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1.1 Problems in Monographing Antarctic Crustose Lichens

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Summary: Our present knowledge of the taxonomy and floristics of Antarctic crustose lichens is still poor and unreliable, for the following reasons:
1. lack of floras and monographs useful for identification of antarctic lichens,
2. unavailability of important type collections,
3. lack of representative collections, adequate to study variability and distribution,
4. underestimation of the extent of phenotypic variation caused by various abiotic and biotic factors such as: physical factors (light, temperature and moisture conditions, freeze-thaw actions, wind erosion), chemical factors (growth stimation in nitrogen-enriched niches, mineral incorporation in lichens growing on substratas rich in heavy metals), animal feeding (in Antarctica by mites), fungal parasitism, and abnormal regeneration,
5. unfamiliarity with species already known from other cool temperate regions in the world (leading to the description of synonymous names).
In an appendix more than 100 lichen species reported from Antarctica but also occurring in other regions are listed.

Zusammenfassung: Ursachen unserer derzeit geringen und wenig zuverlässigen systematischen und floristischen Kenntnisse antarktischer Krustenflechten sind:
1. Mangel an Florenwerken und Monographien, die zum Bestimmen antarktischer Flechten hilfreich sein könnten.
2. Unzugänglichkeit wichtiger Typus-Aufsammlungen.
3. Mangel an für das Studium von Variabilität und Verbreitung der Sippen geeigneten Sammlungen.
4. unzureichende Kenntnisse der hohen Modifikabilität dieser Flechten, wie sie, teils durch physikalische Standortfaktoren (Beleuchtungs-, Temperatur-, Feuchtigkeitsverhältnisse, Wechselfrost, Windschliff), teils durch chemische Faktoren (Wachstumsförderung an stickstoffreichen Standorten, Mineralein- und -auflagerungen bei chalcophilen Flechten), teils durch Tierfraß (in der Antarktis durch Milben), teils durch Befall mit pilzlichen Parasiten oder durch abnorme Regeneration bewirkt wird.
5. mangelnde Kenntnis der aus anderen kalttemperierten Regionen unserer Erde bereits bekannten Arten (was zu zahlreichen überflüssigen Neubeschreibungen geführt hat).
In einem Anhang werden über 100 nicht-endemische, aus der Antarktis gemeldete Flechtenarten gelistet, um den hohen Anteil weitverbreiteter Arten dieser Flora zu verdeutlichen.

1. INTRODUCTION

Scientists working on the terrestrial vegetation of Antarctica are usually confronted with a flora where lichens play a major and often dominant rôle. When the climate becomes very harsh (as, e.g., south of 75°S), fruticose and foliose lichens disappear and saxicolous crustose species form the main component of the lichen vegetation (FRIEDMANN 1982).

Some 75 percent of the 13.500 species of lichens recognized at this time (HAWKSWORTH et al. 1983) are *„crustose lichens"* [a biological, not a taxonomic group]. These small lichens develop only a thin, primitively organized thallus, which is either completely affixed to the substratum over the whole lower surface (like a varnish, rarely thicker than 0.4 mm), or is hidden in the uppermost layer of rock [0.2—1 [—4] mm in endolithic calciphilous lichens (DOPPELBAUR 1959); up to 10 mm in Antarcitc „cryptoendoliths" (FRIEDMANN 1982)].

Crustose lichens can colonize extreme nival and polar habitats, far better than other macroscopically visible plants. In Antarctica crustose lichens have been found as far south as 86°06'S (e.g. *Lecidea cancriformis*[2]; DODGE and BAKER 1938), in the Alps up to the highest icefree rocks (4810 m; *Lecanora polytropa;* SCHLAGINTWEIT 1855), and in the Himalayas even up to 7400 m (*Carbonea vorticosa* and *Lecanora polytropa;* HERTEL 1977). None of the mountaineers who climb the 8000-meter peaks in the Himalayas have yet found time or interest to look for lichens at these high elevations. It is very likely that no altitudinal or southern climatic limit exists for crustose lichens on earth, in contrast to bryophytes, foliose lichens, and vascular plants.

Bryophytes have been collected as far south as 84°37'S in Antarctica (*Sarconeurum glaciale;* KAPPEN 1983), up to 4230 m in the Alps (*Grimmia donniana*, PITSCHMANN and REISIGL 1954, GEISSLER 1982), and they grow at least at an elevation of 6200 m in the Himalayas[3] (V. KOMARKOVA, pers. comm.). Foliose lichens of

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[2] For full name (including author's name) see Appendix I.
[3] A dense bryophyte vegetation containing 8 species of mosses and 4 of hepatics is reported in altitudes between 5750 m and 6060 m, from hot spots on the Socompa Volcano on the Argentina-Chile border (24°25'S) (HALLOY 1986).

the genus *Umbilicaria,* have been collected as far south as 77°55'S in Antarctica (SIPLE 1938), up to 4640 m in the Alps (SCHLAGINTWEIT 1855), and up to 6300 m in the Himalayas (FREY 1936, POELT 1977). Vascular plants reach 68°21'S (*Deschampsia antarctica,* Anonymous 1985), 4270 m (*Ranunculus glacialis;* PODHORSKY 1939) in the Alps and 6250 m (*Arenaria musciformis;* PODHORSKY 1939) in the Himalayas.

In spite of their outstanding rôle as pioneers in extreme cold deserts, and in spite of the fact that these regions have a small flora relative to temperate regions, our knowledge of the taxonomy and distribution of Antarctic crustose lichens still is very poor and unreliable. It is even extremely difficult to give a realistic assessment of the number of lichens present in Antarctica (Antarctica, circumscribed here in the sense of WACE (1960, 1965), including the Antarctic Continent, the South Shetland Islands, the South Orkney Islands, the South Sandwich Islands, and Bouvet Island). According to DODGE (1974) there are 429 species of lichens (including 317 crustose ones) in Antarctica. This number is, however, as LAMB (1970) has already mentioned, undoubtedly excessive, and 160 species, in my opinion, is a more realistic estimate.

