

Studies on *Lethariella* with special emphasis on the chemistry of the subgenus *Chlorea*

(Lichenological results of the Sino-German Joint Expedition to south-eastern and eastern Tibet 1994. IV)

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Summary: All species of the genus *Lethariella* (e.g. *L. canariensis*, *L. cashmeriana*, *L. cladonioides*, *L. flexuosa*, *L. intricata*, *L. mieheana*, *L. sernanderi*, *L. smithii*, *L. togashii*, *L. zahlbruckneri*) have been subjected to TLC-analyses. *Lethariella mieheana*, a pendulous taxon with psoromic acid in the medulla, is described as new. *Lethariella smithii* (Basionym: *Usnea smithii*) is proposed as a new combination. A key to the taxa, mainly based on differences in chemistry and growth-form, is provided. New information on the reproductive characters of *L. intricata* and species of the subgenus *Chlorea* is given. Several taxa of the subgenus *Chlorea* are reported from numerous new collection sites in Tibet and adjacent areas.

Key words: chemistry, *Lethariella*, lichenized ascomycetes, taxonomy, Tibet.

INTRODUCTION

Species of the lichen genus *Lethariella* were formerly included within *Usnea* because of their more or less solid central axis comprising longitudinally arranged hyphae which are strongly agglutinated. In contrast to the related genera *Usnea* (incl. *Neuropogon*) and *Protousnea* which produce usnic acid as main cortical lichen product, the species of *Lethariella* always contain atranorin. *Letharia* (frequently but not constantly with atranorin) is separated from *Lethariella* (probably its closest relative) mainly by the lacerate axis.

The name *Lethariella* was established at generic level by KROG (1976). In her monographic treatment she accepted 6 species (*Lethariella cashmeriana*, *L. canariensis*, *L. cladonioides*, *L. intricata*, *L. togashii* and *L. zahlbruckneri*), which were placed within three subgenera (i.e. *Lethariella*, *Chlorea* and *Nipponica*). Following KROG's paper one new species (*Lethariella sinensis*) has been described (WEI & JIANG 1982: 498) while several other contributions to the knowledge of *Lethariella* taxa (especially to those of the subgenus *Chlorea*) have been published by Chinese lichenologists (WU & ZHANG 1982, WEI et al. 1982, WEI & JIANG 1986, WU 1987, WEI 1991).

During the Sino-German-Joint-Expedition to southeastern and eastern Tibet in the summer of 1994, the author had the opportunity to make approximately 35 collections of the genus *Lethariella* subgenus *Chlorea* from 14 different localities. Some difficulties experienced in their determination have initiated a more detailed study, particularly of the chemistry of the species. The aim of the project was to clarify the delimitation of the taxa of the subgenus *Chlorea* as well as to compare the ascus structure within the subgenera of *Lethariella* and with those of closely related genera.

MATERIAL AND METHODS

Roughly 160 specimens from the herbaria in Graz (GZU), Helsinki (H), London (BM), München (M), Paris (PC), Stuttgart (STU) and Uppsala (UPS) have been examined. Microscopic examinations were conducted with a Zeiss Axioskop light microscope. Amyloid reactions were produced by using Lugol's iodine solution. All specimens cited have been analyzed chemically by TLC using solvent systems A, B' and C (see CULBERSON & AMMANN 1979, WHITE & JAMES 1985, ELIX et al. 1987). In order to obtain a better resolution of the spots, the plates were run to a height of 15 cm above the origin.

RESULTS AND DISCUSSION

Morphological and chemical characters of the genus *Lethariella*

Morphological/anatomical characters are quite useful to separate at least the subgenera *Lethariella* and *Chlorea* (see 'subgenus and genus concept' below). However, within the subgenus *Chlorea*, morphological features (e.g. the surface structure of the thallus or the occurrence of soredia) turned out to be rather variable, so that less emphasis has been placed on them in separating the species. Thus notes on main characters concerning morphology and anatomy are essentially restricted to those given in RAMBOLD 1996b (see below). For further information on the morphology/anatomy of each species see the original descriptions or compare more comprehensive papers like MOTYKA 1936, KROG 1976, WU & ZHANG 1982, WEI & JIANG 1982, WU 1987.

However, chemical features and reproductive characters have been studied in more detail (see below).

a) Summary of characters

The following data set is based mainly on a character list for genera of lichenized and lichenicolous Ascomycetes (see RAMBOLD 1996a, b).

Substrate: bark and wood (frequently, all species), soil and detritus (frequently, non pendulous species of subgenus *Chlorea*), siliceous rock and calcareous rock (*L. intricata*, *L. sernanderi*). - **Life habit:** not lichenicolous. - **Secondary metabolites:** unidentified substance (in *L. intricata*), orcinol depsides (gyrophoric acid in subgenus *Chlorea*; merochlorophaeic acid, 4-O-cryptochlorophaeic acid and submerochlorophaeic acid in subgenus *Lethariella*), *beta*-orcinol depsides (atranorin in all species, chloroatranorin), *beta*-orcinol depsidones (norstictic acid and psoromic acid in subgenus *Chlorea*), higher aliphatic acids (acids of the rangiformic/norrangiformic/isorangiformic acid complex in all species), quinones (canarione in subgenus *Chlorea*), pulvinic acid derivatives (vulpinic acid, 4-hydroxyvulpinic acid in subgenus *Nipponica*), dibenzofuranes and usnic acids (placadolic acid in subgenus *Chlorea*), Ca-oxalate-crystals (in subgenus *Lethariella*). - **Primary photobiont:** chlorococcoid. - **Growth habit:** fruticose (long pendent: *L. canariensis*, *L. mieheana*, *L. smithii*, *L. togashii*, *L. zahlbruckneri* or prostrate to shrub-like erect: *L. cashmeriana*, *L. cladonioides*, *L. flexuosa*, *L.*

intricata, *L. sernanderi*). - **Attachment**: basal holdfasts. - **Thallus-surface**: Structure: smooth or cracked or with ridges. - Colour: grey (*L. intricata*, *L. togashii*, p.p. basal parts of all other species) or orange (at least apical parts of all species of subgenus *Chlorea*). - **Isidia**: present only in *L. intricata*. - **Soralia**: absent (*L. canariensis*, *L. flexuosa*, *L. intricata*, *L. mieheana*, *L. togashii*, *L. smithii*, *L. zahlbruckneri*) or present (*L. cashmeriana*, *L. cladonioides*, *L. sernanderi*). - **Vegetative hyphae**: euamyloid. - **Central axis**: present. - **Ascomata**: very rarely present. - Type: apotheciid. - Location: laminal-lateral. - Shape: circular. - Attachment: sessile or substipitate. - Margin: slightly prominent or prominent. - Cupula: present. - **Excipulum-pigmentation**: hyaline. - **Hypothecium-pigmentation**: hyaline. - **Ephymenium-pigmentation**: brown. - **Interascal filaments**: branching and anastomoses absent or poorly developed. - **Ascus**: Type: Lecanoral. - Shape of ocular chamber: broad. - Wall: euamyloid. - Tholus-type: amyloid and with non-amyloid axial body (see below). - **Ascospores**: Number: 8. - Shape: ellipsoid with obtuse ends. - Septation: not septated. - Length: 6-10 μm . - Width: 3-6 μm . - Pigmentation: hyaline. - Perispore: smooth. - **Conidiomata**: pycnidial. - Location: laminal-lateral. - Attachment: immersed. - **Conidia**: Genesis: pleurogenous. - Shape: bacillariform or slightly dumbbell-shaped. - Size: 7-9 x 1,5 μm (see below).

b) Reproductive characters

Since *Lethariella* species are very rarely fertile, little information has so far been given on their reproductive characters. There are some scattered reports on the shape and/or anatomy of apothecia (e.g. MONTAGNE 1840: 95 and pl. VI, fig. 1; JATTA 1900: 55; FOLLMANN et al. 1973: 8 and fig. 1,2 (p. 7); KROG 1976: 93, 96; WEI & JIANG 1982: 497; WU & ZHANG 1982: 243, pl. 2, fig. 1,2,3,6) and several drawings of asci and/or spores (MONTAGNE 1840: pl. VI, fig. 1e; WU & ZHANG 1982: 243, pl. 2, fig. 7, 8; WU 1987: 165, fig. 132 b,c). Finally, very few observations have been made on the conidiomata or conidia (NYLANDER 1860: 277 and tab. VIII, fig. 15; JATTA 1900: 55). It is worth noting that KROG (1976: 89) regarded pycnidia as being 'unknown'.

In the present work some few fertile collections of *Lethariella* presented the opportunity to study both ascomata and conidiomata in the type species of *Lethariella* (*L. intricata*, R. Türk & J. Poelt s.n. from Calabria, Italy; see fig. 6c) as well as in several taxa of subgenus *Chlorea* (*L. cashmeriana*, W. Obermayer 3511, GZU, see fig. 6a; *L. sernanderi*, W. Obermayer 3414, GZU and H. Smith 14023a, UPS; *L. zahlbruckneri*, H. Smith 5014, UPS-holotype; *L. smithii*, H. Smith 5017, UPS-holotype).

