



## Lichen genus *Usnea* (Parmeliaceae, Ascomycota) in Uttarakhand, India

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### Abstract

*Usnea* is a widespread fruticose lichen popularly known for its medicinal properties across the world. Though it has been mentioned in many floristic studies reported from Uttarakhand, India, no detailed taxonomic account has been conducted for the past two decades. The present study was based on specimens deposited in lichen herbarium of National Botanical Research Institute (LWG), personal herbarium of D.D. Awasthi (AWAS) and herbarium of the department of botany, Lucknow University (LWU). A total of 28 species, including seven new additions to Uttarakhand, namely *U. dendritica* Stirt., *U. lucea* Mot., *U. norketti* G. Awasthi, *U. pseudosinensis* Asahina, *U. sinensis* Mot., *U. spinosula* Stirt., *U. subflorida* Stirt. are presented along with key to species.

**Key words** – Fruticose – herbarium – taxonomy

### Introduction

The lichen genus *Usnea* Dill ex Adans belonging to family Parmeliaceae (Ascomycota) (Eriksson 2005), is a cosmopolitan fruticose lichen commonly found hanging from trees. *Usnea* can easily be recognised by its thread like morphology, central cartilaginous axis and presence of usnic acid (Clerc 1998, Ohmura 2001, 2012). The variation in morphological characters such as colour of the thallus, thickness of main branch and length of thallus, makes it difficult to distinguish one species of *Usnea* from another. According to Clerc (1998), morphological features of *Usnea* that are constant and that don't change with the changing environmental conditions of the geographical area should be used to distinguish species of *Usnea*. Such characters include pigmentation of basal part of the thallus, cortex and medulla; density of fibrils, shape of the branches, branching type and ratio of cortex, medulla and axis (C/M/A) in longitudinal section.

Lichen genus *Usnea* is represented by occurrence ca. 300 species in the world (Ohmura 2012) and India represents 60 species (Singh & Sinha 2010). Motyka (1938) published the first world monograph of genus *Usnea* and divided *Usnea* into six subgenera viz., *Protousnea* Motyka, *Neuropogon* (Nees & Flot.) Motyka, *Lethariella* Motyka, *Chlorea* (Nyl.) Motyka, *Eumitria* (Stirt.) Motyka and *Euusnea* Jatta. All these subgenera later became independent genera except *Eumitria* (Stirt.) Motyka and *Euusnea* Jatta, which were in combination considered as the genus *Usnea*

(Ohmura 2002). G. Awasthi (1986) studied the genus *Usnea* in India and provided a detailed account of 19 species from Uttarakhand.

Uttarakhand is a biodiversity rich state of India lying between 28° 44' & 31° 28' North latitude and 77° 35' & 81° 01' East longitude on the southern slope of the Himalayan range. The present study provides an explicit description and distribution of 28 species of the genus *Usnea* in Uttarakhand. A key for all known species of *Usnea* in Uttarakhand has been provided.

## Materials and methods

The study was primarily based on herbarium specimens deposited in National Botanical Research Institute, Lucknow (LWG), specimens that are deposited in LWG on loan basis from Department of Botany, Lucknow University, Lucknow (LWU), personal herbarium of D. D. Awasthi (AWAS). All specimens were studied morpho-anatomically with the help of a Leica S8APO stereo zoom microscope and a Leica DM 500 micro-system. Secondary metabolites in specimens were determined using thin layer chromatography (TLC) (White & James 1985; Orange et al. 2001) in solvent system C (180 ml toluene: 60 ml 1,4 dioxane: 8 ml acetic acid). Colour tests were also performed with reagents K, P and I. Anatomical measurements of cortex (C), medulla (M) and central axis (A) were made using the microscope according to the method given by Clerc (1987) and C/M/A ratio was recorded. Well developed thicker branches of lichen thallus were used for measurements. Species of *Usnea* were distinguished on the basis of morphological, anatomical and chemical characteristics using relevant keys (Awasthi 2007, Randle et al. 2009, Ohmura 2012).

## Results

The state of Uttarakhand is represented by the occurrence of 28 species of *Usnea* out of which four species, namely *U. indica* Mot., *U. norketti* G. Awasthi, *U. sordid* Mot. and *U. thomsonii* Stirt. are endemic to the Indian Himalayas. Seven species namely *U. dendritica* Stirt., *U. lucea* Mot., *U. norketti* G. Awasthi, *U. pseudosinensis* Asahina, *U. sinensis* Mot., *U. spinosula* Stirt., *U. subflorida* Stirt. are new additions to the state of Uttarakhand.

## Taxonomic descriptions

### *Usnea aciculifera* Vain., Bot. Mag. (Tokyo) 35:45. 1921

Thallus corticolous, pendulous, branching dichotomous to sympodial, branches convergent; surface of the branches cracked but branches are never constricted, surface of branches smooth (papillae absent); isidia present; broken isidia leaves scar that can be confused with pseudocyphellae; pseudocyphellae and soredia absent; central axis thick, medulla thin and compact, C/M/A:14/21/25; stictic, constictic and usnic acids present in TLC.

Known distribution – This species is known from Eastern Asia. In India, it is distributed in Himachal Pradesh and Uttarakhand in North, Arunachal Pradesh, Assam, Manipur, Nagaland, Sikkim and West-Bengal hills in North-Eastern Himalayas and Tamil Nadu in Western Ghats.