The reason for such a discrepancy — 429 versus 160 species — stems from the low reliability of data published by some authors active in the floristics and taxonomy of antarctic lichens. A good example of this situation is represented by a comparison of two recent revisions of *Usnea* subgen. *Neuropogon* (a conspicuous frutescent lichen genus, well known to all terrestrial biologists working in Antarctica). In his lichen flora of the Antarctic Continent DODGE (1974) recognizes no less than 21 different species of *Neuropogon* in Antarctica. In WALKER's detailed monograph (1985), 17 of these 21 „species" are considered as synonyms. One of the remaining four species was excluded, being based on incorrect identifications (the species in question does not occur on the Antarctic Continent). Although WALKER accepts two additional species not included in DODGE's treatment, even so the total number of species for Antarctica is reduced from 23 to 5. While DODGE postulated all of his 21 species to be endemic to Antarctica, WALKER found that none of the accepted 5 species is restricted to Antarctica.

I am confident that this reduction in numbers of species, as shown here, can be generalized across all genera (see also „Appendix II", and it is entirely possible that some 80% of the 149 new species introduced by DODGE (1974), and DODGE and BAKER (1938) and accepted in DODGE's Flora (1974) will turn out to be synonyms.

I am convinced that it requires more experience and knowledge to understand the antarctic lichens than the lichens of any other region, and I believe the following factors account for the difficulties encountered in correctly identifying Antarctic crustose lichens.

2. DIFFICULTIES IN IDENTIFYING ANTARCTIC CRUSTOSE LICHENS

2.1. Lack of modern floras and monographs

2.1.1. F l o r a s

Modern (post-1950) lichen floras which include relatively accurate keys to crustose lichens exist for only a few European regions: Western Europe (CLAUZADE and ROUX 1985), France (OZENDA and CLAUZADE 1970), S. W. Germany (WIRTH 1980), Poland (NOWAK and TOBOLEWSKI 1975, NOWAK 1983), Ukraine (OXNER 1956, OXNER 1968). The lichen flora for the Soviet Union is not yet complete; five volumes published so far (KOPACZEVSKJA et al. 1971, OXNER 1974, BLUM et al. 1975, KOPACZEVSKAJA et al. 1977, GOLUBKOVA et al. 1978). Crustose lichens of extra-European regions are very incompletely known, and for this reason treatments for the floras of Israel (GALUN 1970), Saudi Arabia (ABU-ZINADA et al. 1986), and New Zealand (GALLOWAY 1985) should be considered as first steps toward a better knowledge rather than a reliable means for identifying species of difficult genera such as *Candelariella, Caloplaca, Lecanora* or *Lecidea.*

DODGE's 'Lichen Flora of the Antarctic Continent and Adjacent Islands' (1974) is not a flora in the true sense where one can find help in identifying plants. REDON's (1985) account of the lichens of the Antarctic peninsular region („Líquenes Antárcticos") is of relatively little help in determining most crustose genera (except for *Buellia* and *Verrucaria,* where he follows LAMB 1948a, and LAMB 1968).
Not a flora, but a valuable aid for identification of various groups of lichens are the keys by POELT (1969) and POELT and VEZDA (1977, 1981), although the large, difficult genera of crustose lichens (e.g. *Acarospora,*

Bacidia, Buellia, Cladonia, Lecanora, Lecidea, Verrucaria) are omitted or only partly included.

2.1.2. Checklists

Among various recent checklists, SANTESSON's (1984) critical, highly reliable and informative (also key to literature) list of the lichens of Sweden and Norway is of great value to all who are working on lichens of cool temperate and cold climates, both in the Norhern and Southern hemisphere, because of the high number of bipolar and widespread lichen species in Scandinavia.

2.1.3. Monographs

The number of monographs relevant to Antarctic lichens is still very small. There are worldwide monographs for *Acarospora* (MAGNUSSON 1929 — out of date), *Cladonia* (VAINIO 1887—1897 — out of date), *Ochrolechia* (VERSEGHY 1962 — out of date), *Placopsis* (LAMB 1947), *Sphaerophorus* (OHLSSON 1974), *Stereocaulon* (LAMB 1977, LAMB 1978), and *Usnea* subgen. *Neuropogon* (WALKER 1985). For none of the large genera of crustose lichens (e.g. *Buellia, Caloplaca, Lecanora, Lecidea*, . . .) are there comparable monographs. Species of *Buellia* and *Rinodina* from the Antarctic Peninsula are treated by LAMB (1968); a preliminary key for the saxicolous species of *Lecidea* sensu ZAHLBRUCKNER in the subantarctic region (including a few species from Antarctica) is provided by HERTEL (1984).

2.2. Unavailability of type collections

Type materials of the more than 150 species of crustose antarctic lichens described by DODGE and coworkers were not deposited in public herbaria, as indicated in publications, but kept in private herbaria. For example, according to DODGE and BAKER (1938: 517), type specimens of 66 new lichens species described from Marie Byrd Land and King Edward VII Land should have been deposited in the herbarium of the Missouri Botanical Garden or in the United States National Herbarium in Washington (where the MO collection was later transferred). In fact these specimens were incorporated in DODGE's private collection, which was recently transferred to Farlow Herbarium (FH) and is now finally available for loan and study.

A number of HUE's type specimens (HUE described more than 70 species of crustose lichens from Antarctica) seem to have been lost or misplaced (I was unable to trace these samples at Paris in 1987), although LAMB was able to locate some in the 1950's.

