetoric acid, anziaic acid present in TLC.

Distribution in India: Himachal Pradesh, Nagaland, Sikkim and Uttarakhand; usually on rock or over boulders with bryophytes.

Specimens examined: Uttarakhand, Uttarkashi district, Govind Wildlife Sanctuary, Judatal to Kedarkantha, alt. 2871 m, on bark, 06.06.2013, R. Bajpai 13-020018/C, 13-020088 (LWG)

Genus: *Cetreliopsis* M. J. Lai

Altogether, 7 species are known from world (Randlane et al. 2013). Three cetreliopsis taxa are reported from India (Singh & Sinha 2010) and only one species is known from Govind Wildlife Sanctuary.

Cetreliopsis rhytidocarpa (Mont. & Bosch.) M. J. Lai

Quart. J. Taiwan Mus. 33: 218. 1980; D. D. Awasthi, Comp. Macrolich. India, Nepal and Sri Lanka: 76. 2007.

Description: Thallus foliose to subfruticose, corticolous, up to 12 cm across, lobes 10-15 mm wide, upper side yellowish grey to grey black blotched along the marginal area; laminal pseudocyphellae with or without fibrils along rim; lower side brown-black with similar pseudocypahellae, rhizinate; medulla white; isidia and soredia absent. Apothecia marginal, up to 11 mm in diameter , peltate to slightly nephromoid; ascospores 5–11 × 4–7 µm. Pycnidia absent.

Chemistry: Medulla K+ yellow to red, C–, KC–, P+ orange; fumarprotocetraric, protocetraric, traces of lichesterinic and protolichesterinic acids present in TLC.

Distribution in India: Arunachal Pradesh, Nagaland and Sikkim; usually in shady places, on the trees.

Specimens examined: Uttarakhand, Uttarkashi district, Govind Wildlife Sanctuary, en-route to Kedarkantha around Judatal, alt. 3500 m, 05.11.2012, on bark, R. Bajpai 12-016675 (LWG)

Genus: *Flavocetraria* Kärnefelt & A. Thell

The genus *Flavocetraria* is represented by three species in the world (Randlane et al. 2013), of which two species are represented by in India and in the study area.

Key to the species

1. Thallus yellowish, lobes tubular ..... *F. cucullata*

   1a. Thallus yellow to darker yellow, lobes flat ..... *F. nivalis*

Flavocetraria cucullata (Bellardi) Kärnefelt & A. Thell

Acta Bot. Fenn. 150: 81. 1994; D. D. Awasthi, Comp. Macrolich. India, Nepal and Sri Lanka: 160. 2007.

Description: Thallus foliose to subfruticose, terricolous, suberect to erect, up to 3 cm tall, subdichotomously branched, lobes up to 4 mm wide, canalicuate by connivent margins, lacking isidia and soredia; lower side minutely pseudocyphellate. Thallus 140-250 µm thick. Apothecia absent.

Chemistry: Medulla K–, C–, KC–, P–; lichesterinic and protolichesterinic acids present in TLC.

Distribution in India: Sikkim and Uttarakhand; usually in moist places, on the boulders and rocks of soil.

Specimens examined: Uttarakhand, Uttarkashi district, Govind Wildlife Sanctuary, en-route to Morinda Tal, alt.3643 m, 12 .06. 2012, on rock, D. K. Upreti & R. Bajpai 12-018550 (LWG)

Flavocetraria nivalis (L.) Kärnefelt & A. Thell

Acta Bot. Fenn. 150: 84. 1994; D. D. Awasthi, Comp. Macrolich. India, Nepal and Sri Lanka: 161. 2007.

Description: Thallus fruticose, terricolous, flat to erect, up to 5 cm across, lobes up to 7 mm wide, lacking marginal papillae, isidia and soredia absent; lower side foveolate, with minute pseudocyphellae. Apothecia lacking.

Chemistry: Medulla K–, C–, KC–, P–; no lichen substance present in TLC.

Distribution in India: Uttarakhand; usually in moist places, on the boulders and rocks of soil.

Specimens examined: Uttarakhand, Uttarkashi district, Govind Wildlife Sanctuary, around Morinda Tal, alt. 3695 m, 12.06. 2012, D. K. Upreti & R. Bajpai 12-011472 (LWG)

Genus: *Melanelia* Essl.

Altogether, four species of the genus are reported of genus *Melanelia* from the world (Randlane et al. 2013), of which only single species is known from Govind Wildlife Sanctuary.