Asci: The type of asci within the genus *Lethariella* can be regarded as being rather uniform. The walls of the ascus tips are thickened and show a distinct ocular chamber. A typical (less coloured) axial body can be seen after treatment with Lugol's iodine solution (see fig. 5). In younger stages the paler region does not reach the top of the ascus (see fig. 5a). In summary, the ascus of *Lethariella* closely resembles the ascus of *Parmelia saxatilis*, the type species of the genus *Parmelia*. Indeed, no significant differences have been found in the ascus-types of the genera *Letharia* (see fig. 5e), *Usnea* and *Protousnea* (see fig. 5f).

Conidiomata and Conidia: Conidiomata were found in both *Lethariella intricata* (subgenus *Lethariella*) and in species of subgenus *Chlorea*. They are laminal, immersed in the thallus, show a dark coloured ostiole and do not reach more than 100 μm in diameter. The ontogeny of the conidia is of the *Umbilicaria*-type (VOBIS 1980: 23-25, fig. 5). The conidia of *Lethariella intricata* are slightly inflated in the center or weakly bifusiform (8-9 x 1.2-1.5 μm) (see fig. 5d). In *Lethariella* subgenus *Chlorea* the conidia appear to be somewhat shorter (7-8 x 1.2-1.5 μm) and less dumbbell-shaped (see fig. 5 c).

c) Chemistry

The first comprehensive study of the chemistry of *Lethariella* was carried out by KROG (1976). She reported atranorin (for all taxa) and/or canarione (diagnostic for the subgenus *Chlorea*) as cortical substances. Medullary compounds included merochlorophaeic and cryptochlorophaeic acid (in subgenus *Lethariella*), vulpinic acid (in subgenus *Togashii*) and norstictic, psoromic and gyrophoric acid as well as a hitherto unknown substance (in subgenus *Chlorea*). More recently, several taxa of the subgenus *Chlorea* have been the subject of further chemical analyses (WU & ZHANG 1982; WEI & JIANG 1982; HUNECK & FREMBGEN 1989).

The present paper describes some new chemical data on the species of *Lethariella*, which can be summarized as follows (see also fig. 1):

1. The unknown lichen substance (running 6/6/6) in the holotype material of *Lethariella smithii* (but not in *L. zahlbruckneri*!; see discussion under *L. smithii*) was identified as placodiolic acid by HPLC.

2. In *Lethariella intricata*, submerochlorophaeic acid (minor) 4-O-methylcryptochlorophaeic acid (minor) and chloroatranorin (minor) were identified in addition to atranorin and merochlorophaeic acid. Several other related compounds of the merochlorophaeic acid complex (see ELIX et al. 1987: 68) may also be present. The chemistry of the apothecia did not show any additional compound, but the amount of atranorin was decreased.

3. Vulpinic acid is accompanied by 4-hydroxyvulpinic acid in *Lethariella togashii*.

4. At least one aliphatic acid of the rangiformic/norrangiformic/isorangiformic acid complex (running 4/4-5/5; see fig. 1) has been observed in many specimens of all three subgenera of *Lethariella*. This fatty acid might be a constant minor compound, but due to its low concentration it is not always detectable. In addition, two other aliphatic lichen substances (probably belonging to the above complex) have been found in several specimens.

5. Beside the fatty acid mentioned above (and the cortical substances atranorin and canarione), gyrophoric acid was the most widespread lichen substance in species of subgenus *Chlorea*. It is present as a minor compound both in species with psoromic acid (*Lethariella flexuosa*, *L. mieheana*) and in taxa containing norstictic acid (*L. sernanderi*, *L. zahlbruckneri*). In *Lethariella cashmeriana*, gyrophoric acid is the main medullary substance present, sometimes accompanied by norstictic acid. This combination of norstictic and gyrophoric acid has already been reported by WU & ZHANG (1982: 245, fig. 3, path 1,2,3). However, WU & ZHANG's (1982: 245, fig. 3, path 4) report of norstictic acid in *L. smithii* (sub *L. zahlbruckneri*), together with (most probably) placodiolic acid (see fig. 3, 'D'), could not be confirmed. By the way, psoromic and norstictic acid were never found occurring together in one taxon.

Note: Some few specimens of the *sernanderi/cashmeriana* complex seem to contain more or less equal amounts of gyrophoric and norstictic acid. This is true particularly for samples from Nepal (with more red coloured thalli), but also for collections from Pakistan and the Tibetan fringe-mountains. Studies on sorediate and nonsorediate pieces of the same thalli showed, that in sorediate branches the proportion of norstictic acid can be increased. In this connection, a single study was made of the chemistry of the apothecia (*Lethariella zahlbruckneri*, holotype). The fruiting body contained more or less equal amounts of norstictic and gyrophoric acid, whilst in sterile branches of the same thallus only traces of gyrophoric acid were detected. The occurrence of a lichen compound solely as an hymenial constituent has already been demonstrated by CULBERSON (1969) for *Letharia californica*.

6. As atranorin and chloroatranorin are difficult to distinguish in TLC-solvent systems A, B' and C, the occurrence of chloroatranorin has not been established by thin layer chromatography. Chloroatranorin already has been detected in *Lethariella canariensis* (FOLLMANN & HUNECK 1970) and in *L. intricata* (Jack Elix in litt.)

7. An unknown substance was detected in *Lethariella intricata* running slightly below atranorin in solvent system A (see fig. 1, 'uLi'). It may be an unknown *meta*-depside, biosynthetically related to merochlorophaeic acid (Jack Elix in litt.).

8. Calcium oxalate crystals, which form long straight needles of gypsum after treatment with sulfuric acid, fill the space between the axis and the cortex in *Lethariella intricata*.

9. The pigment, canarione, readily dissolves out of the cortex in water. An orange thallus, which is placed in water for 30 minutes, completely decolorizes. The orange-red solution, which surrounds the thallus, then redeposits straight red needles on the surface of the branches. This behaviour of the pigment explains the fact that in some thalli of the subgenus *Chlorea*, the orange colour is restricted to the apical parts or to the soredia.

Distribution

The worldwide distribution of the subgenera of *Lethariella* has already been outlined by KROG (1976: 89, fig. 6). The monotypical subgenus *Lethariella* (*L. intricata*) occurs in the Mediterranean region, extending to the Macaronesia in the west and (at least) the Crimean Peninsula (see OXNER 1993) and western Anatolia (see MIES 1992: 5) in the east. *Lethariella togashii*, the only species of the subgenus *Nipponica*, is an acutely endangered endemic lichen of Honshu Island (Japan). Subgenus *Chlorea* has its centre of species diversity in the area of the eastern Himalayas, the south-eastern Tibetan highland and especially the adjacent surrounding mountains. The western most collection sites are located in the Karakorum area, the eastern most reports (WU & ZHANG 1982) come from the Qin Ling Mountains in Shaanxi Province, China.

Figs. 2, 3 and 4 indicate the location of the Asian specimens investigated. This extends the floristic knowledge of the taxa from subgenus *Chlorea* (longitude and latitude of the collection sites of Harry Smith, Sweden, are taken from HERNER 1988).

Hitherto published 'distribution' maps and maps of studied specimens can be found in: KROG 1976: 91, fig 7 (distribution of *L. canariensis*). - KROG 1976: 95, fig. 9 ('distribution' of *L. intricata*). - WEI & JIANG 1981: 1150, fig. 1 ('distribution' of species of subgenus *Chlorea*). - WEI & JIANG 1986: 7: fig. 2 ('distribution' of species of subgenus *Chlorea*). - OBERMAYER 1996: 8, fig. 1 (localities of species of subgenus *Chlorea* (except *L. canariensis*) collected between 1986 and 1994).

Subgenus and genus concept

As the present paper is mainly directed towards trying to clarify the species concept in *Lethariella* (see below), no taxonomic conclusions have been drawn concerning the subgeneric or generic level. Nevertheless there appear some good reasons for raising the subgenera of *Lethariella* to generic rank (which will be done in a forthcoming paper). Both chemical and morphological differences might support the separation of subgenus *Lethariella* from the subgenera *Chlorea* and *Nipponica*. Thus *Lethariella* *sensu stricto* would become monotypic. One striking character of *L. intricata* is the hollow axis, a feature which is shared by genus *Usnea* subgenus *Eumitria*. *Lethariella togashii* (originally described by ASAHINA 1952: 295 as *Letharia t.*), the only representative of the subgenus *Nipponica*, chemically resembles *Letharia*, but morphologically comes close to the species of subgenus *Chlorea*. The representatives of the latter subgenus form a group of closely related taxa mainly characterized by the occurrence of the orange-red cortical pigment canarione.

The Species concept - morphological characters versus chemical characters

As morphological characters (at least within subgenus *Chlorea*) proved to be rather variable (see above), special attention has been paid to the chemistry of the taxa, which provides a more reliable discriminator. Consequently the species concept (elaborated below) is based more on the occurrence of chemical compounds than on morphology/anatomy.

I have recognized morphologically quite similar but chemically different taxa at the species level, because lichens, which propagate mainly by vegetative means (*Lethariella* or *Bryoria* etc.), establish genetically quite uniform populations. In such populations, the change from one lichen substance to another probably requires a genetically variation rather than for example the doubling of the thickness of the cortex (or the length of the spores), which can be caused by local environmental conditions. Finally, as species of *Lethariella* have not been investigated in culture and as this group is obviously undergoing strong speciation processes, it is simply more useful to term such segregations as species rather than chemicals strains (or chemovars etc.) of so called collective species or species-aggregates.

