The Genus *Lycoperdon* in Greenland and Svalbard

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Abstract

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The collections of *Lycoperdon* from Greenland and Svalbard kept at the Botanical Museum of Copenhagen are reviewed. In the surveyed material ten species are on record from Greenland whereas only three species were represented in the collections from Svalbard. An arctic-alpine element with wide distributions in Greenland and Svalbard is represented by *L. frigidum, L. niveum* and some forms of *L. molle* s.l. A subarctic-low arctic element consisting of species widespread in temperate regions of N America and Eurasia (*L. lambinonii, L. nigrescens, L. norvegicum, L. perlatum, L. pyriforme* and *L. umbrinum*) are confined to S and SW Greenland. One species, *L. lividum*, although rare, is widely distributed in Greenland but seems to be restricted to regions with low precipitation.

Keywords: *Lycoperdon*, Svalbard, Greenland, taxonomy, distribution patterns.

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Introduction

In 1948 Morten Lange published "The Gasteromycetes of Greenland" which has since served as a basis for the study of puffballs in Arctic regions. Accounts of Arctic *Bovista*-species (Lange 1987) and a survey of the genus *Calvatia* (Lange 1990) have later been added. However, although being fairly frequent in Arctic areas, the genus *Lycoperdon* has not been subject to any regional systematic survey. In the Botanical Museum in Copenhagen (C) there is an extensive material of *Lycoperdon* species collected in Greenland and Svalbard by Morten Lange and others during the latter half of the 20:th century.

The present paper is a provisional checklist based on this material and a status report of the present knowledge of puffballs belonging to the genus *Lycoperdon* in the area. The material is under continuous work and the next step would be a study based on an analysis of molecular data to which could hopefully be added representative sampling from other Arctic areas.

An overview of climatic and edaphic factors of the region, relevant also for the present study, was given by Lange (1987).

This report is dedicated to the memory of Morten Lange, who died on the 10th of November, 2003.

Material and Methods

The herbarium material used in this study consists of about 350 collections deposited at C. The material was primarily worked by M. Lange (ML) and later revised by the author (MJ). Every collection studied is documented on A-5 cards (by ML) and on A-4 sheets with notes and drawings (by MJ). Originals of these notes are kept at C.

The Greenland material originates mainly from the western and southern parts but the East and Northeast coasts are also fairly well represented. The material was collected mainly by M. Lange, H. Knudsen, J. H. Pedersen, S.A. Elborne, T. Læssøe, B. Fredskild, P. M. Petersen and T. Borgen. In Svalbard most of the collecting was performed by M. Lange in the Isfjord and Kongsfjord areas in the West.

The material consists of fruitbodies in different

stages of development. In several cases only immature fruitbodies are included. In this study only collections containing mature or almost mature fruitbodies (stages IV-VI, cfr below) were considered. The collections belonging to *Lycoperdon* studied for Lange's 1948 paper were revised and partly incorporated. Some additional collections from the Akureyri Museum of Natural History (AMNH), the Botanical Museum in Oslo (O) and the personal herbarium (MJ) of the author were also studied.

Demoulin (1971a, 1972) served as a basis for the general taxonomy in *Lycoperdon*. Kreisel's (1969, 1976) contributions to arctic-alpine mycology also proved to be important sources of information.

The holotype collections of *L. niveum* Kreisel, *L. altimontanum* Kreisel, *L. asiaticum* Kreisel as well as paratypes of *L. frigidum* Demoulin were studied.

For microscopic studies spores and capillitium were mounted in lactophenol-Cotton Blue. All samples for microscopic studies were taken from the central part of the mature gleba.

All drawings are originals by MJ.

Diagnostic characters in Arctic *Lycoperdon*

Climatic conditions in Arctic areas are harsh and highly variable. This of course has an impact on fruitbody morphology, especially on the exoperidial development. The period during which fructification may occur is limited and as it seems often interrupted by frost. This means that the fruitbody development is halted and may continue during the next period of thawing in the same season, or the fruitbodies may overwinter under the snow to mature during the next season (M. Lange, personal communication). Collections from Arctic regions often contain immature fruitbodies or those having had a disturbed maturation process. These are often difficult (if not impossible) to interpret. It should also be taken into account that immature fruitbodies having ripened in the laboratory produce unreliable microscopical characters as pointed out already by Kreisel (1962).

In very old and weathered fruitbodies the microscopical details are finally lost and the remaining gleba is characterized by broken spores and an extremely broken up capillitium.

The developmental stages I-VI as defined by Lange (1990) for the genus *Calvatia* are applicable also in *Lycoperdon*. As a rule however only stages IV-V (sometimes VI) can be used for identification since much emphasis has to be put on characters of mature spores and capillitium.

Macroscopic features

Size and shape of fruitbodies: The *Lycoperdon* species occurring in Arctic areas are generally small to medium sized and thus not differing from those met with in temperate regions. Concerning the shape of fruitbodies there is a wide range of variation within a species and even within a single collection (subglobose-pyriform-turbinate). Fruitbodies having grown in open situations are generally more rounded than those originating from sheltered sites under bushes or among trees.

Peridial structures: In *Lycoperdon* the peridium is built up of two strata, the inner endoperidium and the outer exoperidium. The latter is originally whitish and almost smooth, soon however it develops an ornamentation whose nature and complexity is linked with the species but which often shows a considerable variability within a species as well as within a single collection. In Arctic material the exoperidial development often seems to have been disturbed by freezing or drying. The exoperidial ornamentation in *Lycoperdon* can be constructed of granulae or spines (cfr Kreisel 1962). The latter may be either simple or with connected tips, often united in groups or small islands dispersed on the endoperidium. In some species (the *Lycoperdon perlatum*-group) the spines are surrounded by circles of granulae giving the fruitbody an areolate appearance. A somewhat similar areolation is occasionally met with also in samples belonging to the *L. molle*-group but has been interpreted as an effect of unfavourable weather conditions during the fruitbody development.

By weathering the exoperidium is gradually lost and the brownish to greyish more or less papery endoperidium is exposed.The way and the tendency of the exoperidium to fall off is a taxonomically important character but again highly variable due to climatic conditions.

Gleba and subgleba: The colour of the mature gleba shows different shades of brown (olivaceous brown, fuscous or dark brown with or without purplish tinges). In Arctic *Lycoperdon* the colour of the gleba appears to be an unreliable character on species level. All species of *Lycoperdon* considered in this material are provided with a more or less developed lacunar subgleba easily seen in a sectioned fruitbody. The size and colour of this structure however seem to be of limited diagnostic importance (with the exception of *L. pyriforme* typically showing a whitish subgleba).

Microscopical features

Exoperidium: As a general character of the genus *Lycoperdon* the exoperidial spines are constructed of sphaerocysts. It seems however that under Arctic conditions the size and pigmentation of these structures are difficult to interpret. Subsequently the microscopical characters of the exoperidium were not applied to the studied material. It is however possible that these characters could yield some more information providing future collections contain specimens from sheltered situations where the exoperidium is likely to be well preserved.

Spores and debris of broken sterigmata: The spores in the genus *Lycoperdon* are generally sphaerical with an average diametre (excluding the ornamentation) varying between 3 and 5.5 µm according to species. In some Arctic samples the spore diametre varies considerably within a single fruitbody. This probably can be explained by variation in the number of nuclei between spores. In such cases only the diametre of spores provided with a distinct ornamentation were measured. The spore wall in *Lycoperdon* is almost smooth to distinctly warted according to species. The ornamentation can be designated A-D in accordance with the terminology used by Demoulin (1971a), thus A representing almost smooth spores, B faintly warted spores, C distinctly warted spores and D extremely warted spores. In the descriptions below the spore measurements are constantly given excluding the ornamentation. In the present material attempts were made to classify the density of the spore wall ornamentation (sparsely/densely warted). Especially in the *L. molle*-group this seems to be a character apt to considerable variation. A short sterigmal rest (usually less than 3 µm long) is usually seen on the spore. Although there are taxa of *Lycoperdon* presenting distinctly pedicellate spores none of these species were found in the Arctic material. In some of the samples however pedicellate spores occurred among normal apedicellate ones. Since the pedicell was severely deformed (usually swollen – "giant pedicells") and only occurred on the odd spore it was considered an occasional feature.

In most species of *Lycoperdon* remnants of broken sterigmata can be seen in mounts. The occurrence and preservation of this debris is a character of some importance.

Capillitium: The mature gleba of all *Lycoperdon* species contain thin, more or less branched brownish hyphae known as capillitium.

In *Lycoperdon* from temperate regions the properties of the capillitium prove to be fairly constant on a species level. Consequently much emphasis was put on capillitial characters when observing the Arctic collections.

The overall capillitial structure can be classified as fragile (tendency to break up easily at relatively short intervals) or elastic (tendency to form long, elastic threads). In some species intermediate types prevail. They are classified as sub-elastic. In a few samples studied a type of capillitium consisting of broad, snake-like hyphae was observed. These aberrant hyphae were always found to occur among normal capillitium and were therefore considered more or less pathological.

The frequency of septa in the capillitium is an additional character of importance. The septum may occur either at ramifications or along unbranched hyphae. They are "true septa" in the sense of Kreisel (1967). In some samples belonging to the *L. molle*-group (especially *L. molle* s.l. and *L. niveum*) a type of septum described for *L. niveum* by Kreisel (1969) was regularly met with in the material. Although later considered occasional in *L. niveum* by Kreisel (1976) septa reminding of this type is in our experience also met with in Arctic representatives of *Calvatia* as well as in the temperate *Bovista dermoxantha* (Vittad.)De Toni.