2.3. Lack of adequate collections

A distressingly high percentage of lichens collected in Antarctica is sterile, badly developed, or damaged. Usually the specimens are very small (sometimes a few badly developed ascocarps only), much too small to tell anything about the variability of characters.

Tiny and inconspicuous species are extremly under-represented in collections from Antarctica, for many of the specimens were collected by geologists or amateurs.

Because of the general difficulties in determining Antarctic lichens, most of the existing lichen collections from Antarctica lie unstudied and undetermined. Therefore, monographers interested in the material of a particular genus have to visit the herbaria in queston to find and select specimens.

2.4. Underestimation of the extent of phenotypic variation

As SANTESSON (1952) has so aptly pointed out, for a long time many lichenologists practised a kind of taxonomy best described as „individuum descriptions". Describing a single individual specimen or a small group of specimens does not take into account the normal variability and plasticity of any species, which may sometimes be extremely high. As POELT (1973) states, phenotypes of a single species growing in different habitats can sometimes appear so unlike that it calls for detailed analysis and long experience to recognize them as representatives of one and the same taxon. However, increasing attention has been paid to variability and modification in recent years. WEBER (1962) and POELT (1973) have summarized the existing knowledge, and some monographers have devoted special chapters to the problem (e.g. HERTEL 1967, KILIAS 1981, SCHWAB 1986, WUNDER 1974).

Experience in arctic, alpine and subantarctic regions, as well as experience from a careful study of large numbers of specimens from cool temperate and cold regions of the northern and southern hemisphere, rather than field work in Antarctica, has made me familiar with the high rate of obviously environmentally induced modifications in crustose lichens. Because of the more extreme and hostile environment in many parts of Antarctica, an even higher degree of modification should be expected for lichens in Antarctica; FILSON (e.g. 1982) has drawn attention to this problem.

A number of abiotic and biotic factors are responsible for this high variability, as pointed out by WEBER (1962) and POELT (1973).

Before going into details, it should be mentioned that in various cases of obviously environmentally altered lichen specimens, we are not able to explain which particular factors have caused the alteration. Often a combination of factors acting simultaneously or successively may be responsible for the modification in question (see also WUNDER 1974).

2.4.1. Physical factors, e.g.: light, temperature, moisture, freeze-thaw action, wind erosion

Shaded and light-exposed thalli often differ considerably in thallus colour. Light exposed parts of the thallus are usually more intensely coloured.

Specimens of certain species (e.g. *Lecidea lapicida*) collected at high elevation in the Alps or in corresponding parts of the Arctic usually develop a much more conspicuous black prothallus than specimens growing under more temperate conditions do or tend to develop a thallus with isolated areolae or small groups of areoles on a more or less continuous black prothallus (as e.g. in some specimens of *Rhizocarpon superficiale*). [The ability to form a black prothallus seems to be a genetically controlled character, but the degree of manifestation of this structure is environmentally controlled.] One might speculate that the black surface of the prothallus will absorb more solar radiation and so elevate thallus temperature and (as long as water is available) assimilation rate.

While such conspicuous and enlarged prothalli are sometimes found in crustose species collected in the more humid maritime parts of Antarctica, this phenomenon seems to be rarer in dry continental parts of Antarctica. The majority of species there show well-developed, thicker epilithic or even substipitate or stipitate thalli (HALE 1987). My observations however, are so far based only on herbarium specimens (and not on population studies in the field). Interpretation of specimens in the laboratory is often distorted by alterations caused by wind erosion (a specimen which seems to develop only traces of an epilithic thallus may, in reality, produce a well-developed epilithic thallus which subsequently becomes more or less totally eroded). Population studies in the field, or at least much richer collections than are presently available, are neccessary to understand the extent of this kind of variability. It is difficult to decide whether a species such as *Carbonea vorticosa*, which usually has a strongly reduced epilithic thallus when growing in alpine and nival belts of the Alps, Himalayas or in the Arctic, developes a distinct stipitate epilithic thallus when growing in the deserts of Antarctica, or whether two closely related but genetically distinct species (*Carbonea vorticosa*, *Carbonea capsulata*) are involved. This is the kind of problem which is extremely difficult to answer in lichenology.

Freeze-thaw action probably favours pulvinate thallus surface, als FILSON (1982) suggested.

Especially in regions such as continental Antarctica or the Himalaya above 7000 m altitude (KUHLE 1986), where snow permanently drifts around (because the temperature necessary for forming ice or firn cannot be reached), very slow-growing crustose lichens suffer severely from the strong abrasive action of snow crystals and sand. Unusual alterations in gross morphological characters are therefore common in continental Antarctica.

2.4.2. Chemical factors

As WEBER (1962) points out, stimulation of growth is well known in lichens from nitrogen-enriched sites (e.g. ornithocoprophilous lichens). Crustose lichens are more luxuriant and usually develop thick, sometimes almost squamulose thalli. However, only a small number of species in genera such as *Buellia, Candelariella, Caloplaca, Lecanora, Lecidella*, and *Rinodina* tolerate high nitrogen enrichment. In cases where macroscopic thallus characters appear to have taxonomic significance, luxuriant modifications may be troublesome. An example is *Lecidella inamoena*, normally an endolithic species. In the Arctic this taxon was described as „*Lecidella endoli-thea*" (the endolithic growth form) and as „*Lecidea spitsbergensis*" (a specimen with a well developed epilithic thallus). Although it is not mentioned on the label that *Lecidea spitsbergensis* was collected near a seabird colony (unfortunately ecological data are rarely given on specimens labels), I am almost certain that these two taxa are no more than ecotypes of one and the same species. However, it is still not clear whether the very similar eu-thalline *Lecidea alaiensis*, described from the Alai mountains in central Asia, is a distinct taxon or not.