Material examined – Uttarkashi district, (Tehri-Garhwal), on hill top of Siraru near Purola, alt. 2250 m, On branches of trees, Awasthi, 927 (LWG-AWAS); Govind Wild Life Sanctuary, Sankari, behind GMVN guest house, apple orchard, alt. 1944 m, on bark, Bajpai, 12-016655 (LWG); enroute to Kedarkantha, around Judatal, alt. 2829 m, on twigs, Bajpai, 12-018852 (LWG); Pithoragarh district, near village-Kherkini, alt. 1500 m, on bark, Upreti, 79-5 (LWG-LWU); Dhawj, alt. 2000 m, on twigs, D. K. Upreti, 201930/B (LWG).

### *Usnea angulata* Ach., Syn. Meth. Lich. 307.1814

Thallus corticolous, pendulous, branching dichotomous, branches angular in cross section, annularly cracked; isidia present; papillae, pseudocyphellae and soredia absent; C/M/A: 10/21/35; central axis thick, medulla thin, dense; Norstictic and Usnic acid present in TLC.

Known distribution – The species is distributed in Australia, America and W. Africa. In India, it is known from Meghalaya and Uttarakhand in North and Tamil Nadu in South.

Material examined – Pithoragarh district, 10 Km away from Champawat, alt. 1800 m, on bark, Upreti, 201696 (LWG); Almora district, Ranikhet, on the way of Chaubattia, alt. 2040 m, on bark, Singh, 90206/A (LWG); Uttarkashi district, Gomukh area, right bank 6th Moraine, alt. 3600 m, on twigs, Awasthi and Singh, 8548 (LWG–AWAS).

***Usnea baileyi* (Stirt.) Zahlbr., Denkschr. Kaiserl. Akad. Wiss., Wien. Math.–Naturwiss. Kl. 83: 182. 1909**

Thallus corticolous, sometimes saxicolous, pendulous, blackish near base; branching subdichotomous to sympodial; branches stiff, pseudocyphellae and isidia present; soredia absent; central axis hollow, periaxial part of medulla red pigmented; medulla compact; two chemical strains present (i) Norstictic acid and salazinic acid with unknown substances (ii) Norstictic acid with unknown substances.

Known distribution – The species is known from pantropical countries in world. In India, it is distributed in Arunachal Pradesh, Assam, Kerala, Manipur, Meghalaya, Nagaland, Sikkim, West Bengal hills and Uttarakhand in Himalayas and Tamil Nadu in Western Ghats.

Material examined – Almora district, Askote, alt. 1500 m, on bark, Awasthi, 398 (LWG–AWAS); Champawat district, devidhara area, alt. 1700 m, on bark, Mishra, 10–015353 (LWG); Vanlekh forest area, alt. 1700 m, on bark, Mishra, 10–015356, 10–015356 (LWG).

***Usnea compressa* Taylor in Hook.f., London J. Bot. 6: 192. 1847**

Thallus corticolous, shrubby, branching sympodial; branches articulated and inflated between articulations; surface of branches papillate and pseudocyphellate, pseudocyphellae round to elongate, slightly raised; isidia and soredia absent; apothecia terminal, with ciliate margins; C/M/A: 7/29/28; central axis thick, medulla loose; salazinic and usnic acid present in TLC.

Known distribution – This species is known from India and Nepal. In India it is distributed in Himachal Pradesh, Nagaland, Sikkim, Uttarakhand and West–Bengal in Himalayas and Tamil Nadu in Western Ghats.

Material examined – Dehradun district, Chakrata hills, Mussoorie, on way to Lal tibba, alt. 2250 m, on bark, Joshi, 75.322 (LWG–LWU); Chamoli district, on way from Chopta to Tungnath peak, alt. 1200–1400 m, on tree trunk, Dange, 76.547 (LWG–LWU); Almora district, Loharkhet–Dhakuri (enroute to Pindari glacier), alt. 2400 m, on twigs, Awasthi, 611 (LWG–AWAS); Nainital district, on way to naina peak, alt. 2550 m, on bark, Awasthi & Dange, 74.33 (LWG–LWU).

***Usnea dendritica* Stirt., Scott. Naturalist (Perth) 6: 296. 1882**

Thallus corticolous, shrubby to sub-pendent; branching subdichotomous to sympodial; branches non-inflated with cracks on surface, papillate and tuberculate; pseudocyphellae, isidia and soredia absent; apothecia terminal with ciliate margins; C/M/A: 15/17/35; central axis thick, medulla thin and compact; Alectorialic, barbatic and salazinic acids present in TLC.

Known distribution – The species is new record for Uttarakhand. Earlier it was known from Arunachal Pradesh, Meghalaya, Nagaland, Sikkim and West Bengal hills in North Eastern part of Indian Himalaya and from Kerala in Western Ghats. The species has restricted distribution in Himalayas and Western Ghats.

Material examined – Almora district, enroute to Sunderdhunga Glacier, between Jatoli & Dhuniya, alt. 3300 m, on fallen twigs, Upreti & Tondon, 213820 (LWG).

***Usnea eumitrioides* Motyka, Lich. Gen. *Usnea* Monogr. 2(1): 322. 1937**

Thallus corticolous, sub-pendent to pendulous, basally blackish; branching dichotomous to sympodial; branches divergent, non-articulate and non-inflated; isidia present, often filiform and leaves white scars when detach from thallus; papillae, pseudocyphellae and soredia absent,

apothecia absent; C/M/A: 14/15/40; central axis thick, medulla thin and compact; stictic and usnic acid found in TLC.

Known distribution – The species is known from Eastern Asia countries. In India, it is distributed in Himachal Pradesh, Nagaland, Sikkim, Uttarakhand and West Bengal hills in Indian Himalayan regions and Tamil Nadu in Western Ghat region of the country.

