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Lecidea atrobrunnea in Europe and adjacent parts of Asia and Africa

Lecidea atrobrunnea in Europa und benachbarten Teilen Asiens und Afrikas

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Key words: Lichens, *Lecidea atrobrunnea*-complex, chemotaxonomy, determination-key, distribution in Europe and Turkey.

Schlagwörter: Flechten, *Lecidea atrobrunnea*-Komplex, Chemotaxonomie, Bestimmungsschlüssel, Verbreitung in Europa und der Türkei.

Summary: 135 specimens of *Lecidea atrobrunnea* from Europe and some adjacent regions were studied morphologically, anatomically and chemically. As in North American populations, a large number of chemotypes could be discerned, but anatomical or morphological characters correlating with these could not be detected. Six chemical races were accepted at the rank of subspecies (*L. atrobrunnea* ssp. *atrobrunnea*, ssp. *deplanaica* ssp. nova, ssp. *planaica* ssp. nova, ssp. *porphyrilica* ssp. nova, ssp. *saxosa* and ssp. *stictica*). Six other chemotypes (J, K, L, N, P, R) remain undescribed. Specimens in which no lichen substances could be traced – possibly a group of heterogeneous origin – are classified as 'chemotype 0' [zero]. A key for *Lecidea atrobrunnea* and related or often confused species is provided, as well as descriptions and lists of selected specimens.

Zusammenfassung: 135 Herbarbelege von *Lecidea atrobrunnea* aus Europa und benachbarten Regionen in Asien und Nordafrika wurden morphologisch, anatomisch und chemisch untersucht. Wie schon früher an nordamerikanischem Material, so wurde auch hier eine Vielzahl von Chemotypen festgestellt. Korrelationen zwischen den morphologisch-anatomischen und chemischen Merkmalen wurden nicht gefunden. Sechs der Chemotypen werden im Rang von Subspecies geführt (*L. atrobrunnea* ssp. *atrobrunnea*, ssp. *deplanaica* ssp. nova, ssp. *planaica* ssp. nova, ssp. *porphyrilica* ssp. nova, ssp. *saxosa* und ssp. *stictica*), sechs weitere (deren Stoffmuster teilweise eine hybridogene Entstehung nahe legen) bleiben unbeschrieben (Chemotypen J, K, L, N, P, R). Belege, in denen keine Flechtenstoffe nachgewiesen werden konnten sind unter "Chemotyp Null"

zusammengefasst – eine möglicherweise heterogene Gruppe. Ein Schlüssel der innerhalb von *Lecidea atrobrunnea* unterschiedenen Taxa, der auch viele ähnliche, oft mit *L. atrobrunnea* verwechselte Arten umfasst, ist beigefügt.

1. Introduction

Lecidea atrobrunnea (LAM. & DC.) Schaer., a species known to occur on all continents, is usually confined to the high montane to alpine zones of mountain ranges or the corresponding regions in the high latitudes of both hemispheres. Its global distribution is mapped by HERTEL (2006) and its European distribution is given in fig. 1. In an earlier study (LEUCKERT & HERTEL 2003), based mainly on specimens collected in North America, various chemotypes could be distinguished. In HERTEL & PRINTZEN (2004) two of these were treated as species (*Lecidea perlatolica* HERTEL & LEUCKERT, *L. schizopeltica* HERTEL & LEUCKERT) and two as subspecies (*L. atrobrunnea* ssp. *saxosa* HERTEL & LEUCKERT, *L. atrobrunnea* ssp. *stictica* HERTEL & LEUCKERT), but several additional chemotypes remained taxonomically unclear and thus undescribed.

Here we focus on the European populations of *Lecidea atrobrunnea* and report on a study of 135 specimens. Conscious of our studies on North American species of this group, we are aware that 135 specimens are too small a number to obtain more than only very preliminarily results, but time and technical problems limited our project.

Revisions of specimens filed under "*Lecidea atrobrunnea*" in herbaria show that it is often confused with gross-morphologically similar taxa of *Lecidea* and other lecideoid genera. Therefore a key to the European members of the *Lecidea atrobrunnea*-complex is presented which includes some gross-morphologically similar but unrelated taxa.

2. Material and methods

The study is based on selected herbarium specimens from various herbaria (ASU, B, COLO, G, GZU, M, MIN, MSC, O, STU, UPS, W). Anatomical characters were studied by light microscopy using 15-18 µm thick freezing microtome sections through thallus and apothecia. For the chemical methods see LEUCKERT & HERTEL (2003).

3. On the variability of *Lecidea atrobrunnea*

Lecidea atrobrunnea is a very polymorphic species, as reflected by the multitude of varieties and forms described in the literature. As well as its 'chemistry', especially the colour of the thallus, the type of areolation, the pigmentation

of the hypothecium, the size of the ascospores and the length of the pycnospores vary within rather wide limits.

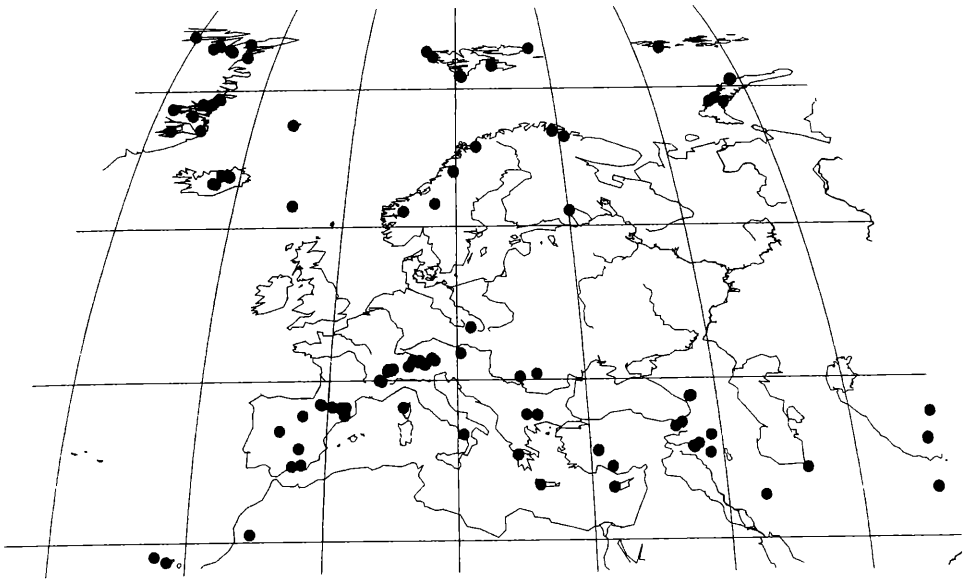

Fig. 1: Known distribution of *Lecidea atrobrunnea* sensu lato in Europe and adjacent regions. The lichen is confined to alpine zones. It is widespread especially in arctic regions and in the high mountain systems of Central and Southern Europe and adjacent parts of Asia. Its absence from the floristically well studied Scottish Highlands is remarkable.

In detail the species can be described as follows:

Thallus: Usually 3-12 cm in diam., sometimes even larger; 0.5-2.5 mm thick (when squamulose). Crustose, flat areolated and appressed to the substrate or bullate areolated or areolate-squamulose or squamulose (causing assignment of this species to *Psora* by some earlier authors). Areolae flat to highly convex or squamiform or lobulate, regular or irregular in shape, angular to round in outline, up to 3 mm in diam., shiny light yellow-brown, greenish-brown, olivaceous-green, pale to dark brown, red-brown or grey-brown; areoles normally with a whitish, greyish or blackish edge and a shiny, smooth or areolate-cracked or furrowed surface. Squamulose areolae have a pale brown to blackish underside. Isidia and soredia normally never developed (however, among the 867 tested worldwide specimens of *L. atrobrunnea*, there was a single sorediate thallus in North American material). Prothallus: Indistinguishable to conspicuous, black or black-green, rarely whitish, sometimes (especially in high alpine sites) dendroidic. Medulla: White, I+ intensely violet, scarcely I+ pale violet, some-

times this coloration patchy, (specimens with I– medulla extremely rare and not observed in European material), K– or K+ red, P– or P+ yellow or P+ ochre.