It is well known that some crustose lichens tolerate high levels of heavy metals toxic to most organisms. *Leca-nora vinetorum* has a copper content of 0.5% of the dry weight of the lichen (POELT and HUNECK 1968); *Lecidea lapicida* (= *Lecidea theiodes*) up to 5.3% Cu dry wt. (PURVIS 1984); *Acarospora sinopica* up to 6.5% Fe dry wt (LANGE and ZIEGLER 1963). *Lecidea theiodes* is, as PURVIS (1984) points out, a modification of *Lecidea lactea* (which is, as suggested by SCHWAB (1986), a chemotype of *Lecidea lapicida*). The characteristic anomalous green coloration of the thallus of *Lecidea theiodes*, which led SOMMERFELT to describe a new species, is caused by crystals of a copper-norstictic acid complex, as it is in two other yellow-green species described from cupriferous rocks: *Acarospora isortoquensis*, and *Acarospora undata*, which were found to be modifications of *Acarospora smaragdula* (PURVIS et al. 1985, PURVIS et al. 1987).

Lichens growing on weathered, iron-rich rocks often show a rusty coloration, caused most likely by iron oxide. As for the lecideoid lichens, SCHWAB (1986) has recently shown that aside from a number of species with constantly rust-coloured thalli (e.g. *Tremolecia atrata*), most rust-coloured lichens described are modifications of whitish or greyish species (this was suspected by various lichenologists, e.g. WEBER 1962).

Ochraceous pigmented modifications seem to be restricted to cool and humid climates, and thus so they are very common in the subantarctic islands, known also from maritime Antarctica, but not yet from Continental Antarctica.

2.4.3. Biotic factors, such as animal feeding and fungal parasitism

In temperate climates, damage to thalli and/or ascocarps caused by predation by small animals, e.g. caterpillars (RAMBOLD 1985), snails (SCHADE 1933, SCHADE 1956), colembolans and mites (GERSON and SEAWARD 1977), plays a significant role in the modification of lichens. In many especially eutrophic habitats of temperate Europe, for example, it is sometimes quite difficult to find any undamaged thalli of certain species (POELT 1973). We usually do not know what kind of animal caused the damage, except in freshly damaged thalli where, for example, radula tracks on cortex and medulla of the lichen can be clearly observed. Gross morphological characters (type of thallus areolation, shape of ascocarps) may be strongly altered.

Hymenia, structures rich in protein, often become selectively eaten. In lichens with carbonized excipular structures (as in species of e.g. *Buellia, Carbonea, Catillaria, Porpidia, Rhizocarpon*) this type of damage may lead to apothecia which seem to have developed very prominent and often narrow margins and flat or concave discs.

Another example of a misunderstood feeding damage form is „*Lecida cyclosora*", a lichen characterized by roundish soredia, which are in reality the basal parts of the apothecia of *Porpidia zeoroides*, totally eaten away (HERTEL 1967).
I have had no personal experience on whether animal predation of lichens plays a significant rôle in the modification of crustose lichens in Antarctica. However, LAMB (1968) found „damage by mites (Acarinidae) with subsequent abnormalities in regeneration" significant for the understanding of polymorphic variation in species of *Buellia* in the Antarctic Peninsula. Most high latitude parts of Antarctica are too cold to support any invertebrates.

Worldwide there are some 500 species of fungal parasites on lichens, belonging mainly to the Ascomycotina and Imperfect Fungi. Some fungal infections cause descolorations or gall-like structures, and massive infections may suppress development of ascocarps or ascospores of the host lichen. Ascocarps of the parasite grow on a sterile thallus and the whole system then is often misunderstood as a „normal lichen". In this way HUE (1915) described *Charcotia* as a new genus of Umbilicariaceae in Antarctica, based on material of *Umbilicaria antarctica* parasitized by a species of *Scutula* (LAMB 1948b). The „antarctic genus *Lethariopsis*" is based on some rather old specimens of *Usnea antarctica* with a few minute fruiting individuals of a *Caloplaca* species epiphytically attached to them (LAMB 1948b). Similar misinterpretations will probably be found.

Endohymenial parasites are sometimes reduced to ascogenous hyphae and asci, which occupay the ascocarps of the host, surrounded by the host paraphyses. Combinations of asci and spores of the hymenial parasite *Arthonia intexta* and the ascocarps and thalli of the host *Lecidella* have been described nine times as species new to science (HERTEL 1969).

Little is yet known of lichen parasites and their modifying influence on host lichens in Antarctica.

2.4.4. Abnormal regeneration

The ability to regenerate damaged structures is well developed in crustose lichens. However, the resulting regenerated thalli or ascocarps may differ considerably in morphology from the undamaged species.

Carbonized structures may develop around damaged tissues. An example is the subantarctic lichen *Lecidea lygomma,* which forms remarkable black rings around the apothecia (HERTEL 1984). This character was so constant throughout the large populations I studied on the Prince Edward Islands that I became convinced it was a good taxonomic character. I used it to establish a new genus *Zosterodiscus* (HERTEL 1984). However, after later studying New Zealand populations, I concluded that this character is not constant and therefore the carbonized rings must be environmentally, not genetically induced structures (HERTEL 1987b).

Regeneration of hymenia may lead to a gyrodisc (HERTEL 1967, KILIAS 1981) and umbonate ascocarp.