Material examined – Almora district, Askote, Dhaulekin range, alt. 1950 m, on twigs of shrubs and trees, Awasthi, 2691/ A (LWG–AWAS); Nainital district, D.S.B. Campus, on *Quercus leucotricophora* bark, Kholia, 09–013704 (LWG); Pauri district, Pauri–Devprayag road, near circuit house, On fallen twigs, Shukla & Joshi, 05–005327 (LWG).

***Usnea fragilis*** Stirt., Scott. Naturalist (Perth) 6: 297. 1881

Thallus corticolous, rarely saxicolous, sub-pendent to pendulous; branching subdichotomous to sympodial; branches non articulated and non inflated, annularly cracked; surface of branches pseudocyphellate–sorediate and isidiate; C/M/A: 13/22/30; central axis thick, medulla compact, outer part of medulla red pigmented; barbatic acid and usnic acid present in TLC.

Known distribution – The species is known from South–East Asian regions. In India, it is distributed in Arunachal Pradesh, Meghalaya, Nagaland, Sikkim, Uttarakhand and West–Bengal hills in Himalayas and Kerala and Tamil Nadu in Western Ghats.

Material examined – Almora district, Aretola–Jageshwar, alt. 1800 m, on tree twigs, Upreti, L–18322 (LWG); Jageshwar ridge, alt. 1950 m, on twigs of *Quercus spp.*, Awasthi, 3495 (LWG–AWAS).

***Usnea himalayana*** Bab., Hooker's J. Bot. Kew Gard. Misc. 4: 243. 1852

Thallus corticolous, pendulous, long, branching dichotomous, branches articulated and characteristically swollen between articulations (fusiform); pseudocyphellae present, round to elongate; isidia and soredia absent; apothecia very rare; C/M/A: 4/39/12; central axis thin, medulla very loose; three chemical strains present: (i) norstictic and usnic acid (ii) salazinic and usnic acid; (iii) stictic and usnic acid.

Known distribution – The species is known from Himalayas, Western Ghats and Africa. In Indian Himalayas it is distributed in Himachal Pradesh, Manipur, Nagaland, Sikkim, Uttarakhand and West Bengal hills and in Tamil Nadu in Western Ghats.

Material examined – Dehradun district, on way to Vyas Shikhar, alt. 2850 m, on *Quercus* tree, Awasthi & Joshi, 76.172 (LWG–AWAS); Chamoli district, way of Nanda Devi Biosphere Reserve, Kothidhar, alt. 3550 m, on *Taxus baccata* tree bark, Rawat & Rawat, 08–010961 (LWG).

***Usnea indica*** Motyka, Lich. Gen. *Usnea* Monogr. 2(1): 380. 1937

Thallus saxicolous, sub-pendent to pendulous, branching filamentose; surface of branches persistent, annularly cracked and minutely papillate; pseudocyphellae, isidia and soredia absent; apothecia not known; central axis thick, medulla dense; usnic acid and stictic acid present in TLC.

Known distribution – The species is endemic in North–West Himalayas and known from Uttarakhand.

Material examined – Almora district, enroute to Sundardhunga glacier, before 5 km Dhakuri, alt. 2700 m, on rock, Upreti & Tondon, 213400 (LWG).

***Usnea longissima*** Ach., Lichenogr. Universalis: 626. 1810

Thallus corticolous, pendulous, extremely long, base pale to blackend, cortex of main branch disintegrates exposing the thin compact medulla, fibrils perpendicular to main branch, papillae absent, isidia and soredia occasionally occur, central axis very thick, colourless and I+ blue; apothecia rarely present; seven chemical strains present, (i) barbatic acid and usnic acid (ii) squamatic acid, barbatic acid and usnic acid (iii) diffractaic acid and usnic acid (iv) evernic acid and

usnic acid (v) fumaroprotocetraric acid and usnic acid (vi) squamatic acid and usnic acid (vii) usnic acid only.

Known distribution – The species is widely distributed in Europe, North–America and North East Asia. In India it is known from Arunachal Pradesh, Himachal Pradesh, Jammu & Kashmir, Sikkim, Uttarakhand and West Bengal hills in Himalayas.

Material examined – Chamoli district, on way from Chopta to Tungnath peak, alt. 3600–4200 m, hanging from trees, Dange, 76.630 (LWG–LWU), Almora district, Dwali–Phurkia (on way to pindari glacier), alt. 2700 m, on trees, Awasthi & Awasthi, 725 (LWG–AWAS), Pithoragarh district, Munsyari, Nain Singh Top, alt. 2700 m, On mature *Kharsu* twigs, Upreti & Tondon, L–104698 (LWG).

***Usnea lucea*** Motyka, Lich. Gen. *Usnea* Monogr. 2(1): 534. 1937

Thallus corticolous, shrubby, sympodially branched; branches somewhat constricted and articulated; surface of branches shiny, papillate; pseudocyphellae, soredia and isidia absent; apothecia terminal, with ciliate margins; central axis thin, medulla loose; C/M/A: 7/30/26; usnic acid and stictic acid present in TLC.

Known distribution – The species is endemic to Western Ghats and earlier known from Tamil Nadu in India. The species is a new addition to the Uttarakhand state.

Material examined – Dehradun district, Mussoorie–Tehri road, alt. 2100 m, on bark, Singh, 97061 (LWG).

***Usnea luridorufa*** Stirt., Scott. Naturalist (Perth) 6: 104. 1881 & 7: 295. 1882

Thallus corticolous, shrubby to sub–pendent, branching dichotomous to sympodial; branches non–articulate and non–inflated but basally constricted; surface of branches lacking papillae, pseudocyphellae, isidia and soredia; apothecia terminal with ciliate margins; central axis thick, medulla dense; C/M/A: 7/29/27; norstictic acid, salazinic acid, stictic acid and usnic acid present in TLC.