Chemosyndroms found in European specimens of *Lecidea atrobrunnea*	**Composition** (M) = major compound – (m) = minor compound – (s) = not detected in all specimens – f = frequently – r = rarely
Confluentic acid syndrome	Confluentic acid (M), 2'-*O*-methylperlatolic acid (m, s), 2'-*O*-methylmicrophyllinic acid (m, s)
	2'-*O*-Methylperlatolic acid (M), confluentic acid (M, s)
	Confluentic acid (M), 2'-*O*-methylperlatolic acid (M), 2'-*O*-methylmicrophyllinic acid (m, s)
Planaic acid syndrome	Planaic acid (M), 2'-*O*-methylperlatolic acid (m, s, f), 4-*O*-demethylplanaic acid (m, s, r)
Norstictic acid syndrome	Norstictic acid (M), connorstictic acid (m, s)
Stictic acid syndrome	Stictic acid (M), norstictic acid (m, s), cryptostictic acid (m, s), constictic acid (m, s)
	Hypostictic acid
	Stictic acid (M), hypostictic acid (m), cryptostictic acid (m, s), constictic acid (m, s)

Fig. 2: The composition of the chemosyndroms found in European specimens of *Lecidea atrobrunnea*.

Apothecia: Black, up to 2 mm in diam., with a slightly or moderately constricted base, and flat to convex, occasionally bluish pruinose discs and usually with persistent thin or thick, prominent, often slightly flexuous dull to shiny margins. In convex apothecia prominent margins sometimes became indiscernible. Excipulum: unpigmented to very pale brownish inside, with a rather thick blue-green-black, green-black or blackish margin, 25-150 µm thick along the flank, composed of parallel-radiate branched and sometimes anastomosing hyphae, 2.5-4.5 µm in diam. Hymenium: (30-)*40-60*(-65) µm tall [absolute minimum and maximum values in brackets, mean values in italics], hyaline to very pale bluish-green, with a bright green to bluish-green, olive-green or green-brown epihymenium. Subhymenium: Hyaline, 10-40 µm tall (not clearly delimited in specimens with a hyaline hypothecium). Paraphyses: discrete, conglutinated in

water, usually simple, occasionally short-branched, rarely anastomosing, 1.5-2.3 µm in diam., with thickened, clavate apical cells up to 4.5 µm in diam. Asci: Clavate, 40-65 × 13-16 µm. Ascospores: Ellipsoid-oblong, (3.2-)*6.6-11.7*(-16) × (2.5-)*3.2-4.6*(-7.0) µm. Hypothecium: Hyaline to medium brown (very rarely dark brown). Pycnidia: Immersed in the thallus or in the prothallus (often in narrow cracks between areoles), with a usually irregular to graphidoid ostiolum. Conidia: Bacilliform to (rarely) filiform, (5.5-)*7.6-20.5*(-26.0) × (0.8-)*1.2* (-1.4) µm. Secondary metabolites: p-depsides of the orcinol-type, β-orcinol depsidones, dibenzofurans may occur. Each chemotype is characterised by the presence of either single lichen substances or chemosyndromes (see fig. 2). Of the 16 chemotypes distinguished, 12 are accounted for in Europe and adjacent parts of Asia (see fig. 3). Ecology: Not lichenicolous and confined to non-calciferous rocks (gneiss, granite, schist, rhyolite, basalt, etc.) in open, usually sun-exposed sites from the nival zone down to the montane zone. *L. atrobrunnea* tolerates rather long dry periods and is hence rather common in, for example, summer-dry mountain ranges in Mediterranean Europe and adjacent Asia.

4. Taxonomic evaluation of the chemotypes of *Lecidea atrobrunnea*

Unfortunately we did not find any clear correlations between the anatomical-morphological and the chemical characters. For all the chemotypes with an adequate number of specimens that we examined, there was an almost identically high variability of the morphological characters. In fig. 4, the variability of some taxonomically important characters of the three commonest chemotypes is compared.

The subdivision of *Lecidea atrobrunnea*, therefore, has to be based primarily on chemical characters. Without molecular genetic investigations, a satisfactory understanding of this complex seems impossible. The arrangement presented here is only a preliminary makeshift proposal to subdivide this confusing complex.

As a basis for our taxonomic judgement we used (a) the geographical distribution (when distinguishable geographical patterns can be discerned) and (b) the lichen substances.

"Single-syndrome" and "complex" chemotypes (see LEUCKERT & HERTEL 2003) are distinguished as follows: Single-syndrome chemotypes contain only one acid or acid syndrome of one of the following three groups (a) p-depsides of the orcinol type (confluentic acid syndrome or planaic acid syndrome or 4-*O*-demethylplanaic acid or perlatolic acid syndrome) or (b) of the depsidones of the β-orcinol type (norstictic acid syndrome or stictic acid syndrome) or (c) of the dibenzofurans (schizopeltic acid or porphyrilic acid). In contrast, complex chemotypes contain components of both the p-depsides of the orcinol type and

Taxonomic treatment of the chemotypes observed in *Lecidea atrobrunnea* s.l. Chemotypes in grey fields are not known to occur in Europe		Lichen substances present in the thallus			
		depsidones of the β-orcinol type		**dibenzofurans**	
		chemotype E Norstictic acid syndrome ***Lecidea atrobrunnea*** ssp. ***saxosa***	**chemotype F** stictic acid syndrome ***Lecidea atrobrunnea*** ssp. ***stictica***	**chemotype G** schizopeltic acid ***Lecidea schizopeltica***	**chemotype H** porphyrilic acid ***Lecidea atrobrunnea*** ssp. ***porphyrilica***
Lichen substances present in the thallus **p-depsides of the orcinol type**	**chemotype A** Confluentic acid syndrome ***Lecidea atrobrunnea*** ssp. ***atrobrunnea***	**chemotype J** norstictic acid syndrome + confluentic acid syndrome ***L. atrobrunnea*** **chemotype J**	**chemotype K** stictic acid syndrome + confluentic acid syndrome ***L. atrobrunnea*** **chemotype K**	**chemotype N** schizopeltic acid + confluentic acid syndrome ***L. atrobrunnea*** **chemotype N**	**chemotype P** porphyrilic acid + confluentic acid syndrome ***L. atrobrunnea*** **chemotype P**
	chemotype B Planaic acid syndrome ***L. atrobrunnea*** ssp. ***planaica***	**chemotype L** norstictic acid syndrome + planaic acid syndrome ***L. atrobrunnea*** **chemotype L**	**chemotype M** stictic acid syndrome + planaic acid syndrome ***L. atrobrunnea*** **chemotype M**	**chemotype Q** schizopeltic acid + planaic acid syndrome ***L. atrobrunnea*** **chemotype Q**	**chemotype R** porphyrilic acid + planaic acid syndrome ***L. atrobrunnea*** **chemotype R**
	chemotype C 4-*O*-demethylplanaic acid ***L. atrobrunnea*** ssp. ***deplanaica***	(unknown)	(unknown)	(unknown)	(unknown)
	chemotype D Perlatolic acid syndrome ***Lecidea perlatolica***	(unknown)	(unknown)	(unknown)	(unknown)

Fig. 3: Taxonomic treatment of the chemotypes observed in *Lecidea atrobrunnea*. The chemotypes A to H, are subsumed as "single-syndrome chemotypes", while chemotypes J to R are subsumed as "complex chemotypes"). As to the composition of the chemosyndromes see fig. 2 and LEUCKERT & HERTEL (2003). The chemotypes D, G, M, and Q (grey fields) are not known to occur in Europe or Turkey.