The capillitial wall thickness can be classified as thin (< 1 µm), medium (±1 µm) or thick (> 1 µm) and the occurrence, frequency and average size and out-

line of pores are found to be fairly constant species characters.

Taxonomy

Kreisel (1962) in his concept of *Lycoperdon* divided the genus into two sections: sectio *Polymorphum* and sectio *Lycoperdon*. The former was later incorporated in the genus *Bovista* as subgenus *Globaria* whereas the section *Lycoperdon* was divided into several series (Kreisel l.c.):

a. *Pyriformia*
b. *Umbrina*
c. *Perlata*
d. *Pedicellata*
e. *Candida*
f. *Atropurpurea*
g. *Echinata*

In the Arctic material at hand four main species-groups could be defined (Fig. 1), two of which contain a majority of the species met with.

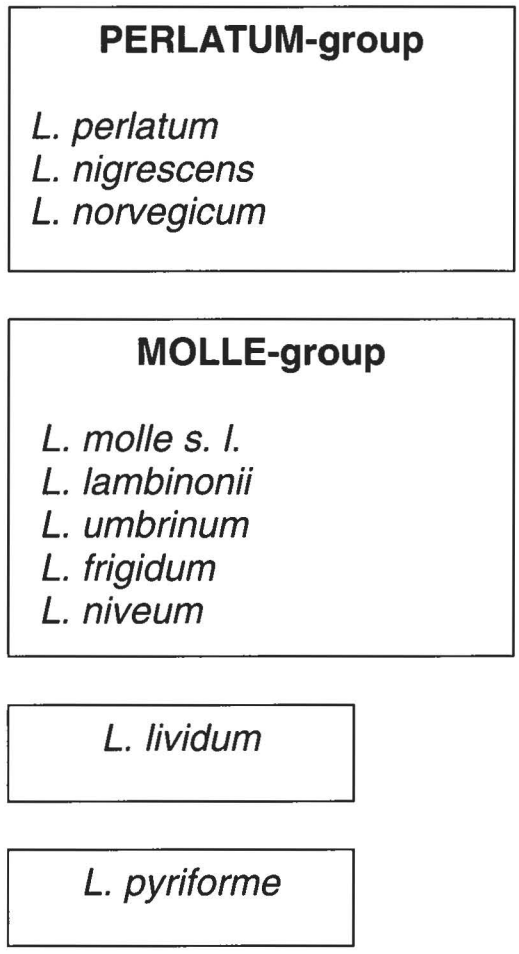


Fig. 1. Species-groups in the genus *Lycoperdon* in Greenland.

1. The *molle*-group

In the present concept the *molle*-group is a combination of Kreisel's sections *Umbrina* and *Atropurpurea*.

Exoperidium with simple or connivent spines in groups, spores weakly to distinctly warted (A-)B-C, 3-5.5 µm in diametre, with more or less abundant sterigmal debris, capillitium with occasional to abundant septa, subgleba brownish-greyish.

Key to the species of the *molle*-group with special emphasis on the samples from Greenland and Svalbard:

1. Spores 3-3.5 µm (B), capillitium subelastic-elastic with only scattered small pores and few septa, capillitial walls medium to thick, exoperidium constructed of small, persistent brownish spines and granulae — *L. lambinonii*
1. Spores larger — 2

2. Spores 4.0-4.5(-5.0) µm, capillitium subelastic (rarely fragile), widespread species — 3
2. Spores larger, 4.5-5,0-5.5 µm, capillitium elastic, subelastic or fragile,arctic-alpine species — 4

3. Spores A-B, very little sterigmal debris present, capillitium subelastic with few septa and scattered pores with regular outline, exoperidium of brownish spines with a tendency to fall off from upper part of the fruitbody exposing the endoperidium — *L. umbrinum*
3. Spores C, mixed with abundant sterigmal debris, capillitium subelastic-elastic (rarely fragile) with few septa and few, small pores with irregular outline (abundant pores may be present in some hyphae), variable species with "arctic forms" (cfr. text below) — *L. molle*

4. Capillitium elastic with medium to thick walls, scattered pores and usually abundant septa, exoperidium of small whitish to pale brown connivent spines in groups often intermixed with small irregular granulae, mature fruitbody usually light brownish with copper-colours towards the base *L. frigidum*
4. Capillitium fragile with thin to medium walls, with abundant pores and septa, exoperidium of whitish-yellowish connivent, often stout spines in groups especially in the upper part of the fruitbody, falling off with age exposing a shining, yellowish-olivaceous grey endoperidium, no copper colours towards the base *L. niveum*

2. The perlatum-group (= Kreisel's section *Perlata*)

Exoperidium complex consisting of groups of connivent spines (or pyramidal warts) surrounded by granulae in an areolate manner, spores weakly to moderately ornamented A-B(-C), 3-4 µm in diametre, capillitium with occasional septa, subgleba brownish-greyish

Key to the species of the *perlatum*-group with special emphasis on the samples from Greenland and Svalbard:

1. Spores distinctly warted (B-C), exoperidum constructed of pyramidal whitish-pale ochre warts surrounded by distinct areolae *L. perlatum*
1. Spores faintly ornamented or appearing almost smooth (A-B) 2

2. Spores weakly but distinctly ornamented (B), 3.5-4.5 µm, exoperidum of brownish slender spines with connivent tips, arranged in groups and surrounded by distinct brownish areolae *L. nigrescens*
2. Spores almost smooth, A-(-B), 3.0-3.5 µm, exoperidum of slender whitish-pale ochre connivent spines arranged in groups and surrounded by indistinct areolae *L. norvegicum*

3. *L. pyriforme* (part of Kreisel's section *Pyriformia*)

Exoperidum granular-verrucose, subgleba white, capillitium elastic and without pores, spores almost smooth *L. pyriforme*

4. *L. lividum* (part of Kriesel's section *Pyriformia*)

Exoperidum granular-verrucose, subgleba brownish-greyish, capillitium fragile with abundant pores, spores moderately ornamented, B. *L. lividum*

Annotated list of species

Lycoperdon frigidum Demoulin 1972

Figs 2, 3, 12 A, 13 A.

L. frigidum is a species in the *L. molle*-group characterized by its big, densely but not very coarsely ornamented spores and its subelastic-elastic capillitium with few and small pores. Its exoperidial ornamentation varies considerably but is in typical cases constructed of small, whitish-brownish slender spines downwards mixed with farinaceous granulae. The fruitbodies often show copper colours towards the base.

L. frigidum was separated from *L. molle* s.str. by Demoulin (1972) as a species with a strictly arctic-alpine distribution (Austria, Norway, Sweden, Finland, Iceland, Svalbard, Alaska and Arctic Canada). Kreisel and Hausknecht (1998) recently added a second finding in the Austrian Alps. According to the material at my disposal it has proved to be among the more regular species in Greenland and Svalbard. It seems however to be a species of subarctic, low arctic and middle arctic environments with only few records in high arctic regions. According to the herbarium labels there seems to be a preference for exposed heathland situations, sometimes among *Dryas*. Borgen (1993) recorded *L. frigidum* in Greenland and there were previous records from Svalbard (Longyearbyen, 1968, leg. S. Woldmar 110 a, b, c, UPS, Demoulin 1972).

Dr. V. Demoulin (Liège, personal communication 2005) has kindly provided some additional records of

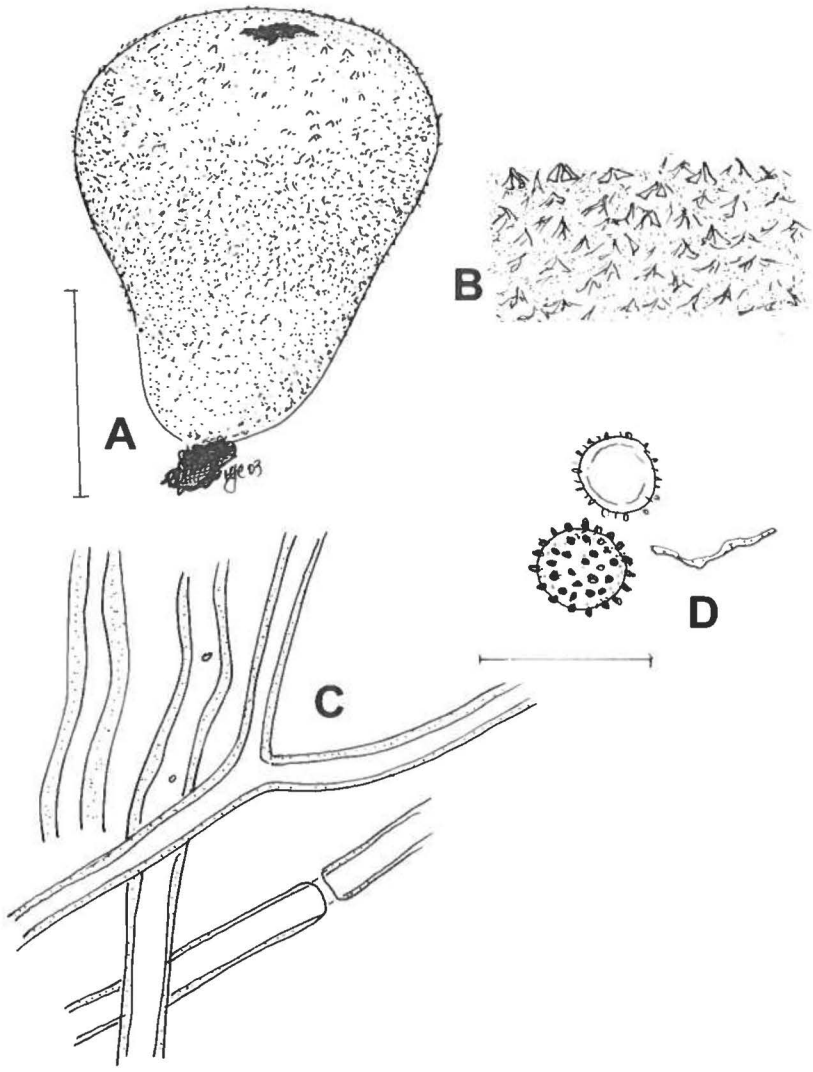


Fig. 2. *Lycoperdon frigidum*. Greenland, Narsarsuaq 27 VIII 1995, leg. M. Lange 95-22. A. Fruitbody. B. Close up of exoperidium. C. Capillitium. D. Spores. Scale bars 10 mm and 10 µm.