Known distribution – The species is known from North and South Asia. In India, it is distributed in Sikkim and Uttarakhand in Himalayas and Kerala and Tamil Nadu in Western Ghats.

Material examined – Bageshwar district, enroute to Pindari glacier from Khati to Dwali, alt. 2210–2734 m, on fallen twigs, Joshi and Joshi, 07–008978 (LWG).

***Usnea nepalensis*** D.D. Awasthi in G. Awasthi, J. Hattori Bot. Lab. 61: 376. 1986

Thallus corticolous, sub–pendent to pendulous, basally blackish; branching sympodial; surface of branches rough, minutely papillate, isidiate, eroded isidia leaves scar that resemble pseudocyphellae; soredia absent; central axis thick, medulla compact; C/M/A: 9/28/27; only usnic acid is present in TLC.

Known distribution – The species is known from Himalayas and Western Ghats. In India, it is distributed in Sikkim and Uttarakhand in Himalayas and in Kerala in Western Ghats.

Material examined – Almora district, near Dhakuri ridge, alt. 2700 m, on *Quercus* tree, Awasthi, 7579 (AWAS); Chamoli district, way to Nanda Devi Biosphere reserve, alt. 3600 m, on *Pinus wallichiana* bark, Rawat, 08–0011250 (LWG).

***Usnea norketti*** G. Awasthi, J. Hattori Bot. Lab. 61: 377. 1986

Thallus corticolous, shrubby to sub–pendent, dichotomous to sympodial branching; branches articulated and inflated; surface of branches minutely papillate; pseudocyphellate; central axis thin, medulla loose; C/M/A: 6/31/25; barbatic acid, salazinic acid and usnic acid present in TLC.

Known distribution – The species is endemic to Himalayas. In India, it is distributed in Sikkim and Uttarakhand. The species is a new record for the state Uttarakhand.

Material examined – Chamoli district, way to Nanda Devi Biosphere reserve, Kanukdhar, alt. 3500 m, on *Pinus wallichiana*, Rawat & Rawat, 08–010996 (LWG).

***Usnea orientalis*** Motyka, Lich. Gen. *Usnea* Monogr. 2(2): 547. 1937

Thallus corticolous, shrubby, sympodially branched, thallus surface densely papillate; isidia and soredia absent, branches articulated and somewhat irregularly swollen; Apothecia present with ciliate margins; central axis thin, medulla loose; C/M/A: 5/31/24; salazinic and usnic acid present in TLC.

Known distribution – The species is known from North–East Asia. In India, it is distributed in Arunachal Pradesh, Himachal Pradesh, Manipur, Nagaland, Sikkim, Uttarakhand and West Bengal hills in Himalayas and Tamil Nadu in Western Ghats.

Material examined – Chamoli district, Mandakini river valley, on way from Rambara from Kedarnath, alt. 3580 m, on tree twigs, Dange, 76.337 (LWG–LWU); Dehradun district, on way to Lal Tibba, alt. 2550 m, on bark of tree, Joshi, 75.384 (LWG–LWU); Pithoragarh district, Kalamuni, alt. 2670 m, on twigs, Singh, 102667 (LWG); Almora district, enroute to Sunderdhunga Glacier, before 5 km of Dhakuri, alt. 1800 m, Upreti & Tandon, 213401 (LWG).

***Usnea pangiana*** Stirt., Scott. Naturalist (Perth) 7: 77. 1883

Thallus corticolous, pendulous, basal disc blackish, branching sub–dichotomous to sympodial, surface of branches annularly cracked at intervals, densely verruculose and pseudocyphellate; isidia present; detached isidia leaves scar that resemble pseudocyphellae; papillae and soredia absent; central axis thick, medulla thin and compact; C/M/A: 11/20/37; usnic acid, barbatic acid, diffractaic acid and salazinic acid present in TLC.

Known distribution – The species is known from North East Asia. In India, it is distributed in Arunachal Pradesh, Assam, Meghalaya, Nagaland, Sikkim, Uttarakhand and West Bengal hills in Himalayas and Kerala in Western Ghats.

Material examined – Almora district, Dhakuri, alt. 2700 m, on twigs, Singh, 89416 (LWG); Bageshwar district, enroute to Pindari Glacier from Khati to dwali, alt. 2210–2734 m, on fallen twigs, Joshi & Joshi, 07–008977 (LWG).

***Usnea perplexans*** Stirt., Scott. Naturalist (Perth) 6: 103. 1881

Thallus corticolous, shrubby to sub–pendent, sympodially branched; surface of branches papillate, pseudocyphellate, sorediate; soredia excavate; isidia absent; apothecia not known; central axis thick, medulla dense; C/M/A: 10/25/30; salazinic acid and usnic acid present in TLC.

Known distribution – The species is widely distributed in North East Asia, Africa, America and Europe. In India, it is known from Himachal Pradesh, Jammu & Kashmir and Uttarakhand in Himalayas only.

Material examined – Almora district, enroute to Pindari Glacier, Dwali–Khati, alt. 2200 m, On *Quercus semicarpifolia* bark, Upreti, Chatterjee & Tondon, L–68983 (LWG); Chamoli district, way to NDBR, Kothidhar, alt. 3550 m, on *Taxus baccata* bark, Rawat, 08–010971/A (LWG); Uttarkashi district, Govind Wild Life Sanctuary, enroute to Kedarkantha, 1 km before Judatal near bugyal, alt. 2420 m, on twigs, Bajpai, 12–018767 (LWG).