However, not only gross morphological, but also internal anatomical characters may be altered by damage and subsequent regeneration. Normally greenish or green-black epihymenia may become brown (SCHWAB 1986). In regenerated hymenia there may be a greater degree of branching and anastomosing of paraphyses, usually a good taxonomic character at the genus level, than in undamaged ones (KILIAS 1981, SCHWAB 1986). SCHWAB (1986 p. 278) mentions that the width of excipular hyphae (usually a good taxonomic character) may also be altered by damage and regeneration in *Porpidia.*

Development as well as regeneration are very slow processes in Antarctica. So a new wave of damage often may occur before an earlier damage is regenerated. In this way very strange thallus and ascocarp structures may develop.

It is usually easy for plant collectors to decide whether a flowering plant is well developed, an extreme shade form, variously damaged (e. g. leaves damaged by insects, or stunted by fungal parasites), without flowers or fruits, or represents the remains of a plant eaten by grazing animals. In all these cases a good trained collector would do his best to find additional, better developed specimens.

Analogous kinds of damage obviously occur in lichens. However, in these cases it is often difficult to recognize whether there is any damage at all and what the nature of it is.

The extreme variability of morphological characters, combined with our present inability to culture these extremly slow-growing, saxicolous, crustose lichens, makes it very difficult to decide whether two similar looking specimens are *either* merely ecotypes of one and the same taxon or are genetically different.

2.5. *Lack of familiarity with Arctic and Alpine lichens*

The degree of endemism among Antarctic crustose lichens in apparently very much overestimated. According to DODGE (1974), nearly all (97%) of the lichens found in Antarctica are claimed to be endemic. I consider 20% endemic species to be a much more realistic estimate. The reminder of the species have a bipolar or otherwise wide distribution. In „Appendix II", I have tried to summarize the non-endemic species in the Antarctic lichen flora, as far as I could determine (the list, based on literature available to me, is undoubtedly incomplete). There are 69 species which may be increase when genera such as *Acarospora, Bacida, Buellia, Catillaria, Caloplaca, Lecanora, Lecidea, Rhizocarpon* and others are monographed on a geographically wide base. Lichenological research in Antarctica started very late, and most of bipolar or widespread species were described much earlier, often in the 18th and 19th centuries, from the Northern Hemisphere, mainly from Central Europe and Scandinavia. Therefore, a profound and detailed knowledge of these floras is an absolute prerequisite when monographing Antarctic crustose lichens or describing new species.

It is usually taken for granted that there is a sharp contrast between the lichen floras of the humid and perhumid subantarctic regions (Tasmania, New Zealand, W. Patagonia, Falkland Islands, South Georgia, Tristan da Cunha, Gough, Prince Edward Islands, Crozet Island, Kerguelen, Macquarie Island), and Antarctica. Appendix II lists 38 southern hemisphere lichen species which share a distribution in both maritime Antarctica (South Orkneys, South Shetlands, Antarctic Peninsula) and subant-arctic regions. This is not particularly surprising, for in subantartic regions there may be habitats (such as at higher altitudes on mountains) where microclimatic situations correspond to macroclimatic conditions in maritime Antarctica.

Although Antarctica is geologically very old, and was formerly a part of Gondwanaland, the opportunities for survival of Gondwanan floral elements are extremely limited due to the heavy glaciation which began at least 20 million years BP (RAVEN and AXELROD 1974). In the lecideoid lichens there seem to be no genera truly endemic to the Antarctic continent, in contrast to subantarctic regions (HERTEL 1987a).

There is no doubt that there are endemic crustose species in continental Antarctica (among the lecideoid species, *Lecidea cancriformis,* widespread and common in continental Antarctica, seems to be a good example). However, as in the Arctic, endemic species are often a minority among the more aggressive, widespread oreophytes, which recolonized the polar areas after Pleistocene glaciations by means of long distance dispersal.

One of the fascinating goals of lichen systematics is to clarify the origin of the Antarctic lichen flora, its diversity and relationships. We urgently need reliable identifications, and specialists who not only study Antarctic lichens exclusively but are also familiar with all other species described from various cold areas. Last but not least, we need more extensive collections from all ice-free parts of Antarctica made by trained lichenologists.

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Appendix I

Index of Latin names mentioned in the text

Appendix II

This list includes a large number of non-endemic lichen species which occur in Antarctica and in other parts of the world. Although most of the information is based on literature only, only those records are included, which seem to me to be reliable. Usually only the more recent literature citations are included.

A. Bipolar and widespread lichen species in Antarctica

1. *Acarospora chlorophana* (Wahlenb. in Ach.) Massal. (ØVSTEDAL 1983)
2. *Alectoria nigricans* (Ach.) Nyl. (LAMB 1964, SMITH 1972, ALLISON and SMITH 1973)
3. *Bacidia trachona* (Ach.) Lettau (ØVSTEDAL 1986a)
4. *Bryocaulon chalybeiformis* (Ach.) Kärnef. [= *Alectoria chalybeiformis* Ach.] (LAMB 1964, SMITH 1972, ALLISON et SMITH 1973)
5. *Buellia coniops* (Wahlenb. in Ach.) Th. Fr. (LAMB 1968, SMITH 1972)
6. *Buellia papillata* (Sommerf.) Tuck. (LAMB 1968)
7. *Buellia punctata* (Hoffm.) Massal. (LAMB 1968, SMITH 1972)
8. *Caloplaca citrina* (Hoffm.) Th. Fr. [= *Caloplaca mawsonii* (Dodge) Dodge] (FILSON 1974a and 1974b, KASHIWADANI 1979)
9. *Caloplaca jungermanniae* (Vahl) Th. Fr. (ØVSTEDAL 1986a)
10. *Caloplaca tetraspora* (Nyl.) Oliv. (J. POELT, pers. comm.)
11. *Caloplaca tiroliensis* Zahlbr. (J. POELT, pers. comm.)
12. *Candelariella vitellina* (Hoffm.) Müll. Arg. (BOWRA et al. 1966, SMITH 1972)
13. *Carbonea vorticosa* (Flk.) Hertel [= *Lecidea vorticosa* (Flk.) Koerb.] (HERTEL 1984, HERTEL 1985)
14. *Cladina mitis* (Sandst.) Hustich [= *Cladonia mitis* Sandst., = *Cladonia laevigata* sensu DODGE 1974] (AHTI and KASHIWADANI 1984)
15. *Cladina rangiferina* (L.) Nyl. [= *Cladonia rangiferina* (L.) Nyl., = *Cladonia vicaria* R. Sant.] (AHTI 1961, SMITH 1972, AHTI 1984, HUNECK et al. 1986)