L. frigidum from Svalbard, studied by him: Hotelnes 20 VIII 1959, A. Heintz (O) and Longyearbyen 16 VIII 1966, Y. K. Kobayasi (TNS).

Description based on Greenland and Svalbard samples

Macroscopical aspect: Fruitbodies up to 2 cm in diameter, subglobose to pyriform. Exoperidium initially white consisting of a dense cover of small spines. At maturity the spines are connivent, whitish to pale brownish, somewhat bigger towards the apex, downwards mixed with farinaceous granulae, sometimes yellowish – copper brown at base. The spines usually fall off at the summit leaving the yellowish-greyish endoperidium exposed. Mature gleba dark brown.

Microscopical aspect: Capillitium subelastic to elastic, 3-6 µm in diameter, walls medium to thick with rare and scattered small pores. Septa are usually abundant. Spores 4.5-5.5 µm in diameter, densely and distinctly although not very coarsely warted B-(C). The spores being rather similar to those of *L. niveum* usually appear less ornamented than in *L. molle*. Debris of broken sterigmata is often abundant.

Discussion

Paratypes of *L. frigidum* along with additional material (Appendix 1) from Central Norway (O) and Iceland (MJ) were examined and found conspecific with the Greenland and Svalbard samples. The description and photo published by Kreisel and Hausknecht (1998) also coincide in essential characters with our concept of this species. *L. frigidum* seems to be very closely related to some forms of *L. molle* from which it can be distinguished by its usually more elastic capillitium

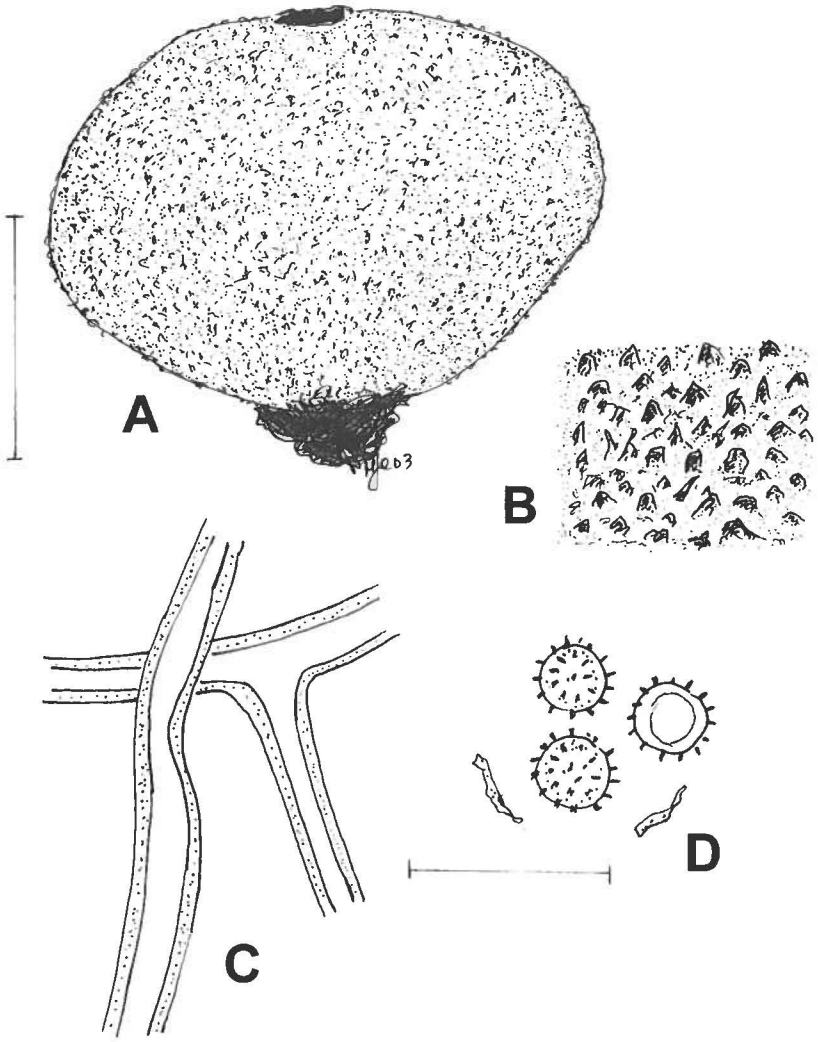


Fig. 3. *Lycoperdon lambinonii*. Greenland, Narsarsuaq 15 VII 1971, leg. M. Lange 71-230. A. Fruitbody. B. Close up of exoperidium. C. Capillitium. D. Spores. Scale bars 10 mm and 10 µm.

and its somewhat bigger and less ornamented spores. The exoperidial ornamentation can be almost similar in the two species which makes field identifications difficult. *L. frigidum* seems to be a species with a true arctic-alpine distribution.

Material examined

Greenland: Qinqua-valley at Tasersuaq lake, 60° 16' N, 44° 33' W, 17 VIII 1983 and 20 VIII 1983, H. Knudsen, T. Borgen and J.H. Petersen. Narsaq, 60° 54' N, 46° 04' W, 11 VIII 1995 and 25 VIII 1995, M. Lange. Narsaq, Kvanefjeldet, 60° 54' N, 46° 04' W, 13 VIII 1981, T. Læssøe. Narsarsuaq, 61° 10' N, 45° 25' W, 15 VIII 1971 (2 coll.) and 27 VIII 1995, M. Lange.

Narsarsuaq, 61° 10' N, 45° 25' W, 17 VIII 1981, T. Læssøe. Narsarsuaq, 61° 10' N, 45° 25' W, 10 VIII 1984, H. Knudsen and T. Læssøe. Kangilinnguit, 61° 14' N, 48° 05' W, 7 VIII 1984, T. Borgen. Paamiut, 62° 00' N, 49° 20' W, 23 VIII 1982 and 26 IX 1993, T. Borgen. Ammassalik, Præstefjeld, 65° 36' N, 37° 37' W, 10 IX 1990, M. Lange. Kangerlussuaq, 67° 01' N, 50° 43' W, 9 VIII 1967 and 23 VIII 1994 (6 coll.), M. Lange. S-side of Annertussup Qáqai, 68° 33' N, 52° 00' W, 8 VIII 1972, P.M. Petersen (2 coll.). Ilulissat, 69° 13' N, 51° 06' W, 16 VIII 1994 (2 coll.) and 17 VIII 1994, M. Lange. Disko, Qeqertarsuaq, Østerlien, 69° 15' N, 53° 33' W, 14 VIII 1967, M. Lange (2 coll.) and 19 VIII 1971, P.M. Petersen. Disko, Qeqertarsuaq, 69° 17' N, 53° 27' W, 13 VIII 1967, M. Lange and 1971, P.M. Petersen. Disko, Qeqertarsuaq, Lyngmarksfjeld, 69° 15' N, 53° 33' W, 8 VIII 1970 and 16 VIII 1970 (2 coll.) and 23 VIII 1971, P.M. Petersen. Disko, Qeqertarsuaq, Skarvefjeld, 69° 17' N, 53° 27' W, 17 VIII 1967, Morten Lange. Mestersvig, Blydal, 72° 11' N, 24° 08' W, 13 VII 1975, M. Lange. Mestersvig, Noret, 72° 13' N, 23° 53' W, 12 VII 1975, M. Lange. Ella Ø, Lemmingbugten, 72° 52' N, 24° 55' W, 14 VII 1975, M.