Key to the subgenera and species of *Lethariella*

- 1 Cortex of the thallus (at least apically) orange or orange-red coloured due to the presence of canarione (if badly preserved, the thallus-colour may be brownish-orange or brownish-grey); axis solid (subgenus *Chlorea*) 3
Cortex of the thallus without the orange(-red) pigment canarione, thallus grey (or with a yellowish tinge) throughout, merochlorphaeic acid (and related compounds) or vulpinic acid present in the medulla; axis solid or hollow 2
- 2 Thallus isidiate, merochlorophaeic acid syndrome present; axis (at least in basal parts) not solid in the center; thallus rigid, shrub-like. - From the Mediterranean region and Macaronesia. (subgenus *Lethariella*) 1. *L. intricata*
Thallus lacking isidia; vulpinic acid present in the medulla (but due to the low concentration not always recognizable as yellow pigment); axis solid throughout; thallus flabby, pendulous. - Endemic to Japan. (subgenus *Nipponica*) 2. *L. togashii*
- 3 Thallus long, pendent (if terricolous with long filiform, flaccid branches) 4
Thallus shrub-like erect or prostrate 6
- 4 Thallus containing only atranorin, chloroatranorin and canarione; surface smooth. - Macaronesia. 3. *L. canariensis*
Thallus with additional lichen substances; thallus surface often with distinct ridges. - Temperate Asia. 5
- 5 Thallus containing norstictic acid (\pm gyrophoric acid) 10. *L. zahlbruckneri*
Thallus containing psoromic acid (\pm gyrophoric acid) 7. *L. mieheana*
Thallus containing placodiolic acid 9. *L. smithii*
- 6 Thallus containing psoromic acid as major compound 7
Thallus containing gyrophoric acid or norstictic acid as major compound 9
- 7 Soredia often present; surface of the branches rather smooth; thallus erect, branches always terete 5. *L. cladonioides*
Soredia always absent; surface of the branches with distinct ridges or reticular swellings; thallus prostrate to suberect, branches terete or \pm strongly compressed 8

- 8 Branches (at least in basal parts) distinctly compressed, rather flabby 6. *L. flexuosa* s.str.
Branches terete, rather rigid 6. *L. flexuosa* s.l.
- 9 Thallus containing gyrophoric acid as major compound (\pm traces of norstictic acid);
surface always with very prominent and sharp, undulating ridges 4. *L. cashmeriana*
Thallus containing norstictic acid as major compound (\pm with varying amounts of
gyrophoric acid); surface scarcely to strongly ridged 8. *L. sernanderi*

TAXONOMICAL PART

Synonyms are not listed but can be found in KROG (1976).

Lethariella (MOTYKA) KROG

Norweg. J. Bot. 23: 88 (1976). - *Usnea* subgenus *Lethariella* MOTYKA, Lich. Gen. *Usnea* Stud. Monogr. Pars Syst.: 39. (1936). Type species: *Lethariella intricata*.

A. SUBGENUS *LETHARIELLA*

Norweg. J. Bot. 23: 89 (1976).
Type species: *Lethariella intricata*.

1. *Lethariella intricata* (MORIS) KROG

Norweg. J. Bot. 23: 94 (1976). - *Stereocaulon intricatum* MORIS, El. Stir. Sard. 3: 22 (1827). - Type: ad arbores in monte Burcei (TO - holotype, not seen).

Characteristics in brief: Thallus corticolous or saxicolous, rigid and shrub-like erect, grey, with filiform isidia (also on the margin of the apothecia; see fig. 6c, d), axis (at least in basal parts) hollow. - Chemistry: atranorin (minor), chloroatranorin (minor; detected with HPLC by Prof. Jack Elix, Canberra), merochlorophaeic acid (major), submero-chlorophaeic acid (minor), 4-O-methylcryptochlorophaeic acid (minor); \pm fatty acid(s) of the rangiformic/norrangiformic/isorangiformic acid complex.

Specimens examined: CANARY ISLANDS, - La Gomera, Fortaleza SE above Chipude, 17°16'W/28°05'04''N, 1180 m alt., on steep rock surfaces, 20.II.1991, J. Hafellner (23717, Lichenotheca Graecensis 34) (GZU). - an der Straße von San Sebastian nach Hermigua, Felsrippe S vom Roque de la Zarcita, 1120 - 1140 m, 17°12'W/28°06'N, SW-exponierter Überhang, 12.II.1991, J. Hafellner (34232) & A. Hafellner (GZU). - Felskuppe W der Straße nach Alajeró, 0,5 km unter der Abzweigung nach Igualero, 1300 m, 17°14'20''W/28°05'10''N, W-exponierte Abbrüche, 17.II.1991, J. Hafellner (34766) & A. Hafellner (GZU). - Teneriffe (H-NYL 36692). - Lomo del Fraile am Nordwesthang des Vulkans Teide oberhalb La Longuera, zerstreut an steilen zerklüfteten Abbruchflächen solitärer halbschattiger Lavafelsen im lichten Kiefernwald des Nebelgürtels im Stereocaulum vesuvianum, 900 - 1000 m, III.1977, Follmann & Witte (Lichenes Exsiccati Selecti a Museo Historiae Naturalis Casselensi Editi 231) (M). - **FRANCE**, Corse, Soleirol (677, 9106) (H-NYL 36609b, 36693, 36691). - an sommet des hautes montagnes, Soleirol (M). - Haute-Corse, Höhenrücken N der Serra di Pigno über Bastia, 900 - 940 m, 11.V.1990, H. Mayrhofer (9487a, 9487b) & J. Sattler (GZU). - **ITALY**, Basilicata, Prov. Potenza, N-Abhänge des Monte Pollino NW Serra delle Ciavole, 1900 m, auf alter *Pinus leucodermis*, 2.VI.1979, H. Mayrhofer, J. Poelt & P.L. Nimis (Plantae Graecenses Lich. 209) (GZU, M). - Calabria, Prov. Cosenza, Mte. Pollino, Serra del Prete, 1600 m, Buchenmischwald, Weidefläche, Felsrasen, 10.VII.1988, R. Türk & J. Poelt (GZU, with apothecia!). - ibid. Poelt

(GZU). - Prov. Reggio di Calabria, Pietra Impiccata, 1700 - 1750 m, Felshänge, 12.VII.1988, J. Poelt (GZU). - **Sardegna**, Monte Santo di Pula, V.1858, Gennari (Erbar. Crittogam. Ital. 755) (M). - sui basalti, alle vette di Flumini Bina, sopra Orri, 1867, Canepa (Erbar. Crittogam. Ital.-Ser.II. 19) (M). - auf Erde am Monte Santo di Pula, 1896, Canepa (M). - Prov. Núoro, Gennargentu, Arcu Correboi, unterste Abhänge des Mte. Armario, 1235 - 1300 m, Schieferfelsen, 5.V.1986, J. Poelt (GZU). - Prov. Núoro, Barbagia Seulo, Road Seui-Lanusei, M. Arcueri, close to Cantoniera Arcueri, 950 m, on siliceous rocks, 39°49'N/9°21'E, 15.VII.1987, J. Poelt (GZU). Prov. Núoro, Monte Ortobene bei Núoro, 800 m, 25.VII.1985, P.L. Nimis & J. Poelt (GZU). Prov. Núoro, Catena delle Margine N unterhalb Punta Palai, 850 - 920 m, 24.VII.1985, P.L. Nimis & J. Poelt (GZU). - Prov. Sássari, Mte. Limbara SE Témpio Pausania, 1250 - 1300 m, 7.V.1986, J. Poelt (GZU); ibid H. Mayrhofer (6352) (GZU). - Prov. Sássari, Passo La Variante S Témpio Pausania, unterste Abhänge des Lu Colbu, 670 - 720 m, 5.V.1986, H. Mayrhofer (6257) (GZU). - **Isole d'Elba**, auf dem Weg nach Cavo, V.1965, E. Albertshofer (6988) (M). - Westelba, Le Calanche, 2 km S von Poggio, Granit, 800 - 880 m, 27.XI.1989, H. Mayrhofer (8748a, 8748b) & J. Sattler (GZU). - **PORTUGAL**, Beira Alta, prope Gonçalbocas (Guarda), ad rupes graniticas septentrionem spectantes, 800 m.s.m., 11.IX.1962, C.N. Tavares (Lichenes Lusitaniae selecti exsiccati 173) (GZU, M). - Taboaço, alto da Ermida (penedos), VI.1921, Joaq. Sampaio (Lichenes de Portugal 271) (M). - **SIERRA LEONE**, (H-NYL 36694); dubious locality.

B. SUBGENUS *NIPPONICA* KROG

Norweg. J. Bot. 23: 89 (1976). Type species: *Lethariella togashii*.