Characters	All chemotypes = *Lecidea atrobrunnea* sensu lato	Chemotype A = *Lecidea atrobrunnea* ssp. *atrobrunnea*	Chemotype E = *Lecidea atrobrunnea* ssp. *saxosa*	Chemotype F = *Lecidea atrobrunnea* ssp. *stictica*
Scaliness of areolae 1: not squamulose; 5: intensely squamulose	1 - 4 (- 5)	1 - 4 (- 5)	1 - 4 (- 5)	1 - 4 (- 5)
Hypothecium colour: 1: hyaline; 5: dark brown	1 - 4 (- 5)	1 - 4 (- 5)	1 - 4	1 - 4 (- 5)
Mean height of hymenium	34-65 µm	34-62 µm	40-65 µm	40-61 µm
Mean width of ascospores	3.2-5.2 µm	3.2-4.6 µm	3.4-4.8 µm	3.0-4.8 µm
Mean length of ascospores	6.6-11.7 µm	6.7-11.7 µm	7.5-11.6 µm	7.2-11.1 µm
Mean length of pycnospores	7.6-24.7 µm	9.6-20.7 µm	9.4-16.7 µm	8.5-20.9 µm

Fig. 4: Variability of some selected characters in *Lecidea atrobrunnea* sensu lato and in it's most common chemotypes. The data are based on a variable number of records. The mean values of the size of ascospores (based on 25-50 measurements each) are based on 380 records for *Lecidea atrobrunnea* sensu lato, on 110 records for *Lecidea atrobrunnea* ssp. *atrobrunnea,* on 41 records for *Lecidea atrobrunnea* ssp. *saxosa,* and on 68 records for *Lecidea atrobrunnea* ssp. *stictica.* The data indicate that the extent of the anatomical variability is about the same size in the subspecies of *Lecidea atrobrunnea* ssp. *atrobrunnea* as well as in the *Lecidea atrobrunnea* chemotype-complex as a whole.

the depsidones of the β-orcinol type or components of both the p-depsides of the orcinol type and the dibenzofurans (see fig. 3).

We decided to treat:

(1) single-chemo-syndrome chemotypes with markedly restricted distribution patterns as species: *Lecidea perlatolica* HERTEL & LEUCKERT (see fig. 3; South Western U.S.A. [California, Nevada, Utah]) and *L. schizopeltica* HERTEL & LEUCKERT (see fig. 3; Western U.S.A. and Baja California);
(2) widely distributed single-chemosyndrome chemotypes as subspecies;
(3) complex chemosyndrome chemotypes, however, remain taxonomically undescribed (perhaps they are partly of hybrid origin).

5. Chemotypes growing closely together

Often several chemotypes occur together at the same collecting locality, on the same boulder, or even adjacently. Hence duplicate collections deposited in herbaria are sometimes chemically inconsistent. Fig. 5 shows sets of pairs or triples of chemotypes discovered in duplicate collections. Although the chemical conformity of duplicate collections was not investigated in detail, we conclude from the chemical heterogeneity of the duplicate samples randomly tested that a considerable number of *Lecidea atrobrunnea* duplicate specimens in other herbaria also differ chemically. Clearly, some collectors deliberately united morphologically heterogeneous thalli in their collections in order to demonstrate the apparent variability of the material obtained from a particular habitat.

Mosaics of different chemotypes growing sometimes side by side are also known in other genera, e.g. in *Dimelaena oreina* (LEUCKERT et al., 1981), *Cladonia pyxidata* (LEUCKERT et al., 1972), *Ramalina siliquosa* (CULBERSON et al., 1993) and *Thamnolia vermicularis* (KÄRNEFELT & THELL 1995). Whether or not the chemotypes recognised in *Lecidea atrobrunnea* are bound to ecological niches and these heterogeneous collections are from overlapping parts of these niches or are plainly mixtures due to the collector overlooking the ecological heterogeneity of the collecting site remains unanswered (LEUCKERT & HERTEL 2003: 28).

Chemotypes of *Lecidea atrobrunnea* found in collections distributed as duplicates			Collections
ssp. *atrobrunnea*	ssp. *planaica*		BIRD & LAKUSTA 16141 (COLO – UPS) WEBER & DAHL S-1675 (COLO – COLO)
ssp. *atrobrunnea*	ssp. *planaica*	chemotype 0	SHUSHAN S-9845 (MIN – COLO – MSC)
ssp. *atrobrunnea*	ssp. *saxosa*		IMSHAUG 11581 (M – MSC) EGAN 8959 (MIN – MIN)
ssp. *atrobrunnea*	ssp. *stictica*		BRODO CANL-97662 (MIN – M) Crypt. Exs. Vindob. 4213 (B, COLO, W – GZU, M)
ssp. *atrobrunnea*	ssp. *stictica*	chemotype 0	SHUSHAN S-8322 (MIN – MSC – COLO)
ssp. *atrobrunnea*	chemotype J		IMSHAUG 18056 (UPS – MSC)
ssp. *atrobrunnea*	chemotype N		HERTEL 39893 (M – M) NASH 7626 (ASU, COLO – MIN) NASH 8093 (ASU – ASU, MIN) WEBER S-7933 (MIN – COLO) SHUSHAN S-9291 (COLO, COLO, COLO – M)
ssp. *atrobrunnea*	chemotype P		RABENH.: Lich. Eur. 439 (COLO, W — W)
ssp. *atrobrunnea*	chemotype 0		WETMORE 15887 (MIN – MIN) WEBER et al. L-31304 (COLO, W – MSC) FOLLMANN: Lich. Cassel. Exs. 171 (COLO, GZU – W)
ssp. *saxosa*	ssp. *stictica*		SHUSHAN & ANDERSON S-8329a (W –B COLO) Arnold: Lich. Exs. 551 (B – M)
ssp. *saxosa*	chemotype J		WETMORE 16343 (MIN – MIN)
ssp. *planaica*	chemotype 0		WETMORE 18819 (MIN – MIN)

Fig. 5: Chemotypes of *Lecidea atrobrunnea* found in collections distributed as duplicates. Thalli growing side by side at the same boulder sometimes do not belong to one and the same chemotype. The table show the pairs or triplets of different chemotypes we came across in 22 tested sets of duplicates. Interestingly enough we found so far no pair consisting of two complex chemotypes.

6. The taxa of the Lecidea atrobrunnea-complex found in Europe and adjacent regions

6.1. Chemotypes treated as subspecies

6.1.1. *Lecidea atrobrunnea* (LAM. & DC.) SCHAER. ssp. *atrobrunnea*

NASH et al., Lichen Flora of the Greater Sonoran Desert Region II, p. 295-296 (2004).

= Chemotype A (confluentic acid syndrome)

Lecidea atrobrunnea ssp. *atrobrunnea* represents the commonest and most widespread chemotype in the *L. atrobrunnea*-complex. Outside of Europe, we have seen material from Asia (Afghanistan, Kazakhstan, Pakistan, Russia, Tajikistan, Turkey), North America (Canada, Greenland, Mexico, U.S.A.), South America (Chile), Africa (Mt. Kenya, Canary Islands), Australia (see especially RAMBOLD 1989) and Antarctica (Antarctic Peninsula, South Georgia).

Records:

EUROPE

Iceland: Suður-Þingeyjarsýsla: W-Hang des Tungnafellsjökull, Vogelblock, 980 m alt., 1979, HERTEL 21828 (M). Mývatn, unmittelbare Umgebung von Skútustaðir, 290 m alt., 1979, HERTEL 21680 (M). – Norður-Múlasýsla: Möðrudalur, Vegaskarð, Paßhöhe, 710 m, 1979, HERTEL 21612 (M). – Vestre Skaftafellsýsla: Westrand des Vatnajökulls, 1931, SLANAR (W).

Sweden: Torne Lappmark: Par. Kiruna, valley S of Låktatjåkka railway station, W of Abisko, near ANS hut, ca. 3 km S of railway, 750 m alt., 1986, SIPMAN 21175 (B).

Czech Republic: Sudeten Mts.: Jeseník (Gesenke), in parte superiore convallis Velká Kotlina, 1350 m alt., 1929, SUZA (COLO, M, W – SUZA: Lich. Bohemosl. 97).

Austria: Kärnten: Schobergruppe, Felsabbrüche oberhalb der Wangennitz-seehütte, am Wege zum Petzeck, 2650 m alt., 1967, HERTEL 7934[1] (M). – Steiermark: Zirbitzkogel, östl. vom Lavantsee, 2100 m alt., 1930, FREY 598 (G). – Tirol: Ötztaler Alpen, Kühkampleseck, 1878, ARNOLD (M). Ötztaler Alpen, zwischen Breslauer Hütte und Vernagt-Hütte, 2700–2800 m alt., 1952, POELT (M).