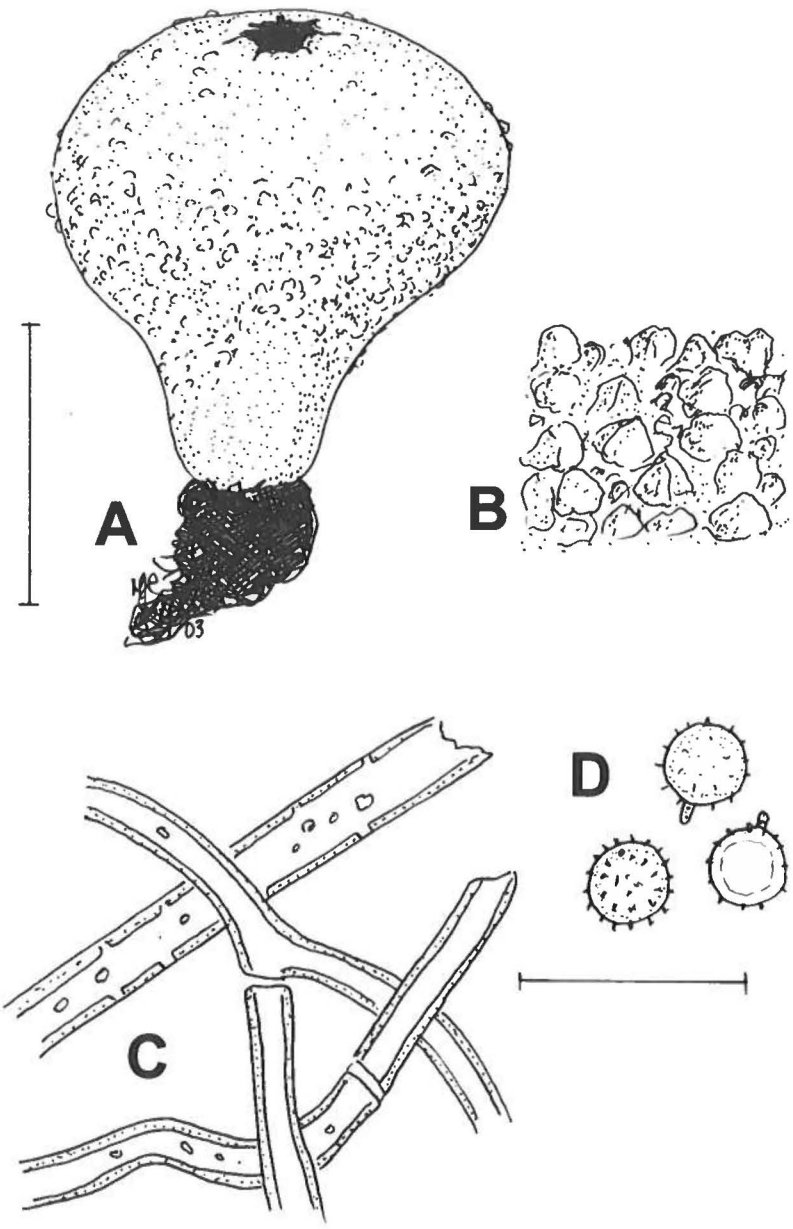


Fig. 4. *Lycoperdon lividum*. Greenland, Sdr. Strømfjord, St. Saltsø, 8 VIII 1986, leg. T. Borgen 86-160. A. Fruitbody. B. Close up of exoperidium. C. Capillitium. D. Spores. Scale bars 10 mm and 10 µm.

Lange (2 coll.). Zackenberg, 74° 31' N, 20° 20' W, 16 VIII 1999, T. Borgen.

Svalbard: Adventsdal, 04 VIII 1989, M. Lange. Hotelnes, 11 VIII 1982, 13 VIII 1982 and 18 VIII 1982 (2 collections), M. Lange. Kongsfjord, Ny Ålesund, 14 VIII 1988, M. Lange. Longyearbyen, Haugen, 03 VIII 1989, M. Lange.

Lycoperdon lambinonii Demoulin 1972

Figs 4, 13 B.

Lycoperdon lambinonii belongs to the complex around *L. molle*. It is distinguished microscopically by the fairly thickwalled, subelastic-elastic capillitium with few small pores and rare septa. Its spores are smaller (usually c. 3 µm in diameter) than those of the other members in the *L. molle*-group and their ornamentation is usually intermediate between *L. molle* and *L. umbrinum*. Macroscopically *L. lambinonii* is characterized by a persistent exoperidium consisting of a dense cover of small, brownish spines which sometimes (which is the case in one of the Greenland collections) can be reduced to warts or granulae. One Greenland

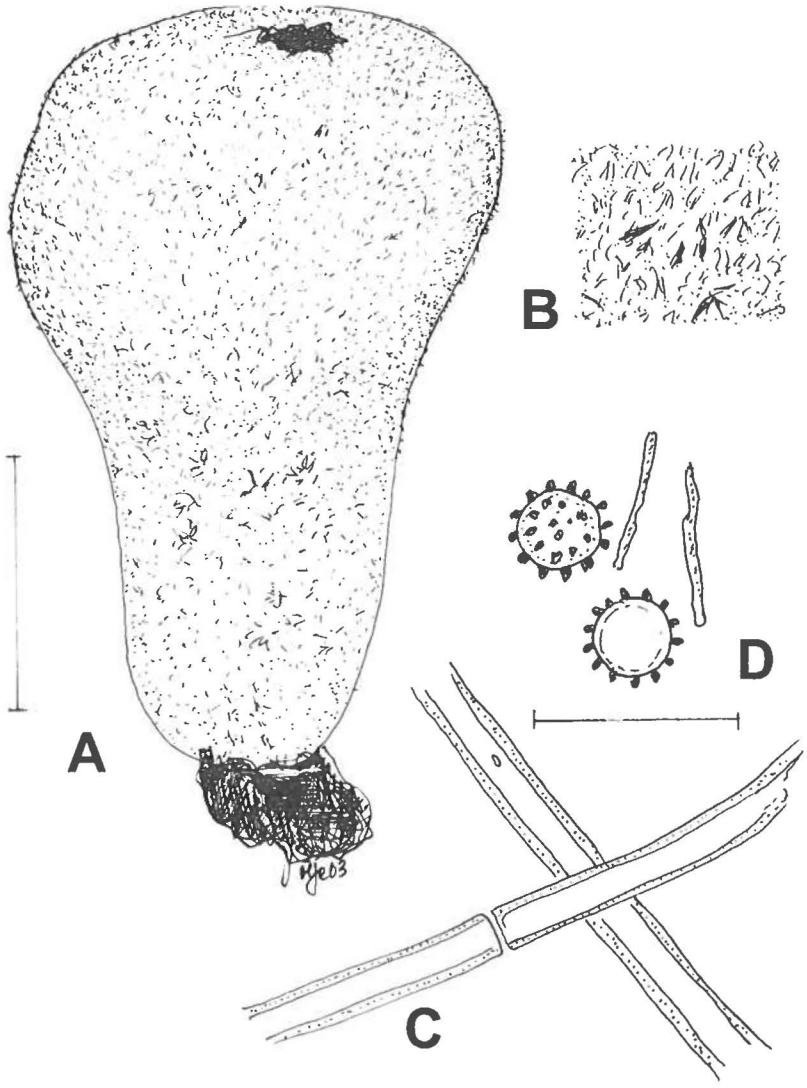


Fig. 5. *Lycoperdon molle*. Greenland, Qinqua-valley at Tasersuaq lake, 27 VII-23 VIII 1983, leg. H. Knudsen, T. Borgen, J. H. Pedersen 527. A. Fruitbody. B. Close up of exoperidium. C. Capillitium. D. Spores. Scale bars 10 mm and 10 µm.

sample (from the West) is somewhat doubtful since the spores are slightly larger than would be expected.

L. lambinonii has a wide distribution being on record from Siberia, the Himalayas, Europe (from the Mediterranean area all the way up in the subalpine vegetation in Northern Fennoscandia and Iceland) and areas with boreal and oceanic influences in the Pacific NW of the USA (cfr. Demoulin 1972). In Fennoscandia it shows a concentration of findings in the boreal-subalpine vegatation zones.

Bearing in mind the fact that there are only two collections of *L. lambinonii* in the extensive material at my disposal it probably is a rare species in Greenland, as it seems restricted to the S and SW. Unfortunately there are no ecological data on the herbarium labels.

There were no previous records of *L. lambinonii* in Greenland, and it was not found among the samples from Svalbard.

Material examined

Greenland: Narsarsuaq, 61° 10' N, 45° 25' W, 15 VIII 1971, P.M. Petersen. Qeqertarsuaq, Lyngmarksbugten, 69° 15' N, 53° 33' W, 16 VIII 1967, M. Lange.

Lycoperdon lividum Pers. 1809

Figs 5, 13 C.

Syn. *L. spadiceum* Pers. 1809

The Greenland samples of *L. lividum* agree well with the general concept of this species. Mature fruitbodies were described by Lange (1948).