2. *Lethariella togashii* (ASAHINA) KROG

Norweg. J. Bot. 23: 95 (1976). - *Letharia togashii* ASAHINA, J. Jap. Bot. 27: 295 (1952). - Type: Japan, Honshu, Prov. Kai, Oshino-mura, Minami-Tsuru-gun, on twigs of *Picea polita*, elevation about 960 m, August 11, 1952, M. Togashi; (O - holotype, not seen; H! - isotype, distributed in Lichenes Rariores Et Critici Exsiccati 66).

Characteristics in brief: Thallus on bark or wood, pendulous, flaccid, grey to slightly grey-yellow or brownish, without isidia or soredia. - Chemistry: Atranorin, vulpinic acid and 4-hydroxyvulpinic acid (minor) (only in the medulla); ± fatty acid of the rangiformic/norrangiformic/iso-rangiformic acid complex.

Additional specimen examined: JAPAN, Mt. Huzi, Yamanaka, 14.VII.1953, M. Togashi (Lichenes Japoniae Exsiccati 26, sub *Letharia togashii*). (H).

C. SUBGENUS *CHLOREA* (MOTYKA) KROG

Norweg. J. Bot. 23: 89 (1976). - *Usnea* subgenus *Chlorea* MOTYKA, Lich. Gen. *Usnea* Stud. Monogr. Pars Syst.: 43. (1936). - Type species: *Lethariella cladonioides* (NYL.) KROG. - Other species: *Lethariella canariensis*, *L. cashmeriana*, *L. cladonioides*, *L. flexuosa*, *L. mieheana*, *L. sernanderi*, *L. smithii*, *L. zahlbruckneri*.

3. *Lethariella canariensis* (ACH.) KROG

Norweg. J. Bot. 23: 91 (1976). - *Alectoria canariensis* ACHARIUS, Lich. Univ.: 597 (1810). - Type: Dillenius, Historia Muscorum, tab. 13, fig. 15 (1742) (lectotype, here designated).

Note: In his original description ACHARIUS (1810: 597) referred to two figures, one published in DILLENIUS (1742, tab. 13, fig. 15), the other published in PLUKENET (1694, tab. 309, fig. 1). Since illustrations can act as a type, it is not necessary to designate a neotype (as done by MOTYKA 1936: 14,15, and by FOLLMANN et al. 1973: 8). According to article 9 of the International Code of Botanical Nomenclature (GREUTER et al. [eds.] 1994: 10,11), a lectotype has to be selected from the 'original material' (in this case the two figures mentioned). Thus the illustration (consisting of only one single thallus) of *Alectoria canariensis* in DILLENIUS' 'Historia Muscorum' is chosen as lectotype (see above). - One specimen in H-NYL (no. 36708) seems to be an iso-epitype, as the only text on the label ('Dillenius t. 13, f. 15') refers to the figure of DILLENIUS (1742).

Characteristics in brief: Thallus corticolous or saxicolous, long pendulous (shrubby specimens are supposed to occur; PH. CLERC in litt.), orange, surface smooth (without ridges). - Chemistry: Atranorin, chloroatranorin (fide FOLLMANN & HUNECK 1970), canarione; ± fatty acid(s) of the rangiformic/norrangiformic/isorangiformic acid complex.

Discussion: Within the subgenus *Chlorea*, *Lethariella canariensis* is characterized by the absence of aromatic lichen compounds in the medulla, by its smooth thallus surface and by its distribution (restricted to Macaronesia).

Specimens examined: CANARY ISLANDS, [without any label text except:] Dillenius t. 13, f. 15 (H-NYL 36708, probably an iso-epitype). - In Canariis (H-NYL 36706). - Canaries., Webb. (H-NYL 36705). - Gran Canaria, oberhalb von Fontanales an steilen Felswänden aus stark poröser Lava, 450 m, 26.VIII.1981, K. Kalb & S. Moosburger (Plantae Graecenses Lich 270) (GZU, M). - Hierro, Municipio Valverde, an der Straße von Valverde nach San Andres, unmittelbar an der Abzweigung nach Isora, alter Lavazug, auf Fels und Erde, 1020 m, 30.VII.1987, T. Feuerer (26658c) (M). - Ad ramos *Pini canariensis* in insula Ferro, 1855, de la Perrandièrre (H-NYL 1314). - La Gomera, an der Straße von San Sebastian nach Hermigua, Felsrippe S vom Roque de la Zarcita, 1120 - 1140 m, 17°12'W/28°06'N, Vulkanit auf dem Gipfel, 12.II.1991, J. Hafellner (34225) & A. Hafellner (GZU). - Fortaleza SE ober dem Ort Chipude, 1180 m, 17°16'W/28°05'40''N, in den N- bis NW-seitigen Abbrüchen, 20.II.1991, J. Hafellner (33696) (GZU). - Felskuppe W der Straße nach Alajeró, 0,5 km unter der Abzweigung nach Igualero, 1300 m, 17°14'20''W/28°05'10''N, W-exponierte Abbrüche, 17.II.1991, J. Hafellner (34760) & A. Hafellner (GZU). - La Palma, Volcán de San Antonio, III.1981, G.B. Feige (2946) (M). - Rastplatz an der neuen Bergstraße von Santa Cruz de la Palma zum Pico de los Muchachos, 28°44'N/18°W, an Stamm und Ästen von *Pinus canariensis* 1700 m, A. Binggeli (GZU). - an der Straße von Santa Cruz de la Palma auf den Pico de los Muchachos, Lomo de las Vacas, 1710 m, 28°43'20''N/17°48'35''W, *Pinus canariensis*-Wald, an Stammborke von *Pinus canariensis*, 29.XI.1991, J. Hafellner (30618) (GZU). - ibid. M Matzer (1376) (GZU). - Tenerife, secus viam inter Arafo et Las Canadas del Teide, 1450 m.s.m., ad lavam in pineto (*Pinus canariensis*), 14.I.1985, P.L. Nimis (Lichenes Selecti Exsiccati 2170) (M). - Road from Arafo to Las Cañadas, 1500 m, N-exposed subvertical siliceous rocks, I.1986, P.L. Nimis (GZU). - **MADEIRA**, Pico Areeiro, SW below the summit, 32°44'N/16°55'30''W, 1700 m alt., volcanic rocks, on small shrubs of *Erica* spec., 16.II.1990, J. Hafellner (23716) & A. Hafellner (Lichenotheca Graecensis 31) (GZU). - ibid. on *Pinus*, 18.II.1990, J. Hafellner (27249) & A. Hafellner (GZU). - 1865, Mand[?] (H-NYL 36707).

4. *Lethariella cashmeriana* KROG

Norweg. J. Bot. 23: 91 (1976). - Type: Flora of Kashmir, Astor district, above Doyen, Astor valley, 11000-12000 ft., 14.8.92, J.F. Duthi (BM! - holotype).

Characteristics in brief: Thallus on bark or wood, fruticose, erect, rather stout and strongly branched, orange (at least in apical parts), surface always very strong reticulately ridged (see fig. 6b). - Chemistry: Atranorin (major), canarione (major), gyrophoric acid (major); norstictic acid and \pm fatty acid(s) of the rangiformic/norrangiformic/isorangiformic acid complex.

Discussion: *Lethariella cashmeriana* and *L. sernanderi* seem to be very closely related taxa, perhaps even conspecific. Although the habit of the respective type specimens look quite dissimilar (*L. cashmeriana* has a much more stout thallus which rather thick branches and a very strongly reticulately ridged surface; see fig. 6b) and even the chemistry of the main medullary substances is different (gyrophoric acid in *L. cashmeriana*, norstictic acid in *L. sernanderi*), a few collections appear to be intermediate, either in morphology or in chemistry (see also under 'Chemistry').