***Usnea pseudosinensis*** Asahina in Hara (ed.), Fl. Eastern Himal. Lichens: 600. 1966

Thallus corticolous, shrubby to sub–pendent, branching subdichotomous to sympodial; branches articulated and inflated; surface papillate, verruculose–pseudocyphellate; isidia and soredia absent; central axis thick, medulla loose; C/M/A: 7/29/27; apothecia terminal; barbatic and psoromic acid present in TLC.

Known distribution – The species is a new record for Uttarakhand and restricted in Himalayas only. In India, it is distributed in Sikkim, West Bengal and Uttarakhand.

Material examined – Pithoragarh district, Munsyari, khuliya top, alt. 2700–3000 m, on fallen twig, Upreti et al., 09–013451 (LWG).

***Usnea robusta*** Stirt., Scott. Naturalist (Perth) 6: 295. 1882

Thallus corticolous, shrubby to sub-pendent, branching sub-dichotomous to sympodial, surface of branches annularly cracked, densely papillate and pseudocyphellate; isidia and soredia absent; apothecia terminal; central axis thick; C/M/A: 10/24/33; salazinic acid and usnic acid always present in TLC, sometimes with barbatic acid.

Known distribution – The species is restricted in Himalayas only. In India, it is distributed in Sikkim, West Bengal and Uttarakhand.

Material examined – Bageshwar district, enroute to Pindari Glacier from Dwali to Phurkia, alt. 2734–3210 m, on fallen twigs, Joshi & Joshi, 07–008972 (LWG).

***Usnea rubicunda*** Stirt., Scott. Naturalist (Perth) 6: 102. 1881

Thallus corticolous, sometimes saxicolous, sub-pendent to pendulous, branching subdichotomous to sympodial; surface of the branches appears reddish due to presence of cortical pigment, papillate and tuberculate; branches articulated but not inflated; isidia and soredia present; soredia punctiform; central axis thick, medulla compact; C/M/A: 16/13/41; two chemotypes are present (i) norstictic acid, salazinic acid and usnic acid (ii) stictic acid complex and usnic acid.

Known distribution – The species is cosmopolitan. In India, it is distributed in Arunachal Pradesh, Manipur, Meghalaya, Nagaland, Sikkim, Uttarakhand and West Bengal hills in Himalayas and in Tamil Nadu in South.

Material examined – Almora district, Ranikhet–Chaubattia, alt. 1950 m, on *Pinus* tree trunk, Awasthi, 3532 (LWG–AWAS); Pithoragarh district, Gori-ganga Catchment, Majthan, alt. 1800 m, On bark of *Pinus roxburghii*, Pant, 20–87145 (LWG).

***Usnea sinensis*** Motyka, Lich. Gen. *Usnea* Monogr. 1: 248. 1936

Thallus corticolous, shrubby, branching sympodial; surface of branches minutely papillate and tuberculate; branches somewhat inflated; pseudocyphellate, isidia and soredia absent; central axis thin, medulla loose; C/M/A: 6/31/25; usnic acid is present in TLC.

Known distribution – The species is distributed in North East Asia. In India, it is known from Sikkim and Uttarakhand in Himalayas and from Tamil Nadu in South.

Material examined – Nainital district, on way to Naina Peak, alt. 2500 m, on *Quercus semicarpifolia* twigs, Kholia, 09–014477 (LWG); Chamoli district, on way from Chopta to tungnath peak, alt. 1400 m, on bark, Dange, 76.552 (LWG–LWU).

***Usnea sordida*** Motyka, Lich. Gen. *Usnea* Monogr. 2(2): 619–20. 1938

Thallus corticolous, shrubby, branching sympodial, branches articulate and inflated; surface of branches smooth; annularly cracked; densely papillate and pseudocyphellate; isidia and soredia absent; apothecia terminal with ciliate margins; central axis thin, medulla loose; C/M/A: 6/37/12; salazinic acid and usnic acid present in TLC.

Known distribution – The species is endemic in Himalayas. In India, it is distributed in Sikkim, Uttarakhand and West Bengal hills.

Material examined – Almora district, near Dhakuri to Khati, alt. 2400 m, on twigs, Awasthi, 7614 (LWG–AWAS); Chamoli district, Tungnath, alt. 3250 m, on *Quercus semicarpifolia* twigs, Upreti & Nayaka, 07–010190 (LWG).

***Usnea spinosula*** Stirt., Scott. Naturalist (Perth) 6: 107. 1881

Thallus corticolous, shrubby, branching sub-dichotomous to sympodial; branches non-articulate and non-inflated; surface of branches annularly cracked, minutely papillate; lateral branches bear fibrils that resemble spinules; pseudocyphellae, isidia and soredia absent; apothecia

terminal with ciliate margins; central axis thin, medulla loose; C/M/A:7/31/23; stictic acid complex and usnic acid present in TLC.

Known distribution – The species is a new record for Uttarakhand. It is distributed in Kerala and Tamil Nadu in Western Ghats and in Uttarakhand in Himalayas.

Material examined – Pithoragarh district, Dhawj–temple, alt. 2700 m, on bark of tree and twigs, Upreti, L/18443 (LWG); Munshyari, Kalamuni, alt. 3000–3200 m, on bark, Kholia, 18481 (LWG).

***Usnea splendens*** Stirt., Scott. Naturalist (Perth) 6: 296. 1882

Thallus corticolous, sometimes saxicolous, shrubby, sympodially to sub dichotomously branched; branches non–articulate and non–inflated; surface of branches papillate and pseudocyphellate; isidia and soredia absent; central axis thick, C/M/A: 8/29/28; salazinic acid and usnic acid present in TLC.

Known distribution – The species is known from Himachal Pradesh, Sikkim, Uttarakhand and West Bengal hills in Himalayas and Kerala and Tamil Nadu in Western Ghats.