W of Serfaus, Oberes Inntal, along trail from Kölner Haus to Mt. Furgler, around Furgler See, 2450 m alt., 1991, SIPMAN 31888 (B). - Galtür im Paznauntal, 1893, ARNOLD (B). - Ötztaler Alpen, gegenüber Gurgl, 1874, ARNOLD (M).

[1]) Two thalli are adjacent, the darker one contains both confluentic acid and 2-*O*-methylperlatocic acid (both major substances) and the lighter one only 2'-*O*-methylperlatolic acid.

Switzerland: Bern: Oeschinensee, 1700 m alt., 1923, MAGNUSSON 10623 (UPS). – Graubünden: Silvretta-Gruppe, Heidelberger Hütte gegen Riezenjoch (Fuorcla Larain), 2500 m alt., 1960, POELT (M). Engadiner Nationalpark: Varusch-Chanels b. Scanfs, 1800 m alt., 1923, *Frey 7153* (G). St. Moritz, HEPP (COLO). – Wallis: St. Bernhard, SCHAERER (M).

France: Alpes Maritimes: Vallon de Fontanalbe prés de la Vacherie supérieure, 2200 m alt., 1968, LAMBINON 68/F/654 (COLO). - Vallon de Boréon, NE of St. Martin Vésubie, Cime de Mercantour, 1700 m alt., 1966, WEBER L-43431 (COLO). – Hautes Alpes: Col du Lautaret, Crête de Chaillol, 2400 m alt., 1970, HERTEL 11985 (M). - Umgebung Col du Lautaret, Arète des Clochettes, 2300 m alt., 1957, CLAUZADE & POELT (M). - Col de Granon, NNW von Briançon, 2300 m, 1970, HERTEL 11586 (M). – Hautes Pyrénées: Pic du Midi, ?DUBY (W). – Pyrénées orientales: Montlouis, La Bouillouse, Pic Carlitte, sommet en gneis, 2920 m alt., 1950, FREY 28237 (G). – Corsica: Asco-Tal, Anstieg von Haut Asco zum Grat nördlich des Campo Strancicone, 1600 m alt., 1990, OBERMAYER 2348 (GZU).

Italy: Piemonte, Prov. Vercelli: Val Sesitana: Riva, in montibus Valdobbia prope Hospitum, 1858, CARESTIA (COLO, W – RABENHORST: Lich Eur 439). - Alta Valle di Susa, c. 2 km ENE of Bardonecchia, in the valley Vallone di Rochemolles, between Serra Monte and Colle Sommeier, 2850 m alt., 1995, TRIEBEL & RAMBOLD (M - HERTEL: Lecid. Exs. 345). – Lombardia, Prov. Sondrio: Valtellina, In alpibus bormiensibus, ANZI (M). – Braulio, Münstertal, Grenzkamm, 2600 m alt., 1927, FREY (G). – Trentino-AltoAdige, Prov. Bozen: Dolomiten, Grödental, Raschötz oberhalb von St. Ulrich, 1896, ARNOLD (M). Dolomiten, Damers auf dem Schlern, 2100 m alt., 1867, ARNOLD (M). - Vinschgau, St. Martin am Vorberg oberhalb Latsch, 1700 m alt., 1970, HERTEL 11557 (M). - Ortler-Gruppe: Vordere Schöntaufspitze über Innersulden, 1970, HERTEL 11489 (M).- Prov. Trento: Porphyr der kahlen Höhe rechts vom Col Briccon, 1883, ARNOLD (M). – Prov. Potenza: N-Hänge des Monte Pollino, Vacquarro, 1450–1500 m, 1979, MAYRHOFER (GZU).

Spain: Gerona: Pyrenees, Nuria, 15 km E of Puigcerda, c. 1 km NE of the Monastery, 2450 m alt., 1976, SIPMAN 8101 (B). - Pyrenäen, Caralps, Santuario de Nuria, 2050 m alt., 1972, WIRTH & LLIMONA (STU). – Huesca: Pyrenäen, Pic Agueras, Balneario de Panticosa, 3050 m alt., 1962, SCHAUER (M). – Granada: Sierra Nevada, NW-Aufschwung des Mulhacén, 3100 m alt., 1975, FOLLMANN (COLO, GZU – FOLLMANN: Lich. Cass. 171).

Bulgaria: Cepalarska Planina: In monte Karlak dag prope Pasmakli, 1700–2100 m alt., 1929, SZATALA (UPS). – Pirin: Chvojnati vrch prope Vichren, ad saxa granitica, 2600 m alt., 1967, VĚZDA (STU).

Makedonija: Baba Planina, [Pelister-Nationalpark] N-Hänge des Pelister, 1977, POELT (GZU).

ASIA

Turkey: 04 Ağri: S-Flanke des Ararat über Ganikor-Su, nahe Dogubayasit [Doğubayazıt], 3700 m alt., 1969, SCHAUER (GZU). S-Flanke des Ararat [= Büyükağrı Dağı] über Ganikor-Su, nahe Dogubayasit [Doğubayazıt], 2700 m alt., 1969, SCHAUER (GZU). – 13 Bitlis: Nimrud Dag [Nemrut Dağı], N-Ufer des Wan-Sees, 1914, PIETSCHMANN 1959/6477 (W), 1959/6428 (W). – 35 Elazıg: Kurdistania occ.: Taurus Armen. In monte Hasarba Dagh [Hazarbaba Dağ] ad lacum

Göldsch, 2200 m, 1910, HANDEL-MAZZETTI 2589 (W). – 38 Kayseri: Erdschias Dagh [Erciyes Dağı], Pelikartyny, 2700 m alt., 1902, ZEDERBAUER (W). – 42 Konya: Akscheher [Akşehir] (Wilajet Konia), Sultandağ, 1899, BORNMÜLLER 3564 (W). – 65 Van: Taurus Armenus: Trajectus "Luk" inter pagos Dhosab et Başkale dit Wan, 2200 m alt., NABELEK (W). - Taurus Armenus: Warak-Dar prope Wan, 2650 m alt., NABELEK (W). — Gelo-Dar dit. Gulmerik, ad tentoria aestiva "Djeme", 2900 m alt., NABELEK (W).

Russia, Kavkas: Caucasus Magnus, regio montis ignivomi Elbrus, ad latere austro-occid. montis Čeget, supra convexum torrentis Baksan dictis, 3000–3100 m alt., 1980, VĚZDA (B, COLO, W – VĚZDA: Lich. Sel. Exs. 1734). – Tyrnyauz, Elbrus, in declivibus boreo-orient. montis Cheget, 2650 m alt., 1980, VASAK (M). – Kabaridino-Balkarskaya AR, Kosch-Asau, am Eingang des Terskoll-Tales unter dem Elburs, 1885, LOJKA, Iter Caucas. 385 (M). – "Kosch Aschau" am Eingange des Terskoll-Thales unter dem Elbrus, 1985, LOJKA (W – ZWACKH: Lich. Exs. 982).

AFRICA

Canary Islands: Tenerife: Las Canadas, La Fortaleza, 2100 m alt., 1987, BREUSS (W).

6.1.2. *Lecidea atrobrunnea* ssp. *deplanaica* HERTEL & LEUCKERT ssp. nova

= Chemotype C (4-*O*-demethylplanaic acid)

Diagnosis: Similis Lecideae atrobrunneae ssp. atrobrunneae sed thallus acidum 4-*O*-demethylplanaicum continens. Simul desunt acidi e familia "dibenzofurani" dicta et familia "depsidoni" dicta.

Typus: Turkey: 06 Ankara: Kizilca Hamam, [Kızılcahamam, 40°28' N, 32° 39' E], Andesit-Fels, XI.1957, MARKGRAF (M; holotype).

Description: Characterised by the presence of 4-*O*-demethylplanaic acid in the thallus. A very rare chemotype, known only from in Turkey and North America (Nevada).

Etymology: Most names for the subspecies of *L. atrobrunnea* are derived from the names of lichen acids characteristic for these taxa. Since the acid characteristic of this subspecies, 4-*O*-demethylplanaic acid, is unsuitable for such a derivation, the abbreviation 'deplanaica' is proposed.