Additional specimens examined: CHINA, Prov. Gansu, Kansu occidentali, in valle fluv. Baga-Rolonsug, 6.V.1986, G.N. Potanin (73) (UPS). - Prov. Sichuan, Shalui Shan Mts., 30 km NNE of Batang, SSE of Yidun, 30°16'N/99°25'E, 4000 - 4150 m alt., south-facing slope with *Quercus* cf. *aquifolioides*, *Juniperus tibetica* and *Picea* spec., on *Juniperus*, 26.VI.1994, W. Obermayer (3511, 3514) (GZU). - Shalui Shan Mts., 35 km NNE of Batang, SE of Yidun, 30°16'N/99°28'E, 4200 - 4300 m, pasture with shist outcrop and single *Juniperus* trees, on *Juniperus*, 27.VI.1994, W. Obermayer (3453, 3505, 3512 together with the separated *L. sernanderi* (6419) and *L. mieheana* (6418)) (GZU). - Sikang, Kangting (Tachienlu) distr., in jugo inter Tapaoshan [=Dabaoschan] et Yara [-30°22'N/101°55'E], 4000 m.s.m, in ramo mortuo Laricis, 1934, H. Smith (Plantæ Sinenses 14017) (M). - Tibet (Prov. Xizang), Riwoqe County, Riwoqe, 4400 m, *Juniperus* Wald, 31°18'N/96°30'E, auf *Juniperus*, 16.IX.1994, A. Bräuning (STU). - Himalaya Range, 230 km ESE of Lhasa, Tsangpo valley, 15 km ESE of the village Xang Xian (=Namshan), 29°00'N/93°13'E, 3300 - 3400 m alt., canyon of a tributary to the Tsangpo with *Cupressus gigantea*, on dead *Cupressus gigantea*, 4.VIII.1994, W. Obermayer (5133, growing together with the separated *L. sernanderi* 6420) (GZU). - PAKISTAN, Karakorum, Upper Phubarash valley, above Phubarash, 2680 m, *Picea-Pinus*-forest, 17.VIII.1992, U. Schickhoff (0802) (GZU). - Rakaposhi South Range, Upper Dainyor valley (Manu Gah), *Picea smithiana*-forest, 3110 m, on wood, 31.VII.1992, U. Schickhoff (1147) (GZU). - Baghrot valley, 36°0'-8'N/74°30'-42'E, 2970 - 3930 m, on *Juniperus* and *Picea*, 19.IX.-30.IX.1990, G. & S. Miehe (3775, 4213, 4236, 4247, 4454) (GZU). - Shinghai Gah to Pahot Gali, 35°48'-55'N/74°10'-17'E, 3200 - 3740 m, on *Juniperus*, *Pinus* and *Betula*, 25.VII.-2.VIII.1990, G. & S. Miehe (771, 845, 906, 1540) (GZU). - Hunza- und Nagar-Gebiet, Chapiotrücken, S-Hang, an abgestorbenem Baumwacholder, 3750 m, 9.VI.1959, H.J. Schneider (840) (M). - Kutto Darukush, 36°32'N/74°14'E, auf *Juniperus*, 3300 m, 6.VIII.1959, F. Lobbichler (746) (M). - Nanga Parbat Area, Rakhiot valley, *Pinus wallichiana* forest, 3230 m, on wood, 30.VII.1993, U. Schickhoff (1619) (GZU) - Rakhiot-Tal, bei Märchenwiese, 3300 m, 6.VIII.1990, Th. Peer (GZU).

5. *Lethariella cladonioides* (NYL.) KROG s.str.

Norweg. J. Bot. 23: 93 (1976). - Type: Herb. Ind. Or. Hook. fil. & Thomson (1731) (PC! - holotype; BM!, H-NYL 36695!, H-NYL 36696! - isotypes). Note: The label-text of the isotype-specimen in BM gives the additional information: 'Sikkim, Lachoong, regio alp., 12000 ped., coll. J.D.H[ooker]!').

Characteristics in brief: Thallus terricolous or lignicolous, erect, branches rather slender, orange (at least in apical parts), p.p. with soralia. - Chemistry: Atranorin, canarione, psoromic

acid, 2'-O-demethylpsoromic acid (minor); ± fatty acid(s) of the rangiformic/norringiformic/isorringiformic acid complex.

Discussion: KROG (1976: 93) treated the taxon *L. cladonioides* in a rather broad sense. She included specimens containing both norstictic acid and psoromic acid and thus regarded *L. flexuosa* and *L. sernanderi* to be synonymous with *L. cladonioides*. Wei (in WEI & JIANG 1982: 496) subsequently re-segregated *L. cladonioides* from *L. flexuosa*, indicating that norstictic acid was present in the former and psoromic acid in the latter taxon (see key in WEI & JIANG 1986: 67). However, the holotype specimens of both taxa (in PC) contain psoromic acid, but differ distinctly in growth-habit and morphology (erect, *Cladonia furcata*-like thallus, with terete, smooth, p.p. sorediate branches in *L. cladonioides* versus prostrate to suberect thallus, with p.p. flattened, never sorediate branches with a reticulately ridged surface in *L. flexuosa*). The type material of *L. sernanderi* differs mainly from the above taxa by the occurrence of norstictic acid in the medulla.

Additional specimens examined: [INDIA] Sikkim, Himalaya, Chongtam, 6000 ft., J.D. Hooker (1736) (BM). - CHINA, Tibet (Prov. Xizang), [Himalaya Range] mountain directly southwest above Nyalam, 4000 - 4770 m alt., lower to upper alpine belt, 5./6.VII.1986, V. Komarkova (368) (GZU).

6. *Lethariella flexuosa* (NYL.) WEI in WEI & JIANG

Acta Phytotax. Sin. 20(4): 497 (1982). - *Chlorea flexuosa* NYLANDER, Synops. Lich. 1: 276 (1860). - Type: Herb. Ind. Or. Hook. fil. & Thomson (1733) (PC! - holotype; BM!, H-NYL 36697!, H-NYL-36699! - isotypes). Note: The text on the label of the isotype specimen in BM gives the following additional information: 'Tibet, Yatsea Tebo, 17000 ft.). The paratype specimens with the numbers 1734 and 1737 in BM belong to *Lethariella sernanderi*, 1736 to *L. cladonioides*.

Characteristics in brief: Thallus terricolous, prostrate to suberect, orange (at least in apical parts), rather flabby with compressed branches (*L. flexuosa* s.str.) or rather rigid with terete branches (*L. flexuosa* s.lat.), without soredia. - Chemistry: Atranorin, canarione, psoromic acid, 2'-O-demethylpsoromic acid (minor); ± fatty acid(s) of the rangiformic/norringiformic/isorringiformic acid complex.

Discussion: As has already been pointed out in the key, there are most probably two taxa included within *Lethariella flexuosa*. *L. flexuosa* s.str. has rather flabby branches, which are often compressed, whereas the twigs of *L. flexuosa* s.lat. are always terete and rigid. Further field-studies may resolve the question of whether these morphotypes should be separated in the future. For distinguishing features in comparison to related taxa see under *Lethariella cladonioides*.

Additional specimens examined (*L. flexuosa* s.str.): CHINA, Tibet (Prov. Xizang), Himalaya Range, 170 km SE of Lhasa, 80 km SE of Tsetang (Nedong), 2nd pass on way from Tsetang to Lhünze, 28°38'N/92°14'E, 5000 m alt., alpine meadows and debris cones, on ground, 25.VII.1994, W. Obermayer (4929) (GZU). - Himalaya Range, 190 km SSE of Lhasa, 125 km S of Tsetang (Nedong), 20 km S of Nera Tso (=Ni La Hu), on way to Cona (=Tsona), 28°07'N/91°55'E, 4650 - 4800 m alt., alpine meadows, on ground, 30.VII.1994, W. Obermayer (5101) (GZU). - Himalaya Range, 130 km SSW of Lhasa, eastside of Puma Yumco (=Pomo Tso), way to the nearest mountain east of Pomo Tso, 28°31'N/90°37'E, alpine meadows with *Kobresia*, 5200 - 5400 m alt., 15.VII.1994, W. Obermayer (4246) (GZU). - Cona County, Nila Tso (See), südwestl. Ritang, 4900 m, 28°05'N/91°49'E, 30.VII.1994, A. Bräuning (STU). - Tibet, near Serpa Monastery, 14200 ft., Kennedy (8) (det. R. Paulson) (BM) - [INDIA] Sikkim, Donkia pass, reg. alp., 18000 ft., J.D. Hooker (1732) (BM). - Himalaya, reg. alp., 12000 ft., J.D. Hooker (1735) (BM, H-NYL 36698). - NEPAL, Mt. Everest Expedition, 24.VII.1921 (det. R. Paulson) (BM).

Specimens examined *L. flexuosa* (s.lat.): CHINA, Prov. Sichuan, Shalui Shan Mts., 40 km NNE of Batang, SE of Yidun, 30°14'N/99°34'E, 4700 - 4850 m, alpine meadows with *Kobresia* and *Rhododendron* shrubs, on soil, 28.VI.1994, W. Obermayer (3526, 3022 Lichenotheca Graecensis 32 sub *Lethariella* cf. *flexuosa*) (GZU). - Tibet (Prov. Xizang), Taniantaweng Shan Mts., 60 km W of Markam (=Gartog), pass 15 km NE of Zogang (=Wangda), 29°43'N/98°00'E, 4950 - 5010 m alt., on soil, 4.VII.1994, W. Obermayer (5131) (GZU). - Himalaya Range, 170 km SE of Lhasa, 80 km SE of Tsetang (Nedong), 2nd pass on way from Tsetang to Lhünze, 28°37'N/92°13'E, 5100 m alt., alpine meadows and debris cones, on ground, 2.VIII.1994, W. Obermayer (5136) (GZU). - Distrikt Baxoi, Bamda, 4940 m, 30°09'N/97°15'E, alpiner Rohboden, 6.VII.1994, A. Bräuning (STU). - S.E.-Tibet, 1917-1919, G. Forrest (14281, det. R. Paulson) (BM).

7. *Lethariella mieheana* OBERMAYER spec. nova

Speciebus *Lethariella smithii* et *Lethariella zahlbruckneri* similis sed acidum psoromicum et acidum 2'-O-demethylpsoromicum continens.

Type: CHINA, Tibet (Prov. Xizang), 350 km E of Lhasa, 20 km NE of Nyingchi, 5 km E of the pass, near the timber line, *Juniperus-Abies* forest, 29°38'N/94°42'E, 4300 m alt., on *Juniperus*, 26.VIII.1994, W. Obermayer (3415) (GZU! - holotype; isotypes distributed in Lichenotheca Graecensis #35 sub *Lethariella* cf. *sinensis*; see OBERMAYER 1995: 7).