Material examined – Nainital district, Nainital, near tiffin top, alt. 2400 m, on small shrubby branches, Awasthi & Dange, 74.50 (LWG–LWU); Almora district, Dhakuri – Khati (enroute to Pindari glacier), alt. 2400 m, on bark, Awasthi & Awasthi, 681 (LWG–AWAS).

***Usnea subflorida*** (Zahlbr.) Motyka, Lich. Gen. *Usnea* Monogr. 2(1): 335. 1937

Thallus corticolous, sub–pendent to pendulous, base blackish, branching sympodial, red pigment present in cortex and in outer part of medulla; surface of branches papillate and pseudocyphellate; isidia and soredia absent; C/M/A:8/31/23; Usnic acid and protocetraric acid present with or without barbatic acid in TLC.

Known distribution – The species is known from East Africa and North Asia. In India, it is distributed Uttarakhand in North and Kerala and Tamil Nadu in Western Ghats.

Material examined – Pithoragarh district, Kalamuni, alt. 2670 m, on twigs, Singh, 102662 (LWG).

***Usnea subfloridana*** Stirt., Scott. Naturalist (Perth) 6: 294. 1882

Thallus corticolous, shrubby to sub–pendent, much branched, base blacked, branching subdichotomous to sympodial, branches densely papillate and isidiate; soredia vary from punctiform to enlarged, isidiate soredia also present, cortex thin, medulla thick and dense C/M/A: 8/26/30; four chemotypes are present, i. Usnic acid and salazinic acid, ii. Usnic acid and norstictic acid, iii. Usnic acid and squamatic acid, iv. Usnic acid and thamnolic acid.

Known distribution – The species is known from Europe, North East Asia. In India, it is distributed in Himachal Pradesh, Jammu & Kashmir, Sikkim and Uttarakhand in Himalayas only.

Material examined – Chamoli district, Badrinath near Vasundhara Glacier, alt. 3900 m, on twigs, Upreti, 202370 (LWG); Dehradun district, on way to Vyas Shikhar, alt. 2850 m, on bark, Awasthi & Joshi, 76.173 (LWG–LWU); Pithoragarh district, Munshyari, Khulia top, alt. 2700–3000 m, on fallen twigs, Upreti & party, 09–013450 (LWG).

***Usnea thomsonii*** Stirt., Scott. Naturalist (Perth) 6: 107. 1881

Thallus corticolous, shrubby to sub–pendent, branching subdichotomous to sympodial; basal disc black, branches stiff, non–articulated and non–inflated; pseudocyphellae slightly elongate and raised; soredia and isidia absent; central axis thick, medulla loose; C/M/A: 9/28/26; usnic acid always present with or without alectorialic acid and diffractaic acid in TLC.

Known distribution – The species is endemic to Himalayas. In India, it is distributed in Arunachal Pradesh, Himachal Pradesh, Nagaland, Sikkim, Uttarakhand and West Bengal hills.

Material examined – Bageshwar district, enroute to Pindari glacier from Khati to Dwali, alt. 2210–2734 m, on fallen twigs, Joshi & Joshi, 07–008976 (LWG–LWU); Chamoli district, on way

**Table 1** Details of habitat preferences and distribution of *Usnea* species in 13 districts of Uttarakhand. C= corticolous, S= saxicolous,, Alm=Almora, Bag=Bageshwar, Cha=Chamoli, Chm=Champawat, Deh=Dehradun, Har= Haridwar, Nan=Nainital, Pau=Pauri, Pth=Pithoragarh, Rud=Rudraprayag, Teh=Tehri, Udm=Udham–singh nagar, Utk=Uttarkashi; + present, – absent.

Species	Habitat	Distribution in 13 districts												
		Alm	Bag	Cha	Chm	Deh	Har	Nan	Pau	Pth	Rud	The	Udm	Utk
<i>U. aciculifera</i> Vain.	C	+			+	+			+	+				+
<i>U. angulata</i> Ach.	C	+								+				+
<i>U. baileyi</i> (Stirt.) Zahlbr	C,S	+			+									
<i>U. compressa</i> Taylor	C	+	+	+		+					+			+
<i>U. dendritica</i> Stirt.	C	+												
<i>U. eumitrioides</i> Motyka	C	+		+		+		+	+	+			+	
<i>U. fragilis</i> Stirt.	C,S	+												
<i>U. himalayana</i> Bab.	C	+		+		+								
<i>U. indica</i> Mot.	C,S	+												
<i>U. lucea</i> Mot.	C					+								
<i>U. longissima</i> Ach.	C	+	+	+		+				+			+	+
<i>U. luridorufa</i> Stirt.	C		+											
<i>U. nepalensis</i> D.D.Awasthi	C	+	+	+										
<i>U. norketti</i> G. Awasthi	C			+										
<i>U. orientalis</i> Mot.	C	+	+	+		+		+	+	+			+	+
<i>U. pangiana</i> Stirt.	C	+	+							+				
<i>U. perplexans</i> Stirt.	C	+		+		+								+
<i>U. pseudosinensis</i> Asahina	C									+				
<i>U. robusta</i> Stirt.	C		+			+								
<i>U. rubicunda</i> Stirt.	C,S	+								+			+	
<i>U. sinensis</i> Mot.	C			+				+						
<i>U. sordida</i> Mot.	C	+		+		+		+		+				
<i>U. spinosula</i> Stirt.	C									+				
<i>U. splendens</i> Stirt.	C,S	+		+	+	+		+		+				
<i>U. subflorida</i> (Zahlbr.) Mot.	C									+				
<i>U. subfloridana</i> Stirt.	C	+	+	+		+		+		+				+
<i>U. thomsoni</i> Stirt.	C	+	+	+		+		+						+
<i>U. undulata</i> Stirt.	C,S	+		+	+					+			+	+

**Table 2** Details of colour tests and secondary metabolites present in *Usnea* species of Uttarakhand. Usn=Usnic acid, Sal=Salazinic acid, Nor=Norstictic acid, Stc=Stictic acid complex, Bar=Barbatic acid, Pro=Protocetraric acid, Alc=Alectorialic acid, Squ=Squamatic, Dif=Diffraetaic acid, Evr=Evernic acid, Pso=Psoromic acid, Thm=Thamnolic acid; + present, – absent, ± variably present or absent.