Records:

Turkey: 06 Ankara: Typus. – 13 Bitlis: Kurdistania media, Taurus Armenus: In monte Meleto (Meretug) Dagh, districtus Bitlis, in summo cacuminis, 2800 m alt., 1910, HANDEL-MAZZETTI 2837 (W).

6.1.3. *Lecidea atrobrunnea* ssp. *planaica* HERTEL & LEUCKERT ssp. nova

= Chemotype B (planaic acid syndrome)

Diagnosis: Similis Lecideae atrobrunneae ssp. atrobrunneae sed acidum planaicum continens. Simul desunt acidi e familia "dibenzofuranes" dicta et familia "depsidones" dicta.

Type: U.S.A., California, Alpine Co., Hope Valley along E base of Carson Range, road to Alpine Mine W of Sr. 88. Markleeville Quadr., T10N, R18E, Sec. 11, on boulders, 2255 m alt., 8.VI.1975, E. WEIER 1576 (COLO, holotype).

Description: *L. atrobrunnea* ssp. *planaica* is characterised by the occurrence of the planaic acid syndrome (see fig. 3). 2'-*O*-methylperlatolic acid (a member of this syndrome – see LEUCKERT & HERTEL 2003) frequently occurs as a minor substance, while 4-*O*-demethylplanaic acid was detected only occasionally and in traces. *L. atrobrunnea* ssp. *planaica* is rather rare; only 2.5 % of the worldwide tested specimens of *L. atrobrunnea* belong to this subspecies. Besides the records mentioned below, it is known from the Asian part of Russia (Gorno Altay), Kenya (Mt. Kenya) and North America (Canada, U.S.A.).

Records:

EUROPE

France: Pyrenées Orientales: Mt. Canigou, 2800 m alt., 1906, PARRIQUE (W).

ASIA

Turkey: 70 Karaman: Oyuklu Dağı bei Eremek, Paß an der Ostflanke, 1920 m alt., 1992, PAROLLY 92-40-1 (B).

Iran: Mowdereberg bei Sultanabad, 1901, STRAUSS Lich. Persici (W).

6.1.4. *Lecidea atrobrunnea* ssp. *porphyrilica* HERTEL & LEUCKERT ssp. nova

= Chemotype H (porphyrilic acid)

Diagnosis: Similis Lecideae atrobrunneae ssp. atrobrunneae sed acidum porphyrilicum continens. Simul desunt acidum confluenticum, acidum 2'-*O*-methylperlatolicum, acidum planaicumque.

Typus: Wallis: Penninische Alpen: In initialen Gemeinschaften auf Blöcken am Gipfel der La Ruinette im Val Chanrion, 3875 m alt., 1976, SCHUHWERK 1024 (M - holotype).

Description: Characterised by the sole presence of porphyrilic acid. *L. atrobrunnea* ssp. *porphyrilica* is only known from the two specimens mentioned below. It seems to be much rarer than *L. atrobrunnea* chemotype P (with porphyrilic acid and confluentic acid syndrome). Further studies may reveal whether or not ssp. *porphyrilica* can be interpreted as merely a depauperate form of chemotype P

Records:

Switzerland: Wallis: La Ruinette (type).

Spain: Prov. Granada: Sierra Nevada: SW-Flanke des Mulhacén, 3300 m alt., 1975, FOLLMANN 25771 (GZU).

6.1.5. *Lecidea atrobrunnea* ssp. *saxosa* HERTEL & LEUCKERT in NASH et al., Lichen Flora of the Greater Sonoran Desert Region II, p. 296 (2004).

= Chemotype E (norstictic acid syndrome)

Lecidea atrobrunnea ssp. *saxosa* has been described as a new species on several occasions. A detailed and critical description (as *Lecidea saxosa* R. ANDERSON) is given in the excellent but unfortunately unpublished monograph of ANDERSON (1964). Quite a number of the specimens of this subspecies have a rather pale, yellow-brownish and vigorous thallus. However, we found no clear delimitation to the specimens with a thinner and/or darker brown thallus. This problem deserves further attention.

L. atrobrunnea ssp. *saxosa* is the second commonest of the subspecies in the *L. atrobrunnea*-complex; Some 14% (worldwide) of all chemically studied specimens belong to this unit. From outside of Europe we have studied specimens from Turkey and North America (Canada, Greenland, USA). It seems to be one of the chemotypes of *L. atrobrunnea* which is rather widespread in arctic regions.

Records:

EUROPE

Svalbard: Vestspitsbergen: Amsterdamøya, Vogelklippen am Danskegattet östlich Kap Zachau, 100 m alt., 1975, HERTEL 16183, 16193 (M). - Sørkappøy: Strandvall, Melsvatnet, 5 m alt., 1920, LID 689 (O). Kongsfjord: Blomstrand-Halbinsel, Vorland von Peirsonhamna, 35 m alt., 1975, HERTEL 16428 (M).

Arctic Russia: Novaya Zemlya: Fuglefjellet syd for Arkhangel Bay, 1921, LYNGE (O, W).

Iceland: Suður-Þingeyjarsýsla: Myvatn, Umgebung von Skútustaðir, Lavafels, 290 m alt., 1979, HERTEL 21689 (M).

Austria: Tirol: Ötztaler Alpen, Gneisfelsen am Wege von Gurgl zum Eissee, 1873, ARNOLD (M). An Glimmerblöcken bei Gurgl im Ötztale bei 6300' [1920 m], 1973, ARNOLD (B; ARNOLD: Lich. Exs. 551). Kaunergrat: Gipfel der Watzespitze, 3530 m, 1953, POELT T53/167 (M). - Silvretta: Jamtal: zwischen Jamtalhütte u. Futschölpaß, 2520 m alt., 1983, HERTEL 25325 (M). – Osttirol: Gschlößltal bei Windischmatrei [= Matrei i.O.], 1876, ARNOLD (M). – Niederösterreich: Cetische Alpen, Wechsel, Gesteinstrümmer einer Schichtmauer am Hohen Umschusse, 1730 m alt., 1919, BAUMGARTNER (W; holotype of *Lecidea gneissicola* ZAHLBR). - Wechsel, am Hohen Umschuß, 1730 m alt., 1869, LOJKA 267 (W; holotype of *Lecidea syncarpa* ZAHLBR.).

Switzerland: Wallis: Val d'Entremont, Bourg-St. Pierre, Mt. Telliers, Gipfel zwischen Combe de Drône und C. des Planards, 2958 m alt., 1943, FREY 1575 (G). - Riffel bei Zermatt, 7500' [= 2300 m] alt., 1865, METZLER (M). - Zwischbergenpaß ober Gondo, Simplongebiet, 3200 m alt., 1919, FREY 7150 (G).

France: Dépt. Hautes Alpes: Umgebung Col du Lautaret, Combe de Roche-Noire, entre Col du Lautaret et Col du Galibier, 1957, G. CLAUZADE & POELT 642 (M).

Spain: Prov. Granada: Sierra Nevada, Picacho de Veleta, Abbrüche ins Gletscher-Kar, 3450 m alt., 1969, HERTEL 11165 (M). - An der Laguna de las Rio Veleta, S des Picacho de Veleta, 3000 m alt, 1969, HERTEL 11325, 11333 (M).

ASIA

Turkey: 30 Hakkâri: Kurdistania. Gelo-Dar dit Gulmenik ad tentoria aestiva Djerra, NABELEK (W) – 65 Van: Taurus Armenus, Trajectus Cuk inter pagos Chasab et Başkale dit., NABELEK (W). Kargh-Dagh bei Wan, 1914, PIETSCHMANN (W). – ?: Taurus Armenus, Sorr Garabet, NABELEK (W). – In summo monte Tauro (ex herb. NYLANDER – M).

6.1.6. *Lecidea atrobrunnea* ssp. *stictica* HERTEL & LEUCKERT

in NASH et al., Lichen Flora of the Greater Sonoran Desert Region II, p. 297 (2004).