Characteristics in brief: Thallus on bark or wood, long, pendulous, orange, without soredia or isidia. - Chemistry: Atranorin, canarione, psoromic acid, 2'-O-demethylpsoromic acid (minor); ± fatty acid(s) of the rangiformic/norrangiformic/isorangiformic acid complex and traces of gyrophoric acid.

Etymology: The new taxon is dedicated to Prof. Dr. Georg Miehe (Marburg/Lahn, Germany), who kindly invited me to join the Sino-German-joint-Expedition to southeastern and eastern Tibet in 1994.

Description: Thallus corticolous or lignicolous, orange (but p.p. grey because of a bleaching effect), long, pendulous (reaching more than one meter); branches terete to (especially in the axils) compressed, 350 - 600 µm in diam.; surface smooth in apical parts, moderately ridged and longitudinally grooved in basal parts, not shiny, without isidia and soredia (but cortex p.p. arachnoid perforated); branching pattern submonopodial to somewhat irregular (anisotomic-)dichotomous; branching of lateral twigs right-angled to slightly obtuse-angled; cortex 30 - 75 µm; medulla 30 - (below ridges) 200 µm with very loosely interwoven hyphae (3 - 5 µm in diam); algae chlorococcoid, 10 - 13 µm in diam.; axis solid, circular to triangular and 200 - 300 µm in diam., in Lugol's iodine solution turning (violet-)blue; apothecia and conidiomata not seen; chemistry (see above under 'Characteristics in brief').

Discussion: The reasons for describing this taxon at species level are discussed above (see 'species concept').

Additional specimens examined: CHINA, Prov. Sichuan, Shalui Shan Mts., 40 km NNE of Batang, SE of Yidun, 30°14'N/99°34'E, 4700 - 4850 m, alpine meadows with *Kobresia* and *Rhododendron* shrubs, on soil, 28.VI.1994, W. Obermayer (3522, 3555) (GZU). - Shalui Shan Mts., 35 km NNE of Batang, SE of Yidun, 30°16'N/99°28'E, 4200 - 4300 m, pasture with shist outcrop and single *Juniperus* trees, on *Juniperus*, 27.VI.1994, W. Obermayer (3508, 3509, 3513, 6417, 6418 together with the separated *L. cashmeriana* (3512) and *L. sermanderi* (6419)) (GZU). - Tibet (Prov. Xizang), Riwoqe County, Riwoqe, 4400 m, *Juniperus*-Wald, 31°18'N/96°30'E, 16.IX.1994, A. Bräuning (STU).

8. *Lethariella sernanderi* (MOTYKA) OBERMAYER

Fritschiana 3: 7 (1995). - *Usnea sernanderi* MOTYKA, Lich. Gen. *Usnea* Stud. Monogr. Pars Syst.: 46 (1936), nomen novum for *Usnea reticulata* DU RIETZ, Svensk Bot. Tidskr. 20: 91 (1926) non *Usnea reticulata* VAIN. 1899. - Type of *Usnea reticulata* DU RIETZ: [China] Prov. Sze-ch'uan, reg. bor.-occid., mellan Tsago-gamba och Tamba [probably 31°35'N/101°51'E], 4000 m.s.m., 2.X.1922, Harry Smith, Plantae Sinenses No. 5007 (UPS! - holotype).

Characteristics in brief: Thallus on bark, wood, soil or (rarely) rock, orange, prostrate to bushy-erect, branches rather slender, p.p. with soredia. - Chemistry: Atranorin, canarione, norstictic acid (major); ± gyrophoric acid and fatty acid(s) of the rangiformic/norringiformic/isorangiformic acid.

Discussion: KROG (1976: 93) regarded *Usnea sernanderi* (a nomen novum chosen by MOTYKA (1936: 46) for *U. reticulata*) to be a synonym of *Lethariella cladonioides*. However, the alternative chemistry (norstictic acid instead of psoromic acid) and morphology (distinctly reticulate thallus surface instead of a smooth one) convinced me (OBERMAYER 1995: 7) to recognize this taxon at species level. - For distinguishing characters of *Lethariella cashmeriana* see under that species.

Specimens examined: CHINA, Prov. Sichuan, Shalui Shan Mts., 40 km NNE of Batang, SE of Yidun, 30°14'N/99°34'E, 4700 - 4850 m, alpine meadows with *Kobresia* and *Rhododendron* shrubs, on soil, 28.VI.1994, W. Obermayer (3553) (GZU). - Shalui Shan Mts., 35 km NNE of Batang, SE of Yidun, 30°16'N/99°28'E, 4200 - 4300 m, pasture with shist outcrops and single *Juniperus* trees, on *Juniperus*, 27.VI.1994, W. Obermayer (6419, together with the separated *L. cashmeriana* (3512) and *L. mieheana* (6418)) (GZU). - Taofu (Dawo) distr., reg. orient., Lhamo Monde La [probably 30°50'N/101°30'E], in ramo *Juniperi* arborei, c. 4100 m.s.m., 22.IX.1934, Harry Smith (Plantae Sinenses 14023a) (UPS). - Sikang, Kangting (Tachienlu) distr., in jugo inter Tapaoshan et Yara [~30°25'N/101°45'E], in ramo mortuo *Laricis*, ca. 4000 m.s.m. 29.VIII.1934, Harry Smith (Plantae Sinenses 14017) (UPS). - Tibet (Prov. Xizang), Nyainqentanglha Shan, 350 km E of Lhasa, 20 km NE of Nyingchi, 5 km E of the pass, near the timber line, *Juniperus-Abies*-forest, 29°38'N/94°42'E, 4300 m alt., on *Juniperus*, 26.VIII.1994, W. Obermayer (5139 and Lichenotheca Graecensis 34 (3414)) (GZU). - 120 km SSW of Quamdo (=Changtu), 10 km S of Bamda, 30°09'N/97°17'E, 4600 - 4800 m alt., alpine meadows with *Kobresia*, on soil, 5.VII.1994, W. Obermayer (5132) (GZU) and 4500 - 4600 m alt., *Rhododendron* shrub, on soil, W. Obermayer (3878) (GZU). - Himalaya Range, 280 km ESE of Lhasa, 40 km SW of Mainling, 29°03'N/93°56'E, *Juniperus-Rhododendron*-forest, 4300 m alt., on *Juniperus*, 12.VIII.1994, W. Obermayer (5140) (GZU). - Himalaya Range, 230 km ESE of Lhasa, Tsangpo valley, 15 km ESE of the village Xang Xian (=Namshan), 29°00'N/93°13'E, 3300 - 3400 m alt., canyon of a tributary to the Tsangpo with *Cupressus gigantea*, on dead *Cupressus gigantea*, 4.VIII.1994, W. Obermayer (6420, growing together with the separated *L. cashmeriana* 5133) (GZU). - Ningjing Shan Mts., 9 km W of Markam (=Gartog), 29°40'N/98°32'E, 4200 - 4400 m, *Rhododendron* shrubs with *Picea*, on base of *Rhododendron*, 1.VII.1994, W. Obermayer (3625) (GZU). - Himalaya Range, 60 km ESE of Tsetang (Nedong), 30 km SWS of Gyaca, Putrang La pass, 29°02'N/92°22'E, 4800 m alt., on ground and mosses, 2.VIII.1994, W. Obermayer (5130) (GZU). - Himalaya Range, 280 km ESE of Lhasa, 45 km SW of Mainling, way up to a mountain pasture hut, 29°02'-03'N/93°54'-56'E, 4000 - 4100 m alt., *Abies* forest, on decayed wood, 10.VIII.1994, W. Obermayer (5138) (GZU). - Himalaya Range, 280 km ESE of Lhasa, 40 km SW of Mainling, way from a mountain pasture hut (4660 m alt.) to the glacier (5100 m alt.), 29°03'N/93°56'E, 4700 - 4800 m alt., debris vegetation with *Saussurea*, on soil, 11.VIII.1994, W. Obermayer (5137) (GZU). - Salwin-Kiu Chiang divide [near the border to Prov. Yunnan], Tsarong, 28°20'N/98°27'E, 14000 - 15000 ft., on limestone rocks and cliffs, VII.1921, G. Forrest (19879, det. R. Paulson; cited in Paulson (1928: 318) sub *Letharia flexuosa*) (BM). - [Prov. Yunnan] [close the border to Prov. Xizang], Cho-ni valley,

28°19'N/98°59'E, on wood, 13500 ft., 1922, J.W. & C.J. Gregory (det. Paulson; cited in Paulson (1928: 318) sub *Letharia flexuosa*) (BM) - [INDIA], Sikkim, Lachen, regio alp., 13000 ft., J.D. Hooker (1737) (BM). - Kengra Lama, 14000 ft., J.D. Hooker (1734) (BM). - NEPAL, Mahalangur Himal, Khumbu, auf niedrigen Steinen und Erde der Höhe westlich über Gorak Shep, 5250 m, IX.1962, J. Poelt (Cryptogamae exsiccatae editae a Museo Hist.Natur. Vindobonensi 4569) (GZU, M). - windgefegte Rücken westlich über Gorak Shep, 5300 m, IX.1962, J. Poelt (2090) (GZU). - Höhe W Lobuche, windverfegter Rücken, 5050 m, 23.IX.1962, J. Poelt (L839, L840) (M). - Seitenwände niedriger Blöcke bei Phalong Karpoo oberhalb Pheriche, 4400 m, 21.IX.1962, J. Poelt (L841) (M).