16. *Cladonia furcata* (Huds.) Schrad. (LINDSAY 1975)
17. *Cladonia gracilis* (L.) Willd. [= *Cladonia propagulifera* (Vainio) Dodge] (AHTI 1980, HUNECK et al. 1986)
18. *Cladonia pleurota* (Flk.) Schaer. (VAINIO 1903, LINDSAY 1975)
19. *Cladonia pyxidata* (L.) Hoffm. (VAINIO 1903, DARBISHIRE 1912, LINDSAY 1975, JØRGENSEN 1986)
20. *Coelocaulon aculeatum* (Schreb.) Link [= *Cornicularia aculeata* (Schreb.) Ach.] (LAMB 1964, SMITH 1972, KÄRNEFELT 1986)
21. *Coelocaulon muricatum* (Ach.) Kärnef. [= *Cornicularia muricata* (Ach.) Ach.] (KÄRNEFELT 1986)
22. *Cystocoleus ebeneus* (Dillw.) Thwaites [= *Cystocoleus niger* auct.] (LINDSAY 1971b, SMITH 1972, SMITH and CORNER 1973, JØRGENSEN 1986)
23. *Dermatocarpon intestiniforme* (Koerb.) Hasse (LAMB 1948a)
24. *Farnoldia dissipabilis* (Nyl.) Hertel [= *Lecidea sublutescens* Nyl.] (HERTEL 1984)
25. *Hypogymnia lugubris* (Pers.) Krog (LINDSAY 1974, ELIX 1979, REDON 1985)
26. *Lecanora polytropa* (Hoffm.) Rabenh. (DARBISHIRE 1912, LONGTON et HOLDGATE 1979)
27. *Lecidea atrobrunnea* (Ram.) Schaer. [= *Lecidea racovitzae* Dodge] (HERTEL 1984)
28. *Lecidea lapicida* (Ach.) Ach. [= *Lecidea rupicida* Vain.] (HERTEL 1984, HERTEL 1985)
29. *Lecidella carpathica* Koerb. (HERTEL ined.)
30. *Lecidella inamoena* (Müll. Arg.) Hertel (HERTEL ined.)
31. *Lecidella stigmatea* (Ach.) Hertel and Leuckert (HERTEL ined.)
32. *Lepraria neglecta* Vain. (KAPPEN 1985)
33. *Massalongia carnosa* (Dicks.) Koerb. (LAMB 1959, LINDSAY 1975, JØRGENSEN 1986
34. *Ochrolechia frigida* (Sw.) Lynge (LINDSAY 1971c, SMITH 1972, SMITH and CORNER 1973, REDON 1985)
35. *Ochrolechia parella* (L.) Massal. [= *Ochrolechia antarctica* (Müll. Arg.) Darb.] (SMITH 1972, ØVSTEDAL 1986b)
36. *Pannaria hookeri* (Borr. ex Sm.) Nyl. (LINDSAY 1974, REDON 1985, JØRGENSEN 1986)
37. *Parmelia saxatilis* (L.) Ach. [= *Parmelia acervata* Hue] (SMITH 1972, LINDSAY 1973a, SMITH and CORNER 1973, LINDSAY 1975)
38. *Peltigera didactyia* (With.) Laundon [= *Peltigera spuria* (Ach.) DC.] (LINDSAY 1971a, SMITH and CORNER 1973, LINDSAY 1975, VITIKAINEN 1987 in lit.)
39. *Peltigera rufescens* (Weis) Humb. 1917a, SMITH 1972, ALLISON et SMITH 1973, LINDSAY 1975, VITIKAINEN 1987 in lit.)
40. *Phaeorrhiza nimbosa* (Fr.) Mayrh. et Poelt [= *Rinodina nimbosa* (Fr.) Th. Fr.] (LAMB 1968)
41. *Physcia caesia* (Hoffm.) Fürnrohr [= *Parmelia coreyi* Dodge et Baker, = *Parmelia johnstonii* Dodge, = *Parmelia variolosa* Dodge et Baker] (SMITH 1972, FILSON 1974a, NAKANISHI and KASHIWADANI 1976)
42. *Physcia dubia* (Hoffm.) Lettau (NAKANISHI and KASHIWADANI 1976, JØRGENSEN 1986
43. *Physconia muscigena* (Ach.) Poelt (SMITH 1972, KAPPEN 1985, REDON 1985)
44. *Pseudephebe minuscula* (Arnold) Brodo et Hawksw. [= *Alectoria minuscula* (Arnold) Degel., = *Alectoria antarctica* Dodge et Baker, = *Alectoria biformis* (Vain.) Dodge, = *Alectoria congesta* (Zahlbr.) Dodge] (LAMB 1964, KASHIWADANI 1970, BRODO and HAWKSWORTH 1977)
45. *Pseudephebe pubescens* (L.) Brodo et Hawksw. [= *Alectoria pubescens* (L.) R. Howe, = *Alectoria intricata* Hue, = *Alectoria nigerrima* Hue] (LAMB 1964, HAWKSWORTH 1972, SMITH 1972)
46. *Psoroma hypnorum* (Vahl) S. F. Gray [= *Psoroma bryantii* Dodge, = *Psoroma follmannii* Dodge] (SMITH 1972, HENSSEN et RENNER 1981, JØRGENSEN 1986)
47. *Rhizocarpon geographicum* (L.) DC. (SMITH 1972, ALLISON et SMITH 1973, SMITH et CORNER 1973, REDON 1985, HUNECK et al. 1986, ØVSTEDAL 1986a, ØVSTEDAL 1986b)