L. lividum was first reported from dry and steppe-like situations in the Søndre Strømfjord area (SW

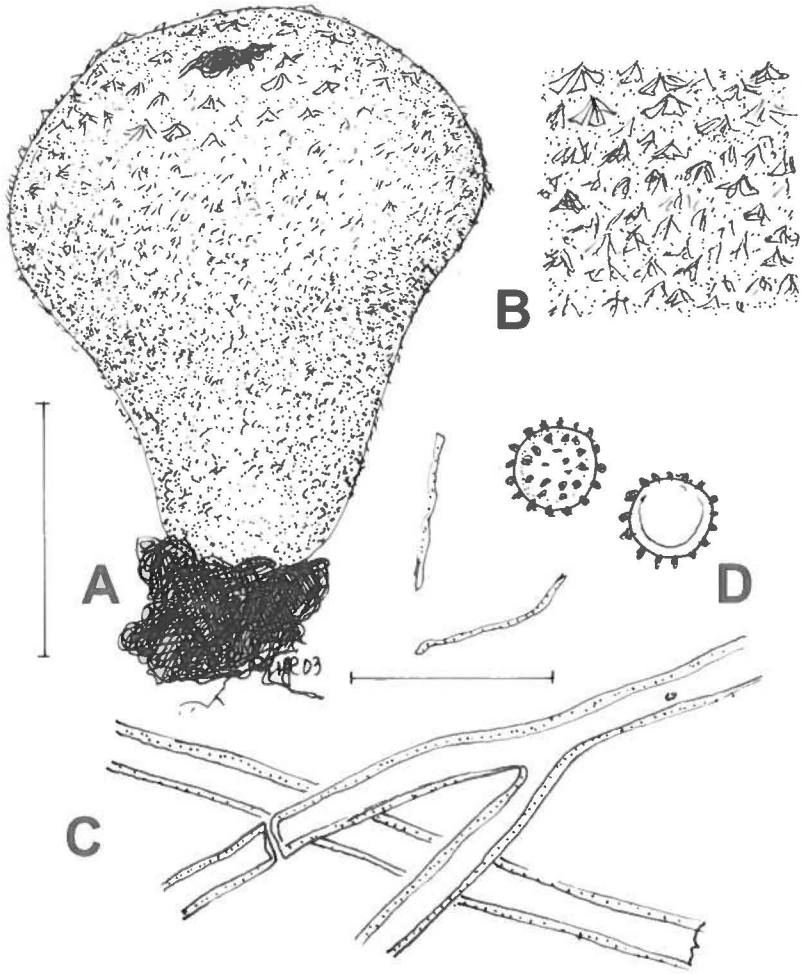


Fig. 6. *Lycoperdon molle*. Svalbard, Adventsdal, 4 VIII 1989, leg. M. Lange 89-38. A. Fruitbody. B. Close up of exoperidium. C. Capillitium. D. Spores. Scale bars 10 mm and 10 µm.

Greenland) by Lange (l.c.). It has since been found also in the north-east of Greenland.

There are additional northern records from dry areas in NE Iceland (Jeppson 1988) and northernmost Norway (Eckblad 1971, Matthiassen and Granmo 1995). The general distribution of *L. lividum* is Eurasian with only a few records in semi-arid regions of western North America. In Europe it is a widely distributed calciphilous species preferring exposed habitats like dry grasslands in continental calcareous areas as well as calcareous sands in coastal regions. The Greenland habitats were characterized by dry heathland with *Dryas*, dry to somewhat humid *Kobresia*-vegetation as well as a mossy snowbed with *Luzula confusa* and *Potentilla hyparctica*. It reaches a maximum Greenland altitude of 700 m on the top of Mt. Nakajanga in Sdr. Strømfjord. It was not met with among the samples from Svalbard.

Material examined

Greenland: Kangerlussuaq, 67° 01' N, 50° 43' W, 22 VIII 1946 and 23 VIII 1994 (2 coll.), M. Lange. Kangerlussuaq, on top of Nakajanga, 66° 54' N, 50° 57' W, 20 VIII 1946 and 10 IX 1946, M. Lange. Kangerlussuaq, near Store Saltsø, 66° 59' N, 50° 36' W, 8 VIII 1986, T. Borgen. Germania Land, Trekroner, 77° 03' N, 20° 08' W, 15 VII 1989, B. Fredskild.

Lycoperdon molle Pers. sensu lato 1801

Figs 6, 7, 8, 12 B, 13 D.

Lycoperdon molle is a species with a world wide distribution. Its ability to adapt to a number of rather different edaphical and climatical conditions seems to have led to a considerable polymorphism. *L. molle* in a wide sense appears to be the most frequent Arctic puffball, and with the exclusion of, as it seems, reasonably clearly defined taxa like *L. frigidum*, *L. lambinonii* and *L. niveum*, it still retains its polymorphous nature.

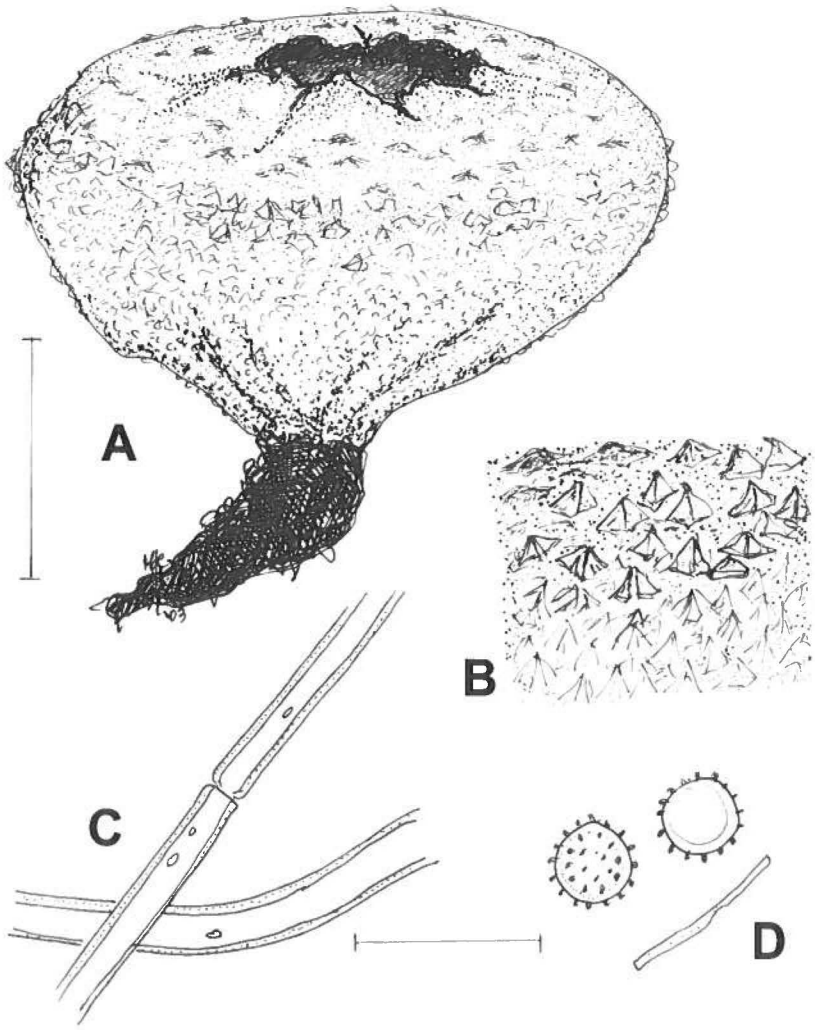


Fig. 7. *Lycoperdon molle*. Greenland, Zackenberg, 25 VIII 1999, leg. T. Borgen 99-437. A. Fruitbody. B. Close up of exoperidium. C. Capillitium. D. Spores. Scale bars 10 mm and 10 µm.

With experience from the variability in the European populations of *L. molle* it seems wise to adopt a wide species concept in the Greenland-Svalbard analysis. Among the samples studied there are specimens from sheltered situations closely reminding of the current European lowland forms but there are also (and more frequent) specimens with small subglobose fruitbodies with stout white connivent spines on a brownish-greyish endoperidium reminding of both *L. frigidum* and *L. niveum*. These forms are macroscopically quite unlike lowland samples but in the material at hand transitional forms seem to be abundant.

In East Greenland there are samples representing extreme forms (cfr. below), which for the moment are kept within a broad concept of *L. molle*.

In total *L. molle* is abundantly represented among the Greenland and Svalbard samples. It was previously recorded from Greenland as *L. umbrinum* by Lange (1948). From Svalbard there was an earlier record published by Ohenoja (1971).

Description based on Greenland and Svalbard samples

Macroscopical aspect: Fruitbodies subglobose-pyriform, 1-3 cm in diameter. Young fruitbodies white. In typical Arctic forms (Fig. 6) the mature specimens have pale, whitish-brownish small but rather coarse and persistent exoperidial spines, towards the summit simple or (mostly) connivent. Downwards the spines become smaller and are often intermixed with warts and granulae of the same colour. The endoperidium is rather thin and papery, olivaceous to greyish, usually more or less exposed in the upper part of the fruitbody due to extreme weathering. Some samples from sheltered situations coincide closely with European lowland forms (Fig. 5) a well developed subgleba, short,