= Chemotype F (stictic acid syndrome)

Lecidea atrobrunnea ssp. *stictica* is characterised by the presence of the stictic acid syndrome with stictic acid (rarely hypostictic acid) as the major substance. Norstictic acid is often present as a minor substance. ssp. *stictica* is one of the commonest subspecies of *L. atrobrunnea*; 11 % (worldwide) of all chemically studied specimens of *L. atrobrunnea* belong to this subspecies. Outside of Europe we have studied specimens from Asia (Pakistan, Turkey) and North America (Canada, USA). Without well developed ascospores, it may be difficult to separate this taxon from *L. praenubila* (see in the key later).

Records:

EUROPE

Norway: Finmarken: Nar byen Vadsö, 1906, HAVAAS (W).– Opland: Lom, Jotunheimen, Visdalen, ca. 1 km NE von Spiterstulen, 1250 m alt. 1984, HAFELLNER & OCHS 12859 (GZU).

Sweden: Torne Lappmark: S-Hänge des Jieprencorru, nördl. Jieprenkiedde am N-Ufer des Torneträsk, 1991, HERTEL 34603 (M). – Lycksele Lappmark: Par. Tärna, N. Storfjället, in latere proclinatis rupis, 900 m alt., 1924, MAGNUSSON (B, COLO; Malme: Lich. Suec. Exs. 996).

Austria: Tirol: Ötztaler Alpen, bei Gurgl im Ötztal, an Glimmer-Blöcken, 1920 m alt., 1873, ARNOLD (M; ARNOLD: Lich. Exs. 511). - Südlich oberhalb Gurgl im Ötztal, am Weg zum Gaisbergferner, 1873, ARNOLD (M). - Gegen den Hochkor südl. oberhalb St. Anton, 1892, ARNOLD (M). - Silvretta: Jamtal, Gneisblöcke auf der linken Talseite am Weg zum Totenfeldkar, 2230 m alt., 1983, HERTEL 25400b (M). - Am rechten Abhang des Kleinen Rettensteins, 1871, ARNOLD (M). –

Kärnten: Karnische Alpen, Hochweißsteingruppe, NE-Grat der Raudenspitze über dem Hochweißsteinhaus, 1967, 2200 m alt., HERTEL 8083 (M).

France: Alpes Maritimes: Camp de Fourche, ridge top outcrops, en route to Col de Restefond, 2300 m alt., 1966, WEBER L-43386 (COLO).

Switzerland: Wallis: Schwarzhorn, S-Seite, über Saas Fee im Saastal, 2900 m alt., 1971, SCHUHWERK 772 (M). - Brittaniahütte südl. Saas Fee, 3030 m, 1971, SCHUHWERK 932 (M). Gipfel der Furka / am Rhonegletscher /an der Grimsel im Berner Oberland [unindicated from which of the three localities mentioned the specimen was collected], 1864, METZLER (M). – Graubünden: Engadiner Nationalpark: Buffaloraalp, 2200 m alt., 1922, FREY 285 (G). - Berninapass, Felsen über dem Hospiz, 2360 m alt., 1931, FREY 877 (G).

Italy: Lombardia, Prov. Bormio: Bormio, 2300 m alt., 1927, MAGNUSSON 10742c (UPS). – Belluno: Marmolada-Gruppe. Am Weg vom Contrin-Haus zum Ombretta-Paß, on slightly calcareous rock, 2600 m alt., 1968, WUNDER (M – contains hypostictic acid instead of stictic acid).

Spain: Prov. Granada: Sierra Nevada, Penones de San Francisco, 2500 m alt., 1969, HERTEL 11247 (M). - Sierra Nevada, Gipfel des Mulhacén, 3360 m alt., 1969, HERTEL 11746 (M).

ASIA

Cyprus: Troodos, UNGER (W).

Turkey: 65 Van: Armenia, trajectus "Cuk" inter pagos Chosab et Başkale dit. Wan, 2200 m alt., NABELEK (W - with hypostictic acid only).

6.2. Taxonomically unclear and undescribed chemotypes

6.2.1. Chemotype J

(Norstictic acid syndrome + confluentic acid syndrome)

A rare chemotype, also known to us from North America (Canada, U.S.A. – 8 records).

Record:

Austria: Tirol: Gschlößtal bei Windischmatrei (= Matrei i. Osttirol), 1876, ARNOLD (M).

6.2.2. Chemotype K

(Stictic acid syndrome + confluentic acid syndrome)

A rather rare chemotype, also known to us from North America (Canada, U.S.A. – 19 records).

Record:

Italy: Lombardia: Bormio, 2300 m alt., 1927, MAGNUSSON 10742c (UPS).

6.2.3. Chemotype L

(Norstictic acid syndrome + planaic acid syndrome)

A rare chemotype, known to us from Spain, Turkey and North America (U.S.A., 8 records).

Records:

EUROPE

Spain: Ávila: Sierra de Gredos, Laguna los Caballeros, 2000 m alt., 1982, SANCHO 250882 (GZU). – Gerona: Tal des Rio Ter, am Anstieg zum Pic de Bastimente an der französischen Grenze, 2500 m alt., 1983, FEUERER & HÖHNE 13638B (M).

ASIA

Turkey: 04 Ağri: Ararat, 2900 m alt., 1968, SCHAUER (GZU).– 42 Konya: Phrygia, Akscheher [Akşehir, Wilajet Konia], in regione alpina montis Sultanadagh, 1800 m alt., 1899, BORNMÜLLER 3552 (W).

6.2.4. Chemotype N

(Schizopeltic acid + confluentic acid syndrome)

This chemotype is relatively widespread in non-arctic North America (Canada, U.S.A. – 36 records), but it is rare in Europe; this may support an hybridogenous origin of chemotype N, for one of the possible parents, the chemotype G, which contains schizopeltic acid (= *L. schizopeltica)*, appears to be confined to Western North America.

Records:

Switzerland: Wallis: Walliser Alpen, Sunnega oberhalb Zermatt, 2300 m alt., auf Serpentinit, 1975, KALB (COLO – Plantae Graecenses Lich. 51 – additionally contains porphyrilic acid). - Simplon, 1885, MÜLLER-ARGAU (COLO).

6.2.5. Chemotype P

(Porphyrilic acid + confluentic acid syndrome)

Outside of Europe and Turkey, this chemotype is known from North America (Canada, U.S.A. – 6 records), where interestingly it is much rarer than in Europe.

Records:

EUROPE

Austria: Tirol: Ötztaler Alpen, bei Gurgl, am Wege zum Eissee, 1873, ARNOLD (M).– Kärnten: Petzeck; Felsabbruch oberhalb des Wangenitzsees, 2700 m alt., 1967, HERTEL 8067 (B, M).

Switzerland: Graubünden: Silvretta, östlich unterhalb des Riezenjochs im Fimbertal, 2500 m alt., 1960, STEINER et al. (M). - Zwischen Heidelberger Hütte und Riezenjoch, Val Fenga, 2570 m alt., 1965, POELT 4863 (GZU).- Silvretta, Val

Fenga, SW der Heidelberger Hütte, 2450 m alt., 1967, POELT 5498 (GZU).- Averser Rheintal, Stallerberg, 2620 m alt., 1958, FREY 22193 (G). – Tessin: Val Piora, Pizzo dell'Uomo, 2650 m alt., 1984, HERTEL 25680, 25690 (M).– Wallis: In monte St. Bernhard, 1849, SCHAERER (G). - Walliser Alpen, Sunnega oberhalb Zermatt, 2300 m alt., 1975, KALB (W – Plantae Graecenses Lich. 51).- Hinteres Valsorey E über Bourg-St. Pierre, Hänge unterhalb der Cabane de Valsorey, 3000 m alt., 1977, SCHUHWERK 1228, 1232 (M). - Fieschergletscher, 2950 m, 1921, FREY 286 (G). Weg von Almagell nach Mattmark, 1780 m alt., 1928, GILOMEN (G).

France: Dauphiné: Col du Lautaret, 2250 m, 1932, FREY 325/7 & SCHMIDT (G). Col du Lautaret, NW-Hang les Clouchettes, 2200 m alt., 1970, HERTEL 11926 (M). – Savoie: Col de la Ponsonnière au départ de Les Mottes, 2600 m alt., 1982, SERUSIAUX 4151 (M).