48. *Rhizocarpon superficiale* (Schaer.) Vain. [= *Rhizocarpon adarense* (Darb.) M. LAMB, = *Rhizocarpon barilochense* Räs., = *Buellia austro-georgica* Müll. Arg., = *Buellia flavoplana* Darb., = *Buellia superba* Darb., = *Buellia tristis* Darb., = *Buellia variabilis* Darb.] (RUNEMARK 1956, SMITH 1972)
49. *Rhizoplaca melanophthalma* (DC.) Leuck. et Poelt [= *Omphalodina exulans* (Th. Fr.) Dodge] (FILSON 1974b, FILSON 1975c, ØVSTEDAL 1986b)
50. *Rinodina olivaceobrunnea* Dodge et Baker [= *Rinodina archaeoides* H. Magn.] (LAMB 1968, KASHIWADANI 1970, FILSON 1975a)
51. *Rinodina turfacea* (Wahlenb.) Koerb. (LAMB 1968, ØVSTEDAL 1986b)
52. *Sphaerophorus globosus* (Huds.) Vain. (LINDSAY 1972a, SMITH 1972, SMITH and CORNER 1973, HUNECK et al. 1986)
53. *Sporastatia testudinea* (Ach.) Massal. (HERTEL ined.)
54. *Stereocaulon alpinum* Laur. (SMITH 1972, ALLISON et SMITH 1973, LAMB 1977)
55. *Stereocaulon vesuvianum* Pers. (LAMB 1977 — 79°12'S!)
56. *Tephromela atra* (Huds.) Hafellner [= *Lecanora atra* (Huds.) Ach.] (VAINIO 1903, SMITH 1972, ALLISON et SMITH 1973)
57. *Tremolicia atrata* (Ach.) Hertel [= *Lecidea dicksonii* auct.] (SMITH 1972, SMITH and CORNER 1973, HERTEL 1984, HERTEL 1985)
58. *Umbilicaria aprina* Nyl. [= *Umbilicaria spongiosa* Dodge et Baker, *Umbilicaria antarctica* var. *subviridis* Frey et M. LAMB, *Umbilicaria saviczii* Llano, *Gyrophora korotkeviczii* Golubkova] (GOLUBKOVA and SAVICZ 1966, LINDSAY 1972b, FILSON 1975b, FILSON 1987)
59. *Umbilicaria decussata* (Vill.) Zahlbr. [= *Umbilicaria eximia* Hue, *Umbilicaria parvula* Hue, *Umbilicaria rugosa* Dodge et Baker, *Umbilicaria cerebriformis* Dodge et Baker, *Umbilicaria pateriformis* Dodge et Baker, *Umbilicaria hunteri* Dodge, *Umbilicaria subcerebriformis* Dodge, *Omphalodiscus decussatus* var. *tortuosus* Llano, *Umbilicaria leiocarpa* var. *nana* Vainio, *Dermatiscum mawsoni* Dodge (LINDSAY 1969, KASHIWADANI 1970, SMITH 1972, FILSON 1975c, HUNECK et al. 1986, FILSON 1987)
60. *Umbilicaria propagulifera* (Vain.) Llano (TOPHAM et al. 1982, SEAWARD et al. 1983, FILSON 1987)
61. *Usnea sphacelata* R. Br. [= *Usnea frigida* Dodge et Baker, = *Usnea laxissima* Dodge, = *Usnea picata* (M. Lamb) Dodge, = *Usnea scabridula* (M. Lamb) Dodge, = *Usnea sulphurea Th. Fr.*, ? = *Usnea striata* Zammuto in Dodge, = *Usnea subpolaris* (M. Lamb) Dodge] (LAMB 1964, WALKER 1985)
62. *Verrucaria ceuthocarpa* Wahlenb. (LAMB 1948a, SMITH 1972)
63. *Verrucaria maura* Wahlenb. (VAINIO 1903, SMITH 1972)
64. *Verrucaria microspora* auct. non Nyl. (LAMB 1948a sub „*Verrucaria microspora* Nyl.", SANTESSON 1984)
65. *Verrucaria mucosa* Wahlenb. (SANTESSON 1938, LAMB 1948a, ØVSTEDAL 1986b)
66. *Xanthoria candelaria* (L.) Th. Fr. [= *Polycauliona coralligera* Hue, *Xanthoria antarctica* (Vain.) Dodge et Baker] (LAMB 1948b, SMITH 1972, LINDSAY 1975, JØRGENSEN 1986)
67. *Xanthoria elegans* (Link) Th. Fr. [= *Gasparrinia austrogeorgica* Dodge, = *Gasparrinia citrina* Dodge, = *Gasparrinia harrissonii* Dodge, = *Polycaulionia johnstonii* Dodge, = *Polycaulionia pulvinata* Dodge et Baker, = *Polycaulionia sparsa* Dodge et Baker, = *Caloplaca sparsa* (Dodge et Baker) J. Murray var. *latespora* J. Murray] (FILSON 1966, LINDSAY 1972b, SMITH 1972, LINDSAY 1975, FILSON 1975c, LINDSAY 1977, FILSON 1984)
68. *Xanthoria parietina* (L.) Beltr. (KASHIWADANI 1979)