Melanelia hepatizon (Ach.) A. Thell

Nova Hedwigia 60: 419. 1995.

Description: Thallus foliose, saxicolous, adnate up to 7 cm across; lobes up to 1.5 mm wide; upper side greenish brown to brown black, occasionally pseudocyphellate at ends of lobes, pseudocyphellae 0.1-0.5 mm long; lower side black, rhizinate. Apothecia absent.

Chemistry: Medulla K–, C–, KC–, P+ orange; stictic and norstictic acid present in TLC.

Distribution in India: Arunachal Pradesh, Jammu & Kashmir and Uttarakhand; usually grows on open exposed boulder and rock.

Specimens examined: Uttarakhand, Uttarkashi district, Govind Wildlife Sanctuary, en-route to Morinda Tal, alt. 3643 m, on soil mosses, 12.06.2012, D. K. Upreti & R. Bajpai 12-018582 (LWG)

Genus: *Nephromopsis* Müll. Arg.

Altogether, 21 species of the genus *Nephromopsis* are known from the world (Randlane et al. 2013). Singh & Sinha (2010) provided a detailed account of 8 species from India. Govind Wildlife Sanctuary is represented by only two species.

Key to the species

1. Apothecia marginal ..... *N. laii*

1a. Apothecia laminal to submarginal .... *N. pallescens*

Nephromopsis laii (A. Thell & Randlane) Saag & A.Thell

Bryologist 100: 111. 1997; D. D. Awasthi, Comp. Macrolich. India, Nepal and Sri Lanka: 301. 2007.

Description: Thallus foliose, corticolous, adnate, up to 12 cm across; upper side greenish yellow, lacking fibrils along margins; lower side brownish; pseudocyphellate on lamellae and plug-like outgrowth; rhizines short; medulla white. Apothecia marginal, round to reniform, up to 5 mm in diameter, exciple two layered;

Table 2. Distribution of major phorophytes in different altitudinal zone of Govind Wildlife Sanctuary and their cetrarioid lichen diversity.

Altitudes (m)	Major Phorophytes	Lichen Species	Localities
1501-2000	*Pinus roxburghii*	*Nephromopsis laii* (A. Thell & Randlane) Saag & A.Thell	Naitwar and Sankari
	Quercus leucotrichophora	*Nephromopsis laii* (A. Thell & Randlane) Saag & A.Thell	
2001-2500	*Quercus leucotrichophora*	*Cetrelia cetrarioides* (Delise ex Duby) W.L. Culb. & C.F. Culb.	Taluka, Jakhol, Dharkand, Talahuti, Judatal near nursery
		Nephromopsis laii (A. Thell & Randlane) Saag & A.Thell	
	Cedrus deodara	*Nephromopsis pallescens* (Schaer.) Park	
2501-3000	*Quercus semecarpifolia*	*Cetrelia braunsiana* (Müll. Arg.) W.L. Culb. & C.F. Culb.	Way to Kedarkantha, Judatal near to nusery, Osla
		Cetrelia cetrarioides (Delise ex Duby) W.L. Culb. & C.F. Culb.	
		Cetrelia pseudolivetorum (Asahina) W.L. Culb. & C.F. Culb	
	Rhododendron	*Nephromopsis laii* (A. Thell & Randlane) Saag & A.Thell	
		Nephromopsis pallescens (Schaer.) Park	
	Pinus roxburghii	*Cetrelia braunsiana* (Müll. Arg.) W.L. Culb. & C.F. Culb.	
	Cedrus deodara	*Cetrelia cetrarioides* (Delise ex Duby) W.L. Culb. & C.F. Culb.	
3001-3500	*Cedrus deodara*	*Cetrelia cetrarioides* (Delise ex Duby) W.L. Culb. & C.F. Culb.	Har-ki-Dun, Kedarkantha, Judatal near to nusery, Judatal to Kedarkantha
		Cetreliopsis rhytidocarpa (Mont. & Bosch.) M. J. Lai	
		Nephromopsis laii (A. Thell & Randlane) Saag & A.Thell	
		Parmotrema thomsonii (Stirt.) A. Crespo et al.	
	Abies	*Cetrelia cetrarioides* (Delise ex Duby) W.L. Culb. & C.F. Culb.	
3501-4000	*Betula*	No corticolous (bark inhabiting) cetrarioid lichen species found	Har-ki-Dun and Morinda Tal
	Taxus		

ascospores 5–9 × 2.5–4.5 µm.