Species	Colour test reactions			Secondary metabolites												
	K	P	I	Usn	Sal	Nor	Stc	Bar	Pro	Alc	Squ	Dif	Evr	Pso	Thm	
<i>U. aciculifera</i> Vain.	+	+	–	+			+									
<i>U. angulata</i> Ach.	+	+	–	+		+										
<i>U. baileyi</i> (Stirt.) Zahlbr	+	+	–	+	+	+										
<i>U. compressa</i> Taylor	+	+	–	+	+											
<i>U. dendritica</i> Stirt.	+	+	–	+	+			+		+						
<i>U. eumitrioides</i> Motyka	+	+	–	+			+									
<i>U. fragilis</i> Stirt.	–	–	–	+				+								
<i>U. himalayana</i> Bab.	+	+	–	+	+	+	+									
<i>U. indica</i> Mot.	+	+	–	+			+									
<i>U. longissima</i> Ach.	±	±	+	+				+	+		+	+	+			
<i>U. lucea</i> Mot.	–	+	–	+			+									
<i>U. luridorufa</i> Stirt.	+	+	–	+	+		+									
<i>U. nepalensis</i> D.D.Awasthi	–	–	–	+												
<i>U. norketti</i> G. Awasthi	+	+	–	+	+			+								
<i>U. orientalis</i> Mot.	+	+	–	+	+											
<i>U. pangiana</i> Stirt.	+	+	–	+	+			+				+				
<i>U. perplexans</i> Stirt.	+	+	–	+	+											
<i>U. pseudosinensis</i> Asahina	–	±	–	+				+						+		
<i>U. robusta</i> Stirt.	+	+	–	+	+				±							
<i>U. rubicunda</i> Stirt.	+	+	–	+	+	+	+									
<i>U. sinensis</i> Mot.	–	–	–	+												
<i>U. sordida</i> Mot.	+	+	–	+	+											
<i>U. spinosula</i> Stirt.	+	+	–	+			+									
<i>U. splendens</i> Stirt.	+	+	–	+	+											
<i>U. subflorida</i> (Zahlbr.) Mot.	–	+	–	+				±	+							
<i>U. subfloridana</i> Stirt.	+	+	–	+	+	+					+				+	
<i>U. thomsoni</i> Stirt.	–	–	–	+						+		+				
<i>U. undulata</i> Stirt.	±	±	–	+	+	+	+		+							

**Table 3** Altitudinal preferences of species of *Usnea* in Uttarakhand.

Species	Altitude (min.) in m	Altitude (max.) in m
<i>U. aciculifera</i> Vain.	1200	3800
<i>U. angulata</i> Ach.	1800	3600
<i>U. baileyi</i> (Stirt.) Zahlbr	1300	2600
<i>U. compressa</i> Taylor	1800	3700
<i>U. dendritica</i> Stirt.	1200	3000
<i>U. eumitrioides</i> Motyka	1200	3300
<i>U. fragilis</i> Stirt.	1500	3600
<i>U. himalayana</i> Bab.	1800	3600
<i>U. indica</i> Mot.	2700	2700
<i>U. lucea</i> Mot.	2100	2100
<i>U. longissima</i> Ach.	1800	4200
<i>U. luridorufa</i> Stirt.	1600	2734
<i>U. nepalensis</i> D.D.Awasthi	1100	3600
<i>U. norketti</i> G. Awasthi	3500	3500

Species	Altitude (min.) in m	Altitude (max.) in m
<i>U. orientalis</i> Mot.	1200	3600
<i>U. pangiana</i> Stirt.	1500	2734
<i>U. perplexans</i> Stirt.	1500	3550
<i>U. pseudosinensis</i> Asahina	1650	4500
<i>U. robusta</i> Stirt.	2700	3200
<i>U. rubicunda</i> Stirt.	1800	3210
<i>U. sinensis</i> Mot.	1400	2500
<i>U. sordida</i> Mot.	2400	3900
<i>U. spinosula</i> Stirt.	1500	3250
<i>U. splendens</i> Stirt.	1500	4000
<i>U. subflorida</i> (Zahlbr.) Mot.	2670	2670
<i>U. subfloridana</i> Stirt.	1600	4350
<i>U. thomsoni</i> Stirt.	1950	3600

from Chopta to Tungnath peak, alt. 3600 m, on tree branches, Dange, 76.607 (LWU–LWG); Nainital district, Kilbury Forest area, alt. 2200 m, on *Quercus leucotrichophora* twigs, Upreti, Chatterjee & Tondon, 217304 (LWG).

*Usnea undulata* Stirt., Scott. Naturalist (Perth) 6: 104. 1881

Thallus corticolous, rarely saxicolous; shrubby, sub-pendent to pendulous; branching subdichotomous to sympodial, branches articulated and inflated; tuberculate and isidiate; papillae and soredia absent; cortex thick, medulla thin and compact; C/M/A: 14/18/37; five chemotypes are present, i. Salazinic and usnic acid, ii. Galbinic, norstictic, salazinic acid and usnic acid, iii. Stictic acid and usnic acid, iv. Protocetratic acid and usnic acid, v. Usnic acid only.