B. Species known from both Antarctica and Subantarctic regions

69. *Bacidia tuberculata* Darb. (ØVSTEDAL 1986b)
70. *Buellia anisomera* Vain. (LAMB 1968, LINDSAY 1973b, ØVSTEDAL 1986)
71. *Buellia augusta* Vain. (LAMB 1968, LINDSAY 1973b)
72. *Buellia falklandica* Darb. (DARBISHIRE 1912, ØVSTEDAL 1986b)
73. *Buellia isabellina* (Hue) Darb. (LAMB 1968, LINDSAY 1973b)
74. *Buellia latemarginata* Darb. (LAMB 1968, LINDSAY 1973b)
75. *Buellia melanostola* (Hue) Darb. (LAMB 1968, LINDSAY 1973b, ØVSTEDAL 1986b)
76. *Buellia russa* (Hue) Darb. (LAMB 1968, SMITH 1972, LINDSAY 1973b, ØVSTEDAL 1986b)
77. *Caloplaca cirrochrooides* (Vain.) Zahlbr. (SMITH 1972, LINDSAY 1976, ØVSTEDAL 1986b)
78. *Caloplaca regalis* (Vain.) Zahlbr. (SMITH 1972, POELT et PELLETER 1984, HUNECK et al. 1986)
79. *Caloplaca sublobulata* (Nyl.) Zahlbr. (SANTESSON 1944, SMITH 1972, REDON 1985, ØVSTEDAL 1986)

80. *Cladina pycnoclada* (Pers.) Leight. [= *Cladonia pycnoclada* (Pers.) Nyl.] (HUNECK et al. 1986)
81. *Coelocaulon epiphorellum* (Nyl.) Kärnef. (LAMB 1964, SMITH 1972, KÄRNEFELT 1986)
82. *Haematomma erythromma* (Nyl.) Zahlbr. [= *Lepraria pallidostraminea* Vain., = *Lecanora orostheoides* Vain.] (FOLLMANN and REDON 1971, SMITH 1972, SMITH and CORNER 1973, FOLLMANN and RUDOLPH 1979, HUNECK et al. 1986)
83. *Himantormia lugubris* (Hue) M. Lamb (LAMB 1964, SMITH 1972, LINDSAY 1975, HUNECK et al. 1986)
84. *Huea austroshetlandica* (Zahlbr.) Dodge (LINDSAY 1974)
85. *Lecania gerlachei* (Vain.) Darb. (ØVSTEDAL 1986b)
86. *Leptogium puberulum* Hue (SMITH 1972, LINDSAY 1975, REDON 1985, JØRGENSEN 1986)
87. *Notolecidea subcontinua* (Nyl.) Hertel [= *Lecidea subcontinua* Nyl.] (HERTEL 1987a)
88. *Pannaria dichroa* (Hook. et Tayl.) Cromb. (JØRGENSEN 1986)
89. *Parmelia gerlachei* Zahlbr. (LINDSAY 1973a, LINDSAY 1975)
90. *Parmelia ushuaiensis* Zahlbr. (LINDSAY 1973a, LINDSAY 1975)
91. *Placopsis contortuplicata* M. Lamb (LAMB 1947, SMITH 1972, ØVSTEDAL 1987b)
92. *Psoroma cinnamomeum* Malme (LINDSAY 1974, REDON 1985)
93. *Psoroma tenue* Henssen (HENSSEN et RENNER 1981)
94. *Ramalina terebrata* Hook. f. et Tayl. (LAMB 1964, SMITH 1972, LINDSAY 1975, REDON 1985, HUNECK et al. 1986)
95. *Rinodina deceptionis* M. Lamb (LAMB 1968, LINDSAY 1973b, ØVSTEDAL 1986b)
96. *Rinodina petermannii* (Hue) Darb. (LAMB 1968, SMITH 1972, LINDSAY 1973b)
97. *Staurothele gelida* (Hook. f. et Tayl.) M. Lamb (LAMB 1948a, REDON 1985)
98. *Stereocaulon antarcticum* Vain. (LAMB 1977)
99. *Stereocaulon glabrum* (Müll. Arg.) Vain. (LINDSAY 1975, LAMB 1977, HUNECK et al. 1986, JØGENSEN 1986)
100. *Usnea (Neuropogon) acromelana* Stirt. (LAMB 1964, WALKER 1985)
101. *Usnea (Neuropogon) antarctica* DR. [= *Usnea crassa* Zammuto in Dodge, = *Usnea crombiei* Dodge, = *Usnea floriformis* Dodge, = *Usnea granulifera* (Vain.) Motyka, = *Usnea propagulifera* Dodge, = *Usnea pseudofruticosa* Zammuto in Dodge, = *Usnea pustulata* Dodge, ? = *Usnea subfoveolata* Dodge, ? = *Usnea subpapillata* Dodge] (LAMB 1964, GOLUBKOVA and SAVICZ 1970, SMITH 1972, WALKER 1985, HUNECK et al. 1986)
102. *Usnea (Neuropogon) aurantiaco-atra)* (Jacq.) Bory [= *Usnea aurantiaca* Motyka, = *Usnea fasciata* Torrey, = *Usnea melaxantha* Ach., ? = *Usnea siplei* Zammuto in Dodge] (LAMB 1964, SMITH 1972, WALKER 1985)
103. *Usnea (Neuropogon) subantarctica* F. J. Walker (WALKER 1985)
104. *Verrucaria elaeoplaca* Vain. (SMITH 1972, ØVSTEDAL 1986b)
105. *Verrucaria tesselatula* Nyl. (LAMB 1948a, SMITH 1972, ØVSTEDAL 1986b)
106. *Zahlbrucknerella patagonica* Henssen (HENSSEN 1977)

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