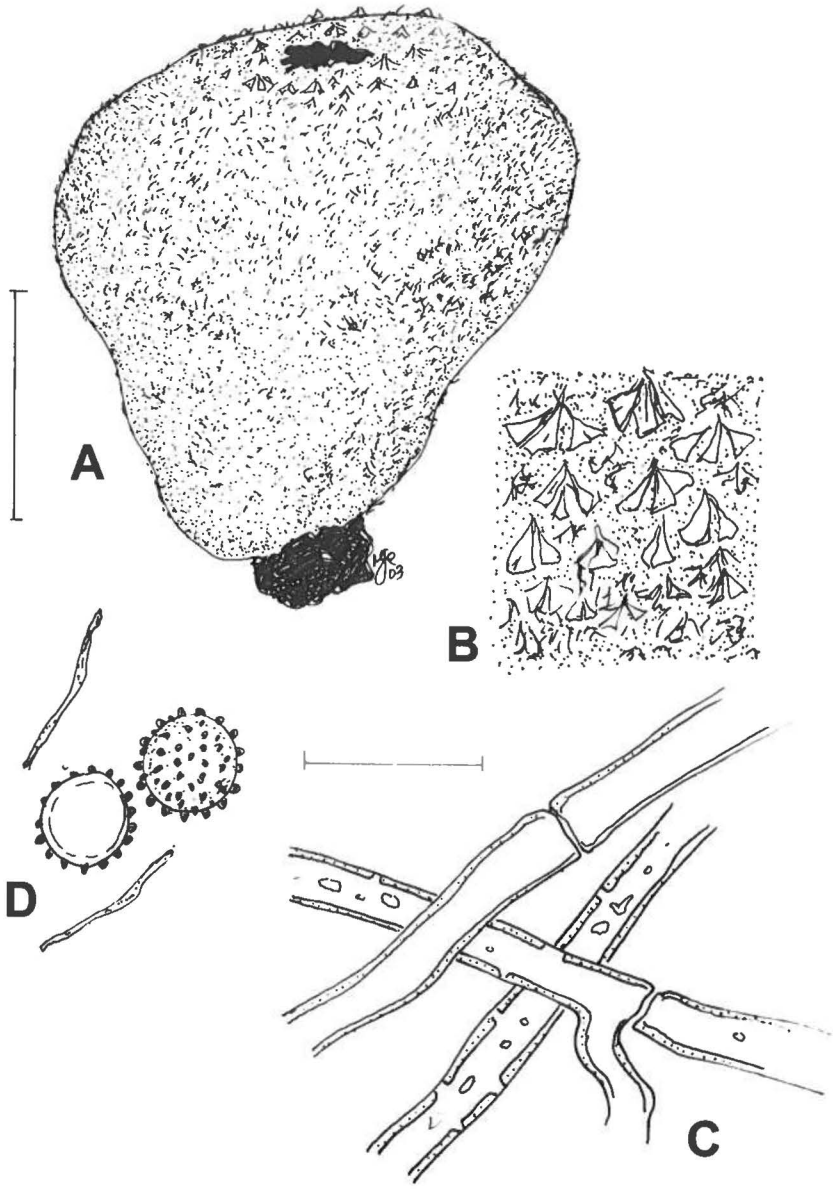


Fig. 8. *Lycoperdon niveum*. Greenland, Ammassalik, Præstefjeld, 10 IX 1990. leg. M. Lange. A. Fruitbody. B. Close up of exoperidium. C. Capillitium. D. Spores. Scale bars 10 mm and 10 µm.

rather fragile, slender spines, some connected in groups, some single, mixed with granulae, over the whole surface of the fruitbody. In those cases the exoperidium is usually quite persistent and only small portions of the endoperidium becomes exposed. The mature gleba is always dark brown, sometimes with violaceous tinges.

Microscopical aspect:The capillitium is subelastic-elastic, occasionally fragile. The capillitial threads have medium to thick walls with only occasional septa and rare pores. Sometimes thinwalled hyphae with numerous pores are seen. In some typically Arctic forms the septa seem to be more numerous. Spores sphaerical, 4.0-4.5 (-5.0) µm, distinctly, and in typical cases, rather sparsely warted (C). Debris of broken sterigmata is numerous and usually well preserved.

Discussion

From East Greenland there are at least two forms, which deviate substantially but for the moment they are maintained within a broad concept of *L. molle*. One of them is represented by a number of samples (e.g. H. Knudsen, S. A. Elborne and. J. H. Pedersen 65, 66, T. Borgen 99-377a, 99-398, 99-407 and 99-437) collected in Jameson Land and Zackenberg (Fig. 8). This form is characterized by somewhat *Calvatia*-like fruitbodies, a rather persistent exoperidium consisting of whitish-

brownish stout spines connected in groups and a thickwalled, subelastic capillitium, the spores are however very similar to those of typical *L. molle* and are mixed with abundant sterigmal debris. The other form, also from Zackenberg, is represented by only one collection, T. Borgen 99-421. Its macroscopical aspect is that of *L. niveum* or *L. molle*. The capillitium is distinctly elastic, in some parts showing intermediate tendencies towards the genus *Bovista* (dichotomous branching, tapering ends) with rare pores and only occasional septa. The spores are large (average 5 µm) and mixed with abundant sterigmal debris. The microscopical characters agree rather well with the holotype of *L. altimontanum* Kreisel, described from Nepal, whereas the macroscopical features of the exoperidium differ (coarser and less regular spines).

Material examined

Greenland: Qinqua Valley at Tasersuaq Lake, 60° 16' N, 44° 33' W, 20 VIII 1983, H. Knudsen. Qaqortoq, Uunartoq, 60° 30' N, 45° 20' W, 4 IX 1970, N. Jacobsen. Narsaq, Kvanefjeldet, 60° 54' N, 46° 04' W, 11 XI 1995, M. Lange. Qassiarsuk, 61° 09' N, 45° 33' W, 29 VIII 1995, M. Lange. Paamiut, 62° 00' N, 49° 40' W, 30 VIII 1978, T. Borgen. Paamiut, head of Eqaluit, 62° 03' N, 49° 25' W, 15 VIII 1998, T. Borgen. Ammassalik, 65° 36' N, 37° 37' W, 6 IX 1990, M. Lange. Ammassalik, Præstefjeld, 65° 36' N, 37° 37' W, 10 IX 1990, M. Lange. Kangerlussuaq, 67° 01' N, 50° 43' W, 28 VII 1946 and 23 VIII 1994 (2 coll.), M. Lange. Kangerlussuaq, Sandflugtsdalen, 67° 03' N, 50° 23' W, 21 VIII 1987, H. Knudsen. Ilulissat, 69° 13' N, 51° 07' W, 17 VIII 1994, M. Lange. Disko, Qeqertarsuaq, Lyngmarksbugten, 6915' N, 5333' W, 16 VIII 1967, M. Lange. Disko, Qeqertarsuaq, Skarvefjeld, 69° 17' N, 53° 27' W, 17 VIII 1967, L. Lange. Jameson Land, Primulaelv, N-side of delta, 70° 45' N, 22° 41' W, 21 VII 1989 (3 coll.), H. Knudsen. Jameson Land, basecamp at mouth of Gåseelv valley, 70° 46' N, 22° 42' W, 4 VIII 1989 (2 coll.), H. Knudsen. Jameson Land, coast SE of Nathorsts Fjeld, 70° 47' N, 22° 38' W, 20 VII 1989 (2 coll.), S. A. Elborne. Jameson Land, copses on slope at head of Gåseelv valley, 70° 48' N, 22° 05' W, 1 VIII 1989, J. H. Petersen. Jameson Land, copse and grassland, N of Gåseelv, between 3. and 4. sideriver, 70° 48' N, 22° 54' W, 1 VIII 1989, J. H. Petersen.

Jameson Land, camp at "Vindelv", river WNW of pt. 330, 71° 00' N, 23° 28' W, 28 VII 1989 (2 coll.), H. Knudsen. Jameson Land, Draba sibirica Elv, 71° 02' N, 24° 00' W, 23 VII 1982, D. Boertmann. Mestersvig, Noret, 72° 13' N, 23° 53' W, 12 VII 1975 (2 coll.), M. Lange. Mestersvig, W of Nyhavn, 72° 15' N, 23° 55' W, 8 VIII 1983, H. Dissing. Zackenberg, 74° 31' N, 20° 20' W, 11 VIII 1999 and 14 VIII 1999 and 19 VIII 1999 (2 coll.) and 21 VIII 1999 (3 coll.) and 23 VIII 1999 (3 coll.) and 25 VIII 1999, T. Borgen. Qaanaaq, 77° 28' N, 69° 14' W, 7 VIII 1987, H. Dissing. Nr. Mellemland, 78° 30' N, 21° 08' W, 31 VII 1990, B. Fredskild.

Svalbard: Adventsdal, 18 VIII 1988, (2 coll.), and 4 VIII 1989 (3 coll), M. Lange. Björnedal 16 VIII 1988, M. Lange. Boltesdal, 17 VIII 1982, M. Lange. Endalen, 27 VII 1989, M. Lange. Hotelnes 1982 and 29 VII 1981, M. Lange. Sassenfjord, 17 VII 1981, M. Lange.

L. nigrescens (Pers. 1797) Lloyd 1905

Syn.: *L. foetidum* Bonord. 1851

Fig. 13 E.

The Greenland material of this species is typical in all respects. Its habitats in Greenland include gravelly soil along pathways, dwarfscrub heaths and grazed areas. It is on record from S and SW Greenland. In N America and Europe it is a species with oceanic tendencies common in coniferous forests as well as in open heathland and grassy pastures under somewhat acidic conditions. There is a number of records from northern stations in the Norwegian Finnmark, northern Finland, Swedish Lapland and northern Canada (Bowerman and Groves 1962, Eckblad 1971, Fries 1914, Kallio and Kankainen 1964, 1966). Lange (1996) reported it from northern Siberia (Polar Urals and Yamal Peninsula) in mixed *Betula* stands as well as in mountains and tundra localities. It is not on record from Iceland.