Italy: Vercelli: Riva (prov. Vallis-Sessitis), in montibus Valdobbia prope Hospitum, CARESTIA (W – RABENHORST: Lich. Eur. 439). - Sulle rupi nei monti della Valdobbia in Valsesia, CARESTIA (M – Erb. Critt. Ital. 81 [1081]) – Trento: Pinzolo, KERNSTOCK (W).

ASIA

Turkey: 13 Bitlis: Armenien, Nimrud Dagh am Wan-See, 1914, PIETSCHMANN (GZU). - Nimrud Dag, N-Ufer des Wan-Sees, 1914, PIETSCHMANN (COLO, W).

6.2.6. Chemotype R

(Planaic acid syndrome + porphyrilic acid)

This chemotype is known only by the following record.

Record:

Italy: Prov. Bozen: Ötztaler Alpen, Oberbergtal oberhalb Kurzras, 2800 m alt., 1964, STEINER (M).

6.3. Acid-deficient specimens – chemotype 0 (zero)

In a number of species, which form different chemotypes, acid-deficient specimens are found predominantly in the cold (alpine or arctic) parts of their range of distribution (LEUCKERT & POELT 1978) and are called '0-races' ('zero-races'). It is possible to imagine that acid-deficient specimens are chemically depauperate members of various chemotypes and thus do not deserve taxonomic rank.

Acid deficient specimens are not rare in *L. atrobrunnea*; some 6% (worldwide) of all tested specimens belong to this possibly heterogeneous group, a percentage which would become considerably higher if collections from arctic regions became the focus of the research. Outside of Europe, this group is known to us from North America (Canada, Greenland, U.S.A.), South America (Chile), Australia (see RAMBOLD 1989) and Antarctica.

Records:

EUROPE

Svalbard: Nordaustlandet: Storøya, Sørodden, 1930, HANSSEN (O).

Iceland: Austur-Barðarstrandarsýsla: Paß zwischen Hvammur und Gilsfjördur, Mjosundi, Drifandagil (Svinadalur), 340 m, 1979, HERTEL 21933 (M).– Suður-Þingeyjarsýsla: W-Hang des Tungnafellsjökull, unterhalb des Gipfels Háhyrna, 1180 m alt, 1979, HERTEL 21838 (M).

Norway: Finmarken: Zwischen Tana-Tal und Rastegaissa [Rastigaissa], 1965, POELT 3294 (GZU).

Sweden: Lycksele Lappmark: Tärna, Umfors, Artfjället, Braket, 1924, STENHOLM (O).

Fennia: Ostrobotnia borealis: Simo, Simonkylä, Hahtiperä, ad saxa aperta prope mare, RÄSÄNEN (W – Lich. Fenn. Exs. 835). - Simo, insula Pikku-Kumurainen, RÄSÄNEN (COLO – Lichenotheca Fenn. 350). - Simo: Simonkylä, Palokari, 1936, RÄSÄNEN (W – Lich. Fenn. Exs. 285).

Russia: Novaya Zemlya: Fuglefjellet syd for Arkhangel Bay, 15 m alt., 1921, LYNGE (W).

Switzerland: Tessin: Val Piora, Pizzo dell'Uomo, 2650 m alt., 1984, HERTEL 25680 (M).

Italy: Prov. Trento: In cacuminis alpis Vocche (Bocche), 2745 m alt., 1884, LOJKA 136a (W).

Spain: Prov. Granada: Sierra Nevada, NW-Aufschwung des Mulhacén, 3100 m alt., 1974, FOLLMANN (W – FOLLMANN: Lich. Cass. 171).

7. Key to the taxa of the *Lecidea atrobrunnea*-complex (including some gross-morphologically similar lichens)

Revisions of specimens filed under "*Lecidea atrobrunnea*" in herbaria show that they are often confused with gross-morphologically similar taxa of *Lecidea* and other lecideoid genera. Therefore the key to the European members of the *L. atrobrunnea*-complex provided here includes some gross-morphologically similar, but unrelated taxa.

This key deals with crustose and squamulose-crustose lichens with an areolated, nitid, light to dark brown thallus and with asci containing 8 colourless and unicellular ascospores. The gloss of the thallus is caused by a (thin to very thick) translucent epinecrotic layer overlaying a sharply delimitated thin (5-10 µm) brownish pigmented layer of the cortex.

Technical remarks: (a) Values in italics are mean values; (b) the medulla I-reaction should be tested microscopically on sections; (c) the key is not dichotomous throughout since there are sometimes 3 or 4 alternatives (as indicated by an exclamation mark, e.g. "12!").

1 Lichen lichenicolous 2
Lichen autonomous – Medulla K– or K+ red (norstictic acid present or absent), medulla I+ violet or I– 4

2 Lichen inhabiting saxicolous brown species of *Acarospora (A.* cf. *impressula),* medulla I–, thallus C+ red (gyrophoric acid); norstictic acid lacking. Very rare (a single record) in the Alps (Austria)..... ***Lecidea grummannii*** HERTEL
Lichen inhabiting thalli of *Bellemerea,* medulla I+ violet, thallus C–, K+ red (norstictic acid) 3

3 Lichen permanently lichenicolous in thalli of *Bellemerea alpina* or *B. cinereorufescens* (both growing on acid rocks). Widespread in the high montane and alpine belt of the Alps ..... ***Lecidea rapax*** HERTEL
Only young thalli lichenicolous occur in thalli of *Bellemerea subcandida* (growing on siliceous rocks containing a certain amount of limestone), later becoming independent from its host. Rather local (as to the substrate) in the high montane and alpine belt of the Alps, Pyrenees and mountains of Northern Spain ..... ***Lecidea leprosolimbata*** (ARNOLD) LETTAU ex POELT

4 Growing on calciferous rocks (at least a weak CO_2-effervescence after dabbing the substrate with dilute HCl) – medulla K+ red (norstictic acid), medulla I+ violet (see under 3-)
..... ***Lecidea leprosolimbata*** (ARNOLD) LETTAU ex POELT
Growing on acid rocks (no CO_2-effervescence after dabbing the substrate with dilute HCl) – medulla K–, K+ yellow or K+ red, medulla I– or I+ violet .. 5

5 Excipulum (to be tested on thin sections microscopically) C+ red (gyrophoric acid); Thallus often C+ red too – spores 9.7-13.7 × 4.4-7.0 µm. Very widespread and common from the lowland to the alpine belt .....
Lecidea fuscoatra (L.) ACH.
(NB. APTROOT & VAN HERK (2007) distinguish between: *L. fuscoatra* with an areolated thallus *and L. grisella* FLÖRKE with a rimose thallus.)
Excipulum C–, gyrophoric acid lacking 6

6 Asci of the *Porpidia*-type – spores large (12-24 × 6.7-13 µm), hymenium high (75-140 µm) – confluentic acid present in the thallus. Widespread in the montane and (sub)alpine belt.....
..... ***Immersaria athroocarpa*** (ACH.) RAMBOLD & PIETSCHMANN
Asci of *Lecidea*-type or *Lecanora*-type, spores smaller, confluentic acid present or absent 7

7 Asci of *Lecanora*-type, miriquidic acid present, hypothecium unpigmented ... 8
Asci of *Lecidea*-type, miriquidic acid absent, hypothecium unpigmented or brownish to blackish-brown pigmented 9

8 Medulla K–, P–, stictic acid absent, excipulum without or (more often) with algae. Widespread in the montane and alpine belt.. .... ***Miriquidica deusta*** (STENH.) HERTEL & RAMBOLD

Medulla K+ yellow, P+ orange (stictic acid present), apothecia usually dark brownish (at least when wet), excipulum without algae. Widespread in the montane and alpine belt ....***Miriquidica garovaglii*** (SCHAER.) HERTEL & RAMBOLD

9 Spores less than 3 µm wide – thallus areoles (0.2-)0.4(-0.7) mm in diam., spores very small (5.0-7.3 × 2.5-2.8 µm), hymenium very low (25-37 µm high), medulla I–, no lichen substances detectable. Restricted to habitats in low altitudes (from lowland up to submontane zone).........***Lecidea variegatula*** NYL.