9. *Lethariella smithii* (DU RIETZ) OBERMAYER comb. nova

Basionym: *Usnea smithii* DU RIETZ, Svensk Bot. Tidskr. 20: 92 (1926). - Type: CHINA, Prov. Sze-ch'uan, reg. bor.-occid., mellan Merge och Sangkar, Läger II, på *Larix*, 4000 m.s.m., 3.IX.1922, Harry Smith, Plantae Sinenses (5017) (UPS! - holotype; BM! - isotype). Note: *Lethariella sinensis* Wei & Jiang, Acta Phytotax. Sin. 20(4): 498 (1982) is probably a synonym. - Type: Xizang, Qamdo, alt. 4300 m, 2.VII.1976, Li Wen-hua 76-95-(1) (holotype in HMAS-L, not seen; see below).

Characteristics in brief: Thallus on bark or wood, long, pendulous, orange, without soredia. - Chemistry: Atranorin, canarione, placodiolic acid (=undetermined substance 6-6-6 in KROG 1976: 90); ± fatty acid(s) of the rangiformic/norringiformic/isorangingiformic acid complex.

Discussion: As a result of poor conservation, the type material of *Lethariella smithii* does not show the bright orange colour typical for all species of the subgenus *Chlorea*, but appears grey, greyish-brown or brownish. That accords well with the protologue of DU RIETZ (1926: 92) ('...thallus ... cinereofuscenscens vel rarius pallide fuscocinereus...'), which excludes the possibility of an interchange of the type-specimens of *Lethariella smithii* and *L. zahlbruckneri* (the latter with a typical orange to orange-grey coloured thallus). The holotype collection of *Lethariella zahlbruckneri* contains norstictic acid, a result which has been checked on 4 different pieces of the thallus. Thus, KROG's (1976: 96) report of the 'unknown 6-6-6' in the holotype of *L. zahlbruckneri* might be the result of a few intermixed branches of *L. smithii*.

Since the type specimen of *Lethariella sinensis* (in HMAS) was not available, the unknown substance recorded for this species (see WEI & JIANG 1982: 498 and fig. 5) has not been compared with placodiolic acid. If this substance is placodiolic acid, *Lethariella sinensis* would become a synonyme of *L. smithii*.

Additional specimens examined: [CHINA], Prov. Sze-ch'uan [=Prov. Sichuan], reg. bor.-occid., mellan Tsago-gomba och Tamba, [probably 31°35'N/101°51'E] ca. 4000 m.s.m., 2.X.1922, Harry Smith (Plantae Sinenses 5014) (BM-Isotype of *L. zahlbruckneri*). - Prov. Sze-ch'uan, reg. bor., Dongrengo [Xuebaoding, 32°35'N/103°50'E], fuktig moss- och gräs-rik *Rhododendron*-shog, på *Juniperus*-stam, 4100 m.s.m., 20.VII.1922, Harry Smith (Plantae Sinenses 5015) (UPS). - Sikang, Taofu (Dawo) distr., reg. orient., Lhamo Monde La [probably 30°50'N/101°30'E], in trunco *Juniperi arborei*, c. 4100 m.s.m., 22.IX.1934, Harry Smith (Plantae Sinenses 14024) (GZU, UPS).

10. *Lethariella zahlbruckneri* (DU RIETZ) KROG

Norweg. J. Bot. 23: 88 (1976). - *Usnea zahlbruckneri* DU RIETZ, Svensk Bot. Tidsk. 20: 92 (1926). - Type: [CHINA] Prov. Sze-ch'uan [=Sichuan], reg. bor.-occid., mellan Tsago-gomba och Tamba [probably 31°35'N/ 101°51'E], 4000 m.sm., 2.X.1922, Harry Smith, Plantae Sinenses (5014) (UPS! - holotype).

Characteristics in brief: Thallus on bark or wood, long pendulous, orange, without soredia. - Chemistry: Atranorin, canarione, norstictic acid (major); ± gyrophoric acid and fatty acid(s) of the rangiformic/norrangiformic/isorangiformic acid complex.

Discussion: see under *Lethariella smithii*.

Additional specimens examined: CHINA, Prov. Sichuan, Qamdo, Paß, 4500 m 31°05'N/96°57,8'E, Fichten-Wacholder-Wald, 18.IX.1994, A. Bräuning (STU). - Shalui Shan Mts., 30 km NNE of Batang, SSE of Yidun, 30°16'N/99°25'E, 4000 - 4150 m, south-facing slope with *Quercus* cf. *aquifolioides*, *Juniperus tibetica* and *Picea* spec., on *Picea*, 26.VI.1994, W. Obermayer (3328, 3331) (GZU). - Tibet (Prov. Xizang), Riwoqe County, Riwoqe, 4400 m, *Juniperus* Wald, 31°18'N/96°30'E, 16.IX.1994, A. Bräuning (STU, 4 specimens).

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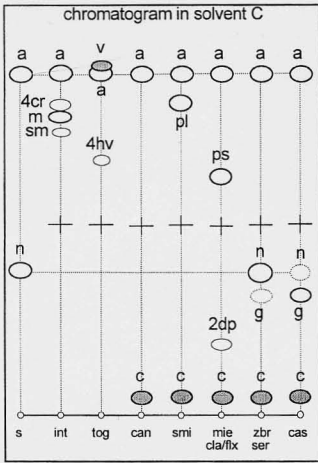
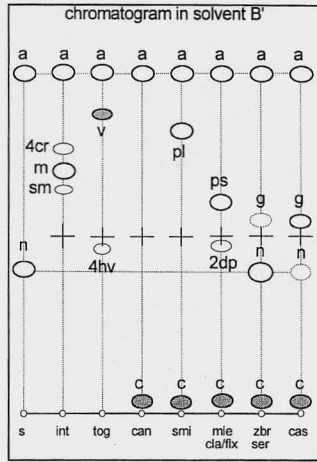
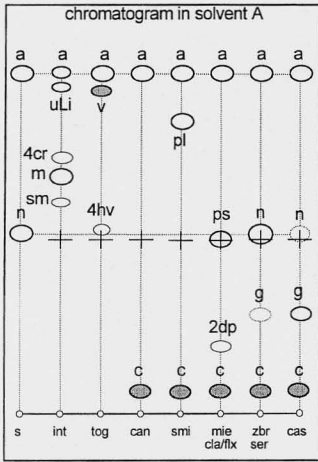


Fig. 1. Chromatograms of the species of *Lethariella*

Substances: a = atranorin, c = canarine, g = gyrophoric acid (if strong with traces of lecanoric acid), m = merochlorophaeic acid, n = norstictic acid, pl = placodiolic acid, ps = psoromic acid, sm = submerochlorophaeic acid, uLi = unidentified metadepsid in *L. intricata* v = vulpinic acid, 2dp = 2'-O-demethylpsoromic acid, 4cr = 4-O-cryptochlorophaeic acid, 4hv = 4-hydroxy-vulpinic acid.

Species: can = *Lethariella canariensis*, cas = *L. cashmeriana*, cla = *L. cladonioides*, fix = *L. flexuosa*, int = *L. intricata*, mie = *L. mieheana*, ser = *L. sernanderi*, smi = *L. smithii*, tog = *L. togashii*, zbr = *L. zahlbruckneri*; (s = standard).

(The cross indicates a fatty acid of the rangiformic/norringiformic/isorringiformic acid complex which can occur in all species.)

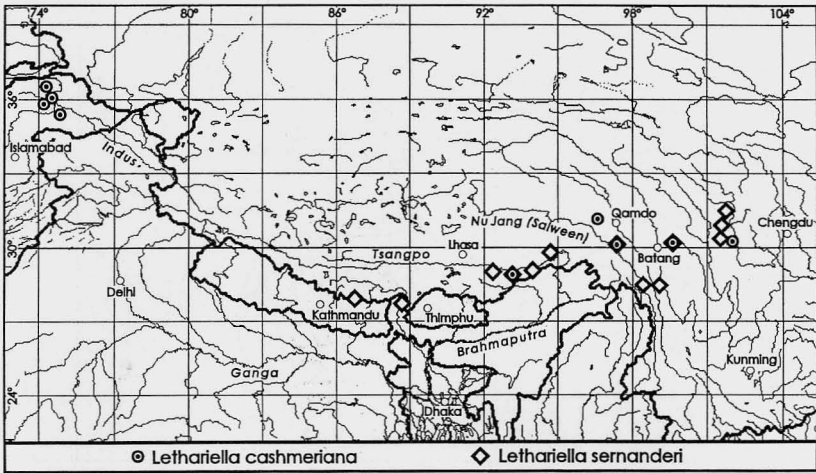


Fig. 2. Locations of investigated, shrub like erect *Lethariella*-taxa of subgenus *Chlorea* (*L. cashmeriana*, *L. sernanderi*).