L. nigrescens was previously reported from Greenland by Lange (1948). It was not found among the samples from Svalbard.

Material examined

Greenland: Tasiusaq, 60° 12' N, 44° 49' W, 11 XI 1900, C. Kruuse. Narsarsuaq, 61° 10' N, 45° 25' W, 12 VIII 1971 (2 coll.), P.M. Petersen. Narsarsuaq, 61° 10' N, 45° 25' W, 1 VIII 1983 and 9 VIII 1983, H. Knudsen. Paamiut, 62° 00' N, 49° 40' W, 7 IX 1978 and 20 IX 1978, T. Borgen. Umanap Sullua, Qorqut, 64° 16' N, 50° 54' W, 13 VIII 1987, H. Knudsen. Umanap Sullua, Qorqut, 64° 16' N, 50° 54' W, 13 VIII 1987, T. Borgen.

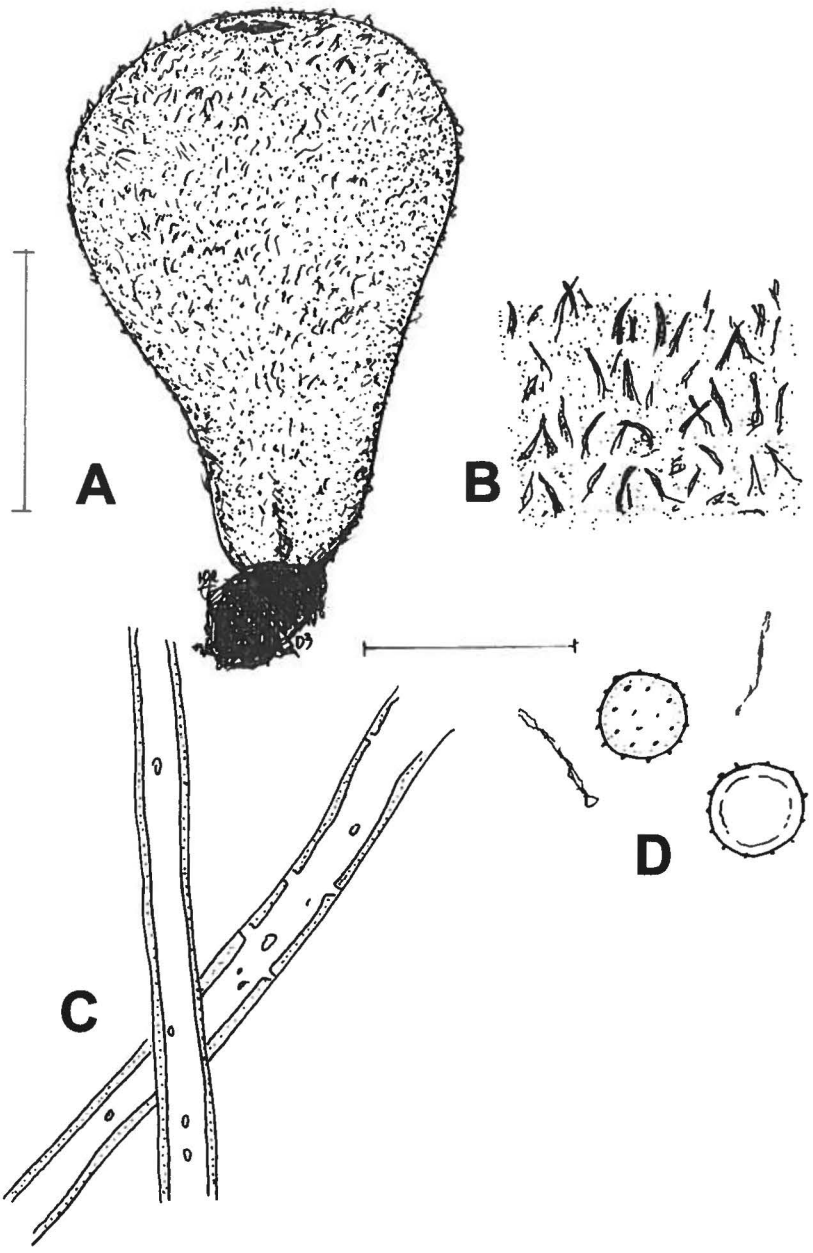


Fig. 9. *Lycoperdon umbrinum*. Greenland, N. of Serfarsuit, 7 VIII 1972, leg. P. M. Petersen. A. Fruit-body. B. Close up of exoperidium. C. Capillitium. D. Spores. Scale bars 10 mm and 10 µm.

Lycoperdon niveum Kreisel 1969

Figs 9, 10, 12 C, 13 F.

L. niveum is a variable species related to the widespread *L. molle*. It shows also certain affinities with the lowland *L. ericaeum* having the fragile, much septate and abundantly perforated capillitium in common, characters on which it can also be separated from *L. molle* and the arctic-alpine *L. frigidum* Demoulin (cfr below). *L. niveum* was originally described from high altitudes in the Himalayas (Kreisel 1969, 1976) and was later reported from arctic-alpine sites in Iceland (Demoulin 1971a, Hallgrímsson 1993) and Svalbard (Ohenoja 1971). The Svalbard material was later revised and regarded as doubtful by Gulden and Torkelsen (1996). Also the record from Finland (Hansen and Knudsen 1997) is dubious.

It has proved to be a frequent species in the drier, northeastern parts of Iceland (Jeppson unpublished) and its appearance among the Greenland samples was awaited. It seems to be a widely distributed species in Greenland with records from subarctic, low arctic, middle arctic and high arctic stations. Its presence in Svalbard could also be established. It seems likely that we are dealing with a circumpolar species whose oc-

Fig. 10. *Lycoperdon frigidum*. Greenland, Sdr. Strømfjord, 23 VIII 1994, leg M. Lange 23-94. Photo M. Lange.

currence in N America and Siberia has yet to be demonstrated.

Description based on Greenland and Svalbard samples

Macroscopical aspect: Fruitbodies subglobose to pyriform, 1-3 cm in diameter. Exoperidium in young fruitbodies whitish, consisting of connivent spines, at least towards the apex connected in groups. At maturity the exoperidial spines are in typical cases yellowish white, rather stout, connivent, at the apex sparsely distributed over an olivaceous-greyish, shining endoperidium. Towards the base the spines are denser, smaller, brownish and less organized. The apical pore is often rather wide. In sections the mature gleba is olivaceous-brownish to dark brown.

Microscopical aspect: Capillitium fragile, 3-5 µm in diametre, slightly to moderately ramified, in typical cases abundantly septate. Capillitial walls thin to medium, provided with numerous rounded to irregular pores. Spores sphaerical, densely, but not very coarsely warted (B-)C, (4.0-)4.5-5.0(-5.5) µm in diametre. Little to abundant debris of broken sterigmata, rather well preserved.

Discussion

Although the spores seem to be somewhat bigger and more ornamented, the Greenland and Svalbard samples agree with the holotype of *L. niveum*. Due to the variability in exoperidial structures much emphasis must be put on microcharacters, which on the other hand tend to be fairly constant.

The differentiating characters towards *L. ericaeum* Bonord. (which is so far not on record from arctic-alpine sites) is to be found in the somewhat larger spores, the presence of sterigmal debris and, macroscopically, in the groups of whitish stout spines dispersed over an exposed, shining endoperidium. Towards some forms of *L. molle* (with which it sometimes shares its stout exoperidial spines) it is characterized by the somewhat larger spores, the fragile capillitium with an abundance of pores and septa. The arctic-alpine *L. frigidum* can be separated by having an ela-

stic capillitium with few and small pores along with a more persistent exoperidium containing smaller spines and granules.

Material examined

Greenland: Narsaq, Kvanefjeldet, 60° 58' N, 45° 59' W, 1995, M. Lange. Qassiarsuk, 61° 09' N, 45° 33' W, 29 VIII 1995 (2 coll.), M. Lange. Kangilinnguit, Grønnedal-hut, 61° 14' N, 48° 05' W, 15 VIII 1985 (2 coll.) and 15 VIII 1991, T. Borgen. Ammassalik, Præstefjeld, 65° 36' N, 37° 37' W, 10 IX 1990, M. Lange. Kangerlussuaq, 67° 02' N, 50° 42' W, 20 VIII 1987, H. Knudsen. Ilulissat, 69° 13' N, 51° 07' W, 16 VIII 1994, M. Lange. Disko, Qeqertarsuaq, at the station, 69° 15' N, 53° 33' W, 1967, M. Lange. Jameson Land, Constable Pynt, 70° 45' N, 22° 37' W, 22 VII 1989, H. Knudsen. Jameson Land, basecamp at mouth of Gåseelv Valley, 70° 46' N, 22° 42' W, 2 VIII 1989 and 4 VIII 1989, H. Knudsen, S.A. Elborne and J.H. Petersen. Zackenberg, 74° 31' N, 20° 20' W, 30 VII 1999 and 21 VIII 1999 and 23 VIII 1999, T. Borgen. Danmarkshavn between Hvalrosodden and Mørkefjord, 76° 46' N, 18° 46' W, 11 VI 1984, B. Lauritzen. Qaanaaq, Kap Ackland, Inersussat, 77° 28' N, 69° 10' W, 8 VIII 1988, S. A. Elborne. Thule Air Base, S side of Akinarsuk, 77° 33' N, 68° 48' W, 1988, S. A. Elborne.

Svalbard: Adventsdal, 18 VIII 1988 and 28 VIII 1988, M. Lange. Hotelnes, 13 VII 1982 and 28 VII 1989 (2 coll.), M. Lange. Endal, 31 VII 1989, M. Lange. Bjørnedal, 16 VIII 1988, T. Borgen.