Known distribution – The species is known from South and East Africa. In India, it is distributed in Arunachal Pradesh, Meghalaya, Nagaland, Sikkim, Uttarakhand and West-Bengal hills in Himalayas and Karnataka, Kerala and Tamil Nadu in South.

Material examined – Champawat district, devidhara area, alt. 1700 m, on bark, Mishra, 10–015358 (LWG); Tehri district, on hill top of Siraru, near Purola, alt. 2250 m, on branches of tree, Awasthi, 927 (LWG–AWAS); Almora district, Shitalakhet, Shai Devi Temple Forest, on *Pinus roxburghii*, Upreti and Prakash, 01–76613 (LWG).

### Key to species of *Usnea* in Uttarakhand, India

1. Central axis solid.....2  
Central axis hollow.....*U. baileyi*
2. Thallus pendulous, branching dichotomous or filamentose.....3  
Thallus shrubby to sub-pendent, branching sympodial to sub-dichotomous.....6
3. Branches articulated, characteristically swollen between articulations.....*U. himalayana*  
Branches articulated but not inflated between articulations.....4
4. Branches circular in cross section.....5  
Branches angular in cross section.....*U. angulata*
5. Cortex of branches persistent, I-.....*U. indica*  
Cortex of branches evanescent, I+ .....*U. longissima*
6. Red pigment present in cortex or in medulla.....7  
Red pigment absent in cortex and in medulla.....10
7. Thallus isidiate.....8  
Isidia absent.....*U. subflorida*
8. Thallus sorediate.....9  
Soredia absent, salazinic and barbatic acid in medulla.....*U. pangiana*
9. Stictic acid in medulla.....*U. rubicunda*  
Barbatic acid in medulla.....*U. fragilis*
10. Thallus pseudocyphellate.....11  
Thallus lacking pseudocyphellae.....18
11. Thallus isidiate.....12  
Thallus lacking isidia.....14
12. Thallus surface papillate.....13  
Thallus surface lacking papillae, five chemical strains present.....*U. undulata*
13. Psoromic acid in medulla.....*U. pseudosinensis*  
Psoromic acid absent, K-, no lichen substance in medulla.....*U. nepalensis*
14. Branches non-articulated and non-inflated.....*U. splendens*  
Branches articulated and inflated.....15
15. Barbatic acid present in medulla.....16  
Barbatic acid absent in medulla.....17
16. Central axis thick, surface of branches annularly cracked.....*U. robusta*  
Central axis thin, medulla loose.....*U. norketti*

17. Surface of branches waxy, central axis thin and medulla loose.....	<i>U. sordida</i>
Pseudocyphellae slightly raised, round to elongate.....	<i>U. compressa</i>
18. Thallus with apothecia.....	19
Thallus lacking apothecia.....	24
19. Branches articulated and inflated.....	20
Branches non-articulate and non-inflated.....	22
20. K+ (salazinic acid or stictic acid in medulla).....	21
Medulla K-, P-.....	<i>U. sinensis</i>
21. Surface of branches shiny, stictic acid complex in medulla.....	<i>U. lucea</i>
Salazinic acid in medulla.....	<i>U. orientalis</i>
22. Lateral branches dense, stictic acid complex in medulla.....	23
Lateral branches dense, barbatic and salazinic acid in medulla.....	<i>U. dendritica</i>
23. Lateral branches bearing fibrils that resemble spinules.....	<i>U. spinosula</i>
Surface of branches lacking papillae, spinules absent.....	<i>U. luridorufa</i>
24. Thallus sorediate.....	25
Thallus esorediate.....	26
25. Soredia excavate, isidia absent.....	<i>U. perplexans</i>
Soredia and isidia present, four chemical strains.....	<i>U. subfloridana</i>
26. Branches convergent, isidia filiform.....	<i>U. aciculifera</i>
Branches divergent, lateral branches sparse to dense.....	<i>U. eumitrioides</i>

## Discussion

Most of the Species of *Usnea* (79%) are corticolous, growing on bark of trees or twigs of the branches. Only few species grow on rocks (Table 1). Majority of *Usnea* species prefer lower temperate to upper temperate regions (between 2100 m to 3200 m altitude) for growth but *U. baileyi* (Stirt.) Zahlbr., *U. luridorufa* Stirt., *U. pangiana* Stirt. *U. sinensis* Mot. are found on lower temperate regions (Table 2 and 3). Moist conditions favour the growth of *Usnea* species ( Halonen 2000) therefore majority of species are found abundantly in old-humid forest types. Corticolous species of *Usnea* grow luxuriantly on *Quercus leucotricophora*, *Quercus semicarpifolia* and *Rhododendron spp.* The trees of *Taxus baccata*, *Cedrus deodara*, *Pinus spp.*, *Betula spp.*, *Abies spp.*, *Pyrus spp.*, and *Berberis spp.* too harbour species of *Usnea*.

Out of 13 districts of Uttarakhand, Almora is the richest in species diversity of *Usnea* with an occurrence of 20 species followed by Pithoragarh and Chamoli districts with 15 and 14 species respectively. Owing to the presence of old-moist forests that provide ideal conditions for growth of *Usnea* species, the districts have wide diversity of *Usnea* species. *Usnea orientalis* Mot. is the most widely distributed species of *Usnea* in Uttarakhand followed by *U. subfloridana* Stirt. and *U. eumitrioides* Mot. Haridwar and Udham-Singh Nagar districts situated in lower altitude (500–1000 m) of Terai region of Himalayas are devoid of *Usnea* species.

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