Thallus and apothecia larger, spores larger, restricted to habitats in the upper montane and alpine belt 10

10 Medulla I+ violet.. 11

Medulla I– (microscopically tested!) 21

11 Thallus K+ red (norstictic acid)... 12!

Thallus K– or K+ yellow (norstictic acid lacking or as a minor accompanying substance of stictic acid)... 13

12 Norstictic acid present, planaic acid, confluentic acid and 2'-O-methylperlatolic acid lacking. Widespread and locally common. In arctic regions often on bird-perching stones.. ....***Lecidea atrobrunnea*** ssp. ***saxosa*** HERTEL & LEUCKERT

Norstictic acid and planaic acid present. Rare.. **.. *Lecidea atrobrunnea* chemotype L**

Norstictic acid and confluentic acid and/or 2'-O-methylperlatolic acid present. Rare...***Lecidea atrobrunnea*** chemotype **J**

13 Ascospores larger (9.2-16.2 × 5.0-7.8 µm), hymenium higher (47-92 µm); stictic acid present (rarely unverifiable); confluentic acid, 2'-O-methylperlatolic acid, planaic acid and schizopeltic acid lacking; apothecia usually rather flat, usually closely fixed to the substrate and not overtopped by the areoles. Widespread in arctic regions and rarer in the (high)alpine belt .... *Lecidea praenubila* NYL. s.l. 14

Ascospores smaller (6.6-11.7 × 3.0-5.7 µm), hymenium less high (35-65 µm); stictic acid may be present or absent... *Lecidea atrobrunnea* (LAM. & DC.) SCHAER. s.l. 15

It is not clear, whether or not the following taxa are really well separated:

14 Hypothecium light to medium brown (The poorly known *L. protecta* H.MAGN. from Sweden, with small apothecia, 0.5-0.6 mm in diam. is included here) .... ***Lecidea praenubila*** NYL.
Hypothecium dark brown to blackish .... ***Lecidea paupercula*** TH. FR.

15 Stictic acid present 16
Stictic acid absent 17

16 Stictic acid (very scarcely hypostictic acid) present (medulla often K+ yellow or ochre-yellow, P+ yellow), 2'-O-methylperlatolic acid, confluentic acid, and planaic acid lacking. Widespread in the alpine belt, apparently in regions with a more continental climate .... ***Lecidea atrobrunnea*** ssp. ***stictica*** HERTEL & LEUCKERT
Confluentic acid and/or 2'-O-methylperlatolic acid present. Rare .... ***Lecidea atrobrunnea*** chemotype **K**

17 Dibenzofurans (schizopeltic acid or porphyrilic acid) present 18
Dibenzofurans (schizopeltic acid, porphyrilic acid) absent .... 20!

18 Porphyrilic acid present, schizopeltic acid absent .... 19!
Porphyrilic acid absent, schizopeltic acid and confluentic acid and/or 2'-O-methylperlatolic acid present. Rare .... ***Lecidea atrobrunnea*** chemotype **N**

19 Confluentic acid, 2'-O-methylperlatolic acid and planaic acid absent. Very rare .... ***Lecidea atrobrunnea*** ssp. ***porphyrilica*** HERTEL & LEUCKERT
Confluentic acid and/or 2'-O-methylperlatolic acid present, planaic acid absent. More widespread, at least in the Alps .... ***Lecidea atrobrunnea*** chemotype **P**
Planaic acid present, confluentic acid and 2'-O-methyl-perlatolic acid absent. One record only (Alps) .... ***Lecidea atrobrunnea*** chemotype **R**

20 Confluentic acid and/or 2'-O-methylperlatolic acid present. Very widespread; the commonest of all chemotypes .... ***Lecidea atrobrunnea*** ssp. ***atrobrunnea***
Planaic acid is the major lichen substance. Widespread but rare .... ***Lecidea atrobrunnea*** ssp. ***planaica*** HERTEL & LEUCKERT
4-O-demethylplanaic acid is the only lichen substance. Rare (Turkey) .... ***Lecidea atrobrunnea*** ssp. ***deplanaica*** HERTEL & LEUCKERT
No lichen substances traceable. Widespread and more common in high alpine and high boreal and arctic regions .... ***Lecidea atrobrunnea*** 'chemotype' **0**

21 Ascospores larger (9.2-16.2 × 5.0-7.8 µm), hymenium higher (47-92 µm) – usually with stictic acid; pannarin lacking; pruina of apothecia - if present - P– (see also 13a) .... ***Lecidea praenubila*** NYL. s. l.

Ascospores smaller (9.2-11.2 × 3.6-5.3 µm), hymenium less high (38-54 µm). Widespread but uncommon; often in places with long-lasting snow cover..... *Lecidea leucothallina* ARNOLD s.l. ..... 22!

22 Medulla P– (pannarin lacking), but pannarin may be present in the pruina of the apothecia (pruina P+ orange)..... ***Lecidea leucothallina*** var. ***leucothallina***
Medulla P+ orange-yellow (pannarin) .....
..... ***Lecidea leucothallina*** var. ***kujalae*** (RÄSÄNEN) HERTEL
Medulla P– or P+ yellow (stictic acid; pannarin lacking)
..... ***Lecidea leucothallina*** var. ***discrepans*** RAMBOLD & HERTEL

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9. Literature

ANDERSON, R.A., 1964: The genus *Lecidea* in the Rocky Mountains National Park, Colorado. Thesis University of Colorado. 209pp. (Unpublished, available through University Microfilms, Inc., Ann Arbor, Michigan).

APTROOT, A. & VAN HERK, C.M., 2007: *Lecidea grisella* sympatric with *Lecidea fuscoatra*, differing in the rimose instead of areolate thallus. – Lichenologist **39**: 293–296.

CULBERSON, W.L., CULBERSON, C.F. & JOHNSON, A., 1993: Speciation in lichens of the *Ramalina siliquosa* complex (Ascomycotina, Ramalinaceae): gene flow and reproductive isolation. – Amer. J. Bot. **80**: 1472-1481.

HERTEL, H., 2006: World distribution of species of *Lecidea* (Lecanorales) occuring in Central Europe. – In: LACKOVICOVA, A., GUTTOVA, A., LISICKA, E. & LIZON, P (eds.). Central European Lichens - diversity and threat, Mycotaxon, Ithaca: 19-70.

HERTEL, H. & PRINTZEN, CH., 2004: *Lecidea*. – In: NASH, TH. H III, RYAN, B.D., DIEDERICH, P., GRIES, C., BUNGARTZ, F. (eds.). Lichen Flora of the Greater Sonoran Desert Region, vol. II, Tempe, Arizona: 287-309.

KÄRNEFELT, E.I. & THELL, A., 1995: Genotypical variation and reproduction in natural populations of *Thamnolia*. – Bibl. Lichenol. **58**: 213-234.

LEUCKERT, CH. & HERTEL, H., 2003: On the *Lecidea atrobrunnea* complex (Lecanorales, Lecideaceae) in the Americas. I. Introduction and chemistry. – Bibl. Lichenol. **86**: 13-31.

LEUCKERT, CH. & POELT, J., 1978: Über Nord-Süd-Gradienten von Chemotypen europäischer Flechten. – Plant Syst. Evol. **130**: 53-77.

LEUCKERT, CH., ZIEGLER, H.G. & POELT, J., 1972 ['1971']: Zur Kenntnis der *Cladonia chlorophaea*-Gruppe und ihrer Problematik in Mitteleuropa. – Nova Hedwigia **22**: 503-534.

LEUCKERT, CH., BUSCHARDT, A. & HERTEL, H., 1981: Die Verteilung der Chemotypen von *Dimelaena oreina* (Lichenes) auf verschiedene Höhenstufen an einem Transsect im Vinschgau (Südtirol, Italien). – Nova Hedwigia **34**: 623-632.

RAMBOLD, G., 1989: A monograph of the saxicolous lecideoid lichens of Australia (excl. Tasmania). – Bibl. Lichenol. **23**: 1-345.

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