L. norvegicum Demoulin 1971

Fig. 13 G.

The Greenland collection originates from a sheep-grazed meadow in the subarctic area in the south. It coincides morphologically with the general concept of this species which was recently described by Demoulin (1971b). According to its author *L. norvegicum* is a species with a boreo-continental distribution in Europe and N America. In Fennoscandia there are several northerly stations (e.g. Finland: Kuusamo-area, Sweden: Haparanda, Norway: Troms). In the mountainous regions of south central Norway (Jotunheimen-Dovre-area) there are records from subalpine pastures and sandy pine forests (Demoulin 1971b, Gaarder and Jordal 1996, Matthiassen and Granmo 1995, herb. Jeppson). It is not a strictly northern or Arctic species since there is a number of additional records from lowland areas in central Europe (Czechia, Slovakia, Poland) (Demoulin l.c.) In N America it is on record from Manitoba (Canada), and from the east central regions of the USA. It was not met with among the samples from Svalbard.

Material examined

Greenland: Qinqua-valley at Tasersuaq Lake, 60° 16' N, 44° 33' W, 10 VIII 1983, H. Knudsen, T. Borgen and J.H. Petersen.

Lycoperdon perlatum Pers. 1801

Fig. 13 H.

All Greenland collections of *L. perlatum* originate from the subarctic area in the south. The specimens, typical in all respects, were collected on stony, gravelly soil as well as in grasslands. *L. perlatum* has a world wide distribution but is generally a species of forests. Although being one of the more common species in N. America and Europe it seems not to be on record from arctic-alpine sites. Records from Iceland originate from subalpine birch woods as well as from subalpine heath communities (Hallgrímsson 1993). There are a number of records from northern stations in the Norwegian Finnmark (Eckblad 1971), northern Canada (Bowerman and Groves 1962) and Alaska (Eckblad 1971).

L. perlatum was previously recorded from Greenland by Borgen (1993). It was not found among the samples from Svalbard.

Material examined

Greenland: Narsarsuaq, valley between Tunulliarfik (Erik Fjord) and Nordre Sermilik Fjord, 61° 10' N, 45° 25' W, 22 VIII 1981, T. Læssøe. Narsarsuaq, 61° 10' N, 45° 25' W, 15 VIII 1971, P.M. Petersen. Narsarsuaq, 61° 10' N, 45° 25' W, 10 VIII 1983 and 15 VIII 1983 and 20 VIII 1983, H. Knudsen, T. Borgen and J.H. Petersen. Narsarsuaq, 61° 10' N, 45° 25' W, 10 VIII 1984, H. Knudsen and T. Læssøe. Narsarsuaq, 61° 10' N, 45° 25' W, 23 VIII 1988, T. Borgen. Narsarsuaq, 61° 10' N, 45° 25' W, 24 VIII 1991, H. Knudsen. Narsarsuaq, 61° 10' N, 45° 25' W, 26 VIII 1995 and 27 VIII 1995, M. Lange.

Lycoperdon pyriforme Schaeff. 1774

Fig. 13 I.

The material of *Lycoperdon pyriforme* is morphologically typical in all respects. In Greenland it seems to have a southern distribution restricted to the subarctic

Fig. 11. *Lycoperdon niveum*. Svalbard, Adventsdal, 4 VIII 1989, leg. M. Lange 34-89. Photo M. Lange.

area. It is a widespread species in Europe and North America frequently seen in wooded nemoral, boreal and subalpine stations. It is a lignicolous species but in subalpine stations of northern Fennoscandia and Iceland it is often met with in open situations, growing on roots or buried wood. There were previous records of *L. pyriforme* from Greenland by Borgen (1993) and Elborne and Knudsen (1990). It was not met with in the material from Svalbard.

Material examined

Greenland: Qinqua valley, 60° 16' N, 44° 33' W, 17 VIII 1983, H. Knudsen, T. Borgen and J.H. Petersen. Narsarsuaq, 61° 09' N, 45° 27' W, 6 IX 1970, N. Jacobsen. Narsarsuaq, Qassiarsuk, (Brattahlid), 61° 10' N, 45° 25' W, 13 VIII 1971, P.M. Petersen. Narsarsuaq, 61° 10' N, 45° 25' W, 15 VI 1979 and 2 VII 1982 and 23 VI 1983, T. Borgen. Narsarsuaq, 61° 10' N, 45° 25' W, 20 VIII 1983, H. Knudsen, T. Borgen and J.H. Petersen. Narsarsuaq, 61° 10' N, 45° 25' W, 20 VII 1984, H. Knudsen and T. Læssøe. Narsarsuaq, 61° 10' N, 45° 25' W, 26 VIII 1995 and 28 VIII 1995, M. Lange.

Lycoperdon umbrinum Pers. 1801

Figs 11, 13 J.

L. umbrinum is yet another species related to the widespread *L. molle*. It is distinguished from the other taxa in the group by its weakly ornamented spores (A-B).The capillitium is subelastic and is provided with some (but rarely numerous) pores and few septa. There usually is a total lack of sterigmal debris.The exoperidial ornamentation in lowland samples is typically constructed of slender, dark brown, connivent spines regularly arranged in groups. At maturity the spines fall off completely at the apex exposing a shining, yellowish brown endoperidium. In the Greenland samples the ornamentation deviates somewhat in reminding of the *L. lambinonii*-type of exoperidium with a dense cover of brownish spines. It differs however macroscopically from this species by the fact that the spines show a tendency to drop off apically to expose the endoperidium.

L. umbrinum has a wide distribution in N America and Europe. It shows somewhat oceanic preferences but there are nonetheless records from northern areas

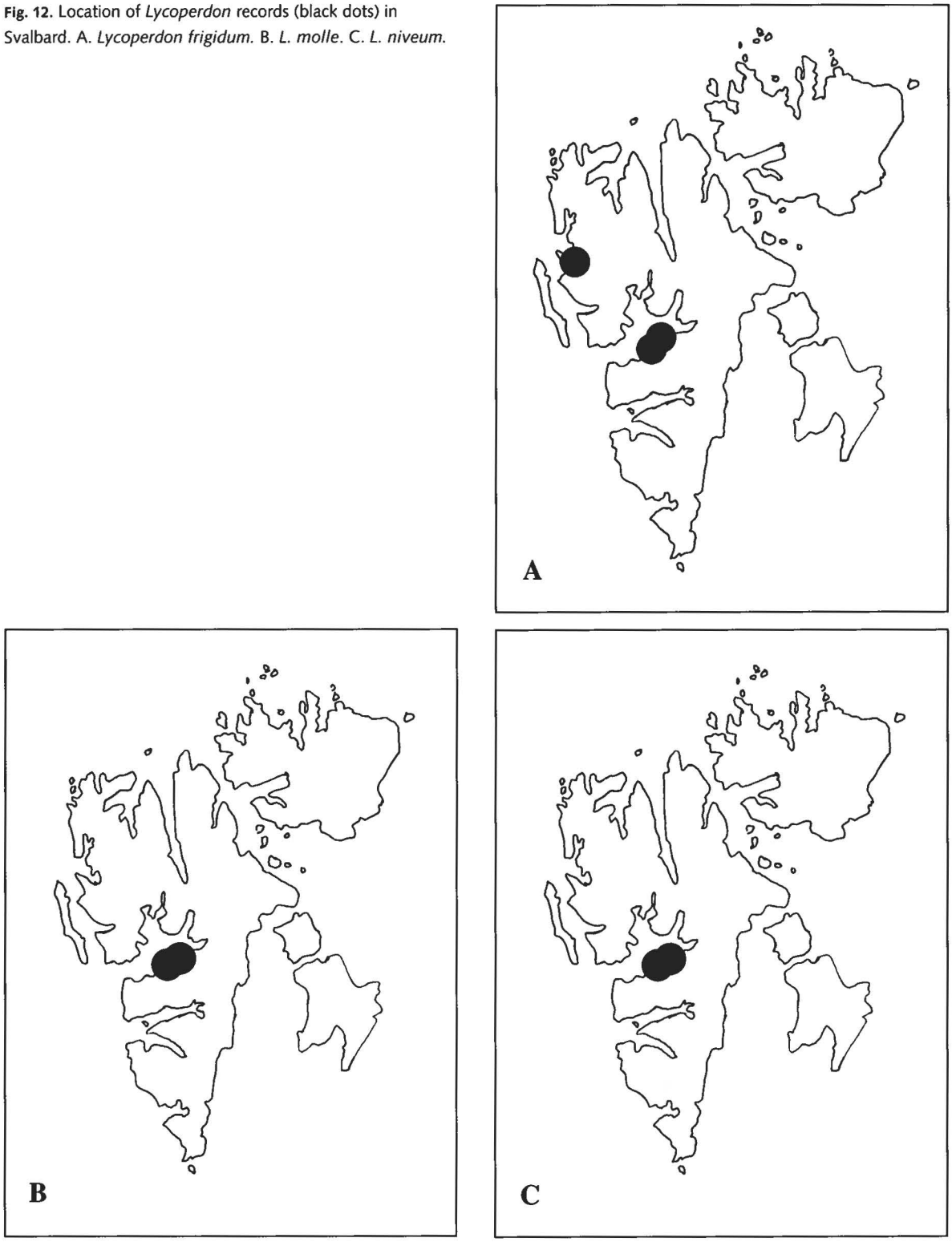