Chemistry: Medulla K–, C–, KC–, P–; usnic acid in cortex; and lichesterinic and protolichesterinic acid present in TLC.

Distribution in India: Nagaland, Sikkim, Uttarakhand and West Bengal; usually grows on shady places of forest on tree and sometimes on rocks.

Specimens examined: Uttarakhand, Uttarkashi district, Govind Wildlife Sanctuary, en-route to Talahuti 2 km from taluka, alt. 2155 m, on bark, 5.4.2013, R. Bajpai, 13-019465, 13-01948 (LWG), Judatal to Kedarkantha, alt. 3260 m, on bark, 06.10.2013, R. Bajpai 13-020066, 13-020116 13-020018/E, 13-020048/A, 13-020016/A, 13-2005/B, 13-18855 (LWG), 05.11.2012, R. Bajpai 12-018855, 12-018976, 12-018951 (LWG), en-route to Judatal near nursery, alt. 2812 m, on bark, 05.10.2013, R. Bajpai 13-021973, 13-019896/B, 13-02005/B, 13-02005 (LWG), 4 km before Sankari en-route to Naitwar, alt. 2800 m, on bark, 7.11.2012, R. Bajpai 12-018337 (LWG), around Osla, near potato field, alt. 2883 m, 10.06.2012, D. K. Upreti & R. Bajpai 12-017470 (LWG).

***Nephromopsis pallescens* (Schaer.) Park**

Bryologist 93: 12. 1990; D. D. Awasthi, Comp. Macrolich. India, Nepal and Sri Lanka: 302. 2007.

Description: Thallus foliose, corticolous, loosely adnate, 8-16 cm across; upper side greenish yellow, scrobiculate- rugose; lower side yellowish grey; pseudocyphellae on lamellae and plug-like outgrowths, rhizines short; medulla white. Apotheica laminal to submarginal, dense, 2-3 mm in diameter , margin thin, ascospores 8–10 × 3–5 µm.

Chemistry: Medulla K–, C–, KC+ red, P–; usnic acid in cortx, lichesterinic and protolichesterinic, alectoronic and a-collatolic acid present in TLC.

Distribution in India: Arunachal Pradesh, Manipur, Nagaland, Sikkim, Uttarakhand and West Bengal hills; usually grows on shady places of trees.

Specimens examined: Uttarakhand, Uttarkashi district, Govind Wildlife Sanctuary, Judatal near nursery, alt. 2312 m, on twigs, 05.10.2013, R. Bajpai 13-020005, 13-020016/B (LWG).

Genus: *Parmotrema* A. Massal.

Out of two cetrarioid *Parmotrema* species known from the world (Randlane et al. 2013), the study area is represented by a single species.

***Parmotrema thomsonii* (Stirt.) A. Crespo et al.**

Taxon 59: 1746. 2010.

Description: Thallus foliose, corticolous, lobes up to 15 mm wide, dentate, marginally cilite; cilia 1 mm long, black and pycnidiate at apices; upper side grey to brownish; lower side centrally black with rhizines, marginal zone, brown, nude; medulla white. Apotheica submarginal up to 15 mm in diameter, always perforated, margin inflexed, ascospores 18–32 × 14–20 µm, epispore 3.2-4 µm thick.

Chemistry: Upper cortex K+ yellow; medulla K–, C–, KC+ reddish, P–; atranorin in cortex and alectoronic and α-collatolic acids in medulla in TLC.

Distribution in India: Arunachal Pradesh, Kerala, Manipur, Nagaland, Sikkim, Uttarakhand and West Bengal; usually grows on shady places of trees.

Specimens examined: Uttarakhand, Uttarkashi district, Govind Wildlife Sanctuary, Judatal near nursery, alt. 3500 m, on twigs, 06.11.2013, R. Bajpai 13-21976/A, 13-21976/B.

ACKNOWLEDGEMENTS

The authors are thankful to the Director, CSIR-National Botanical Research Institute, Lucknow for providing laboratory facilities under project BSC-106. One of the authors (GKM) is grateful to Department of Science and Technology (DST-SERB), New Delhi (SB/FT/LS-258/2012) for award of Young Scientist fellowship.

REFERENCES

Acharius E. 1810. Lichenographia Universalis. Göttingen.

Awasthi D. D. 2000. Lichenology in Indian Subcontinent. In: A Supplement to "A Hand book of lichens". Dehradun, India: Shiva Offset Press, 1-124.

Awasthi D. D. 2007. A Compendium of the Macrolichens from India, Nepal and Sri Lanka. Bishen Singh Mahendra Pal Singh, Dehradun, India.