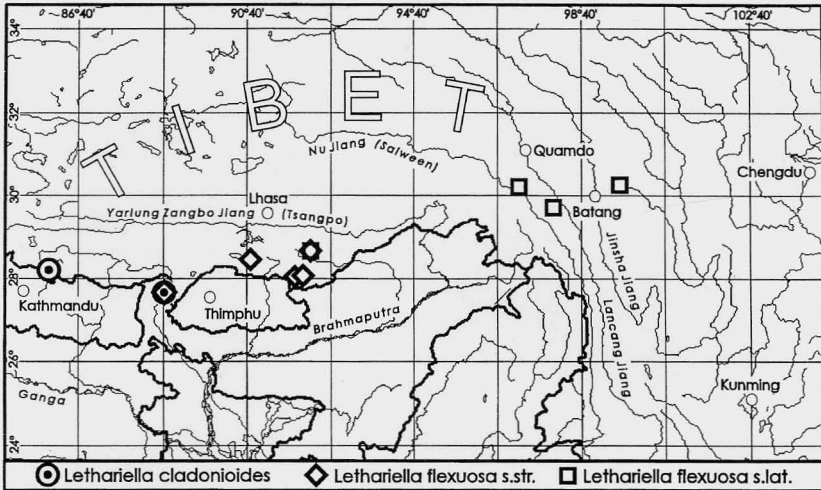


Fig. 3. Locations of investigated, shrub like erect or prostrate *Lethariella*-taxa of subgenus *Chlorea* (*L. cladonioides*, *L. flexuosa*).

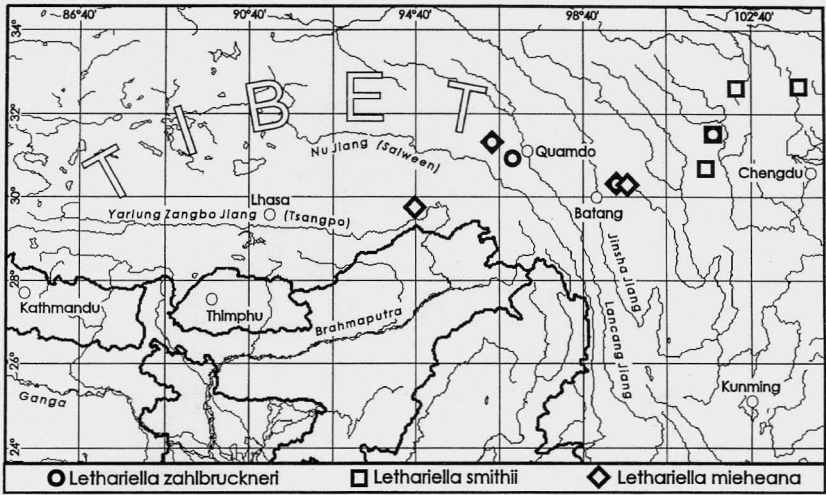


Fig. 4. Locations of investigated pendulous *Lethariella*-taxa of subgenus *Chlorea* from Asia (*L. zahlbruckneri*, *L. smithii*, *L. mieheana*).

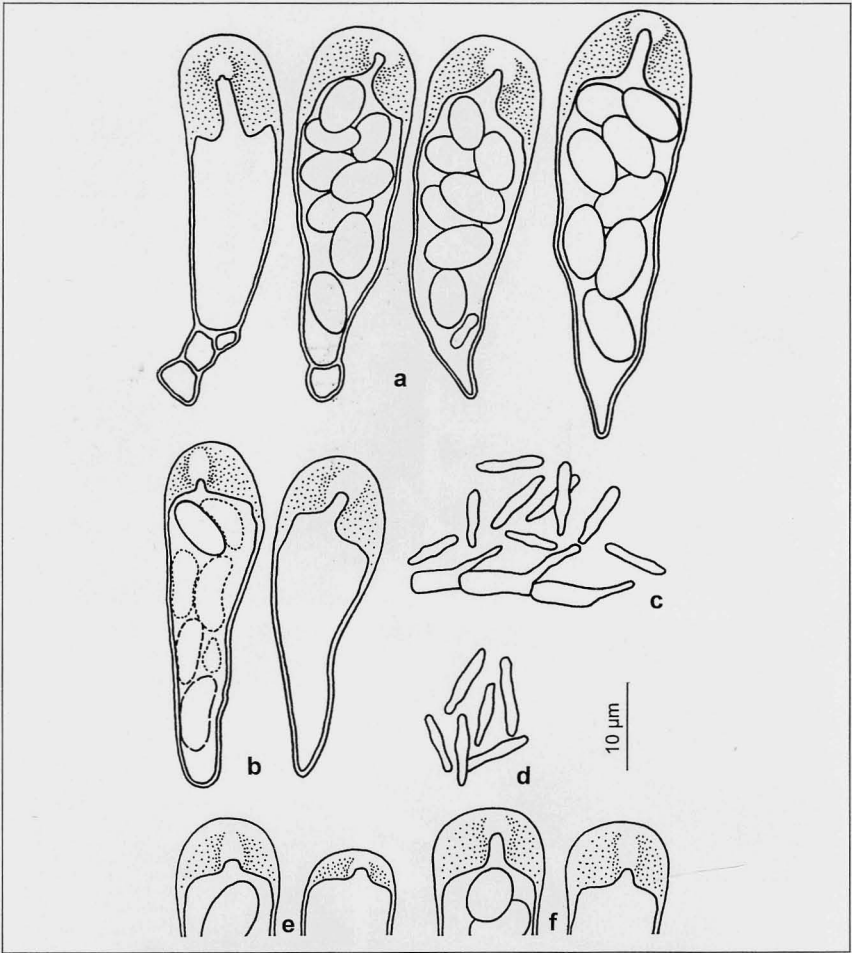
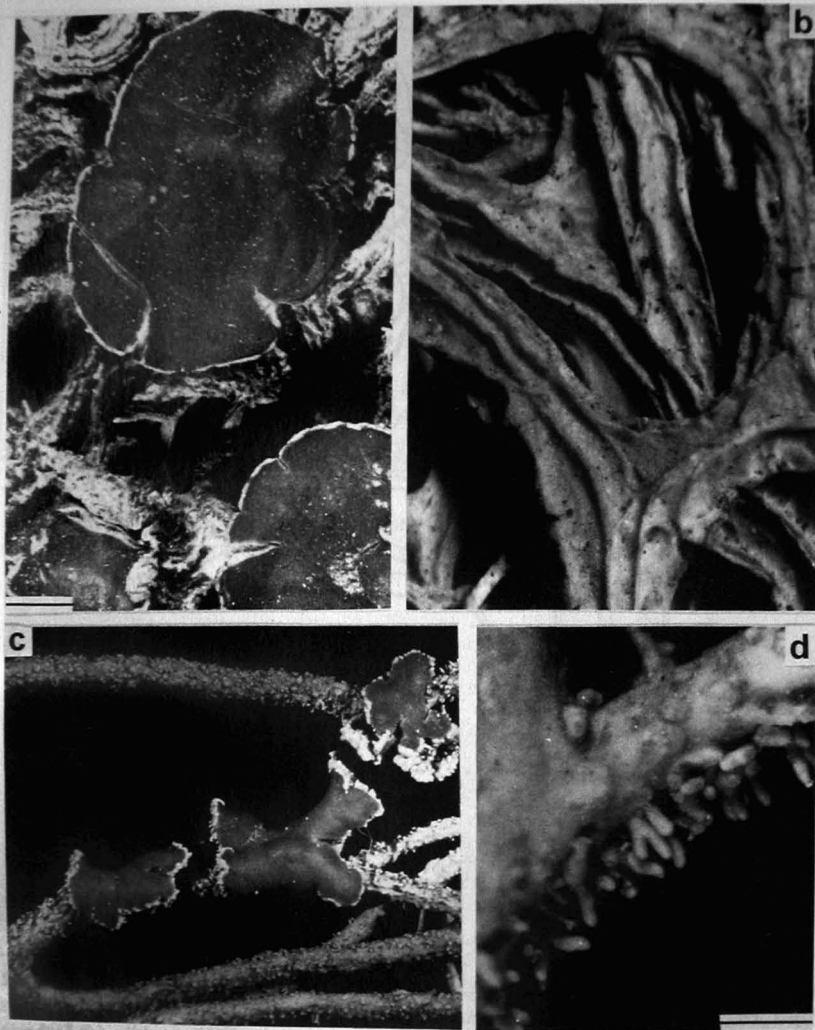


Fig. 5. (a) *Lethariella zahlbruckneri* (UPS-holotype), asci. (b) *Lethariella intricata* (Türk & Poelt s.n., GZU), asci. (c) *Lethariella sernanderi* (Obermayer 3414, GZU), conidigenous cells with conidia. (d) *Lethariella intricata* (Türk & Poelt, s.n., GZU), conidia. (e) *Letharia vulpina*, tips of asci. (f) *Protousnea magellanica*, tips of asci.



cashmeriana
 Fig. 6 (a, b). *Lethariella zahbruckneri* (Obermayer 3511, GZU). (a) apothecia. (b) surface of the thallus with ridges. (c, d) *Lethariella intricata* (Türk & Poelt, s.n., GZU). (c) apothecia. (d) branch of a thallus with isidia. Scale = 100 μ m.