Babington C. 1852. Lichenes Himalayenses: being an enumeration of the lichens collected in the Himalayan Mountains by Captain R. Strachey of the Bengal Engineers and J. E. Winterbottom, Esqr. F. L. S. during the years 1847- 48. Hooker's J. Bot. 4: 243- 252.

Beguinot J. 1982. Le genre *Cetrelia* (lichens *Parmeliacees*) en autunois. Presence d'une espece nouelle, *Cetrelia chicitae*. Bulletin de la

Societe d'Historie Naturelle d'Autun 104: 9-12.

Culberson W. L. & Culberson C. F. 1968. The lichen genera *Cetrelia* and *Platismatia* (Parmeliaceae). Contrib. U.S. Natl. Herb. 34: 449-558.

Divakar P. K. & Upreti D. K. 2006. Notes on some new records and new species of cetrarioid lichens from India. Botanical J. Linn. Soc. 150: 249-251.

Elix J. A. 1994. Cetrelia. pp 33-34 in Orchard, A. E. and Grgurinovic, C. (Editors) - Flora of Australia. Vol. 55. Lichens -Lecanorales 2, Parmeliaceae. Australian Government Publishing Service. Canberra.

Kärnefelt I. 1979. The brown fruticose species of *Cetraria*. Opera Botanica 46: 1-150.

Kärnefelt I., Mattsson J.-E. & Thell A. 1992. Evolution and phylogeny of cetrarioid lichens. Plant Systematics and Evolution 183: 113-160.

Lai M. J. 1980a. Notes on some *Hypogymnia* (Parmeliaceae) from East Asia. Q. J. Taiwan Museum 33: 209-214.

Lai M. J. 1980b. Studies on the cetrarioid lichens in Parmeliaceae of East Asia (I). Quart. J. Taiwan Museum 33: 215-229.

Lai M. J. 2001. Cetrarioid lichens (Parmeliaceae, Ascomycotina) of Taiwan. Endemic Species Res. 3: 49-66.

Mark K., Saag L., Saag A., Thell A. & Randlane T. 2012. Testing morphology-based delimitation of *Vulpicida juniperinus* and *V. tubulosus* (Parmeliaceae) using three molecular markers. Lichenologist 44: 757-772.

Nelsen M.P., Chavez N., Sackett-hermann E., Thell A., Randlane T., Divakar P.K., Rico V.J. & Lumbsch H.T. 2011. The cetrarioid core group revisited (Lecanorales: Parmeliaceae). Lichenologist 43: 537-551.

Orange A., James P. W, White F. J. 2001. Microchemical methods for the identification of lichens. British Lichen Society.

Randlane T. & Saag A. 1993. World list of cetrarioid lichens. Mycotaxon 48: 395-403.

Randlane T. & Saag A. 1998a. Changes in systematics of cetrarioid lichens. Sauteria 9: 43-50.

Randlane T. & Saag A. 1998b. Synopsis of the genus *Nephromopsis* (fam. Parmeliaceae, lichenized Ascomycota). Cryptogamie, Bryologie-Lichenologie 19: 175-191.

Randlane T., Saag A., Thell A. & Ahti T. 2013. Third world list of cetrarioid lichens- in a new database form, with amended phylogenetic and type information. Mycologie 34 (1): 79-84.

Randlane T., Thell A., Saag A. & Kärnefelt I. 1994. The genus *Tuckneraria* Randlane & Thell - a new segregation in the family Parmeliaceae. Act Bot. Fennica 150: 143-151.

Rassadina K. A. 1950. *Cetraria* in the U.S.S.R. Trudy Botanicheskogo Instituta Akademii Nauk S.S.S.R., ser. 2, Sporovye Rastenija 5: 171-304. (in Russian).

Singh K. P. & Sinha G. P. 2010. Indian Lichen: An Annotated checklist (Eds.). Botanical Survey of India.

Thell A., Hognabba F., Elix J. A., Feuerer T., Karnefelt I., Myllys L., Randlane T., Saag A., Stenroos S., Ahti T. & Seaward M. R. D. 2009. Phylogeny of the cetrarioid core (Parmeliaceae) based on five genetic markers. Lichenologist 41: 489-511.

Thell A., Randlane T., Saag A. & Karnefelt I. 2005. A new circumscription of the lichen genus *Nephromopsis* (Parmeliaceae, lichenized Ascomycetes). Mycol. Progress 4: 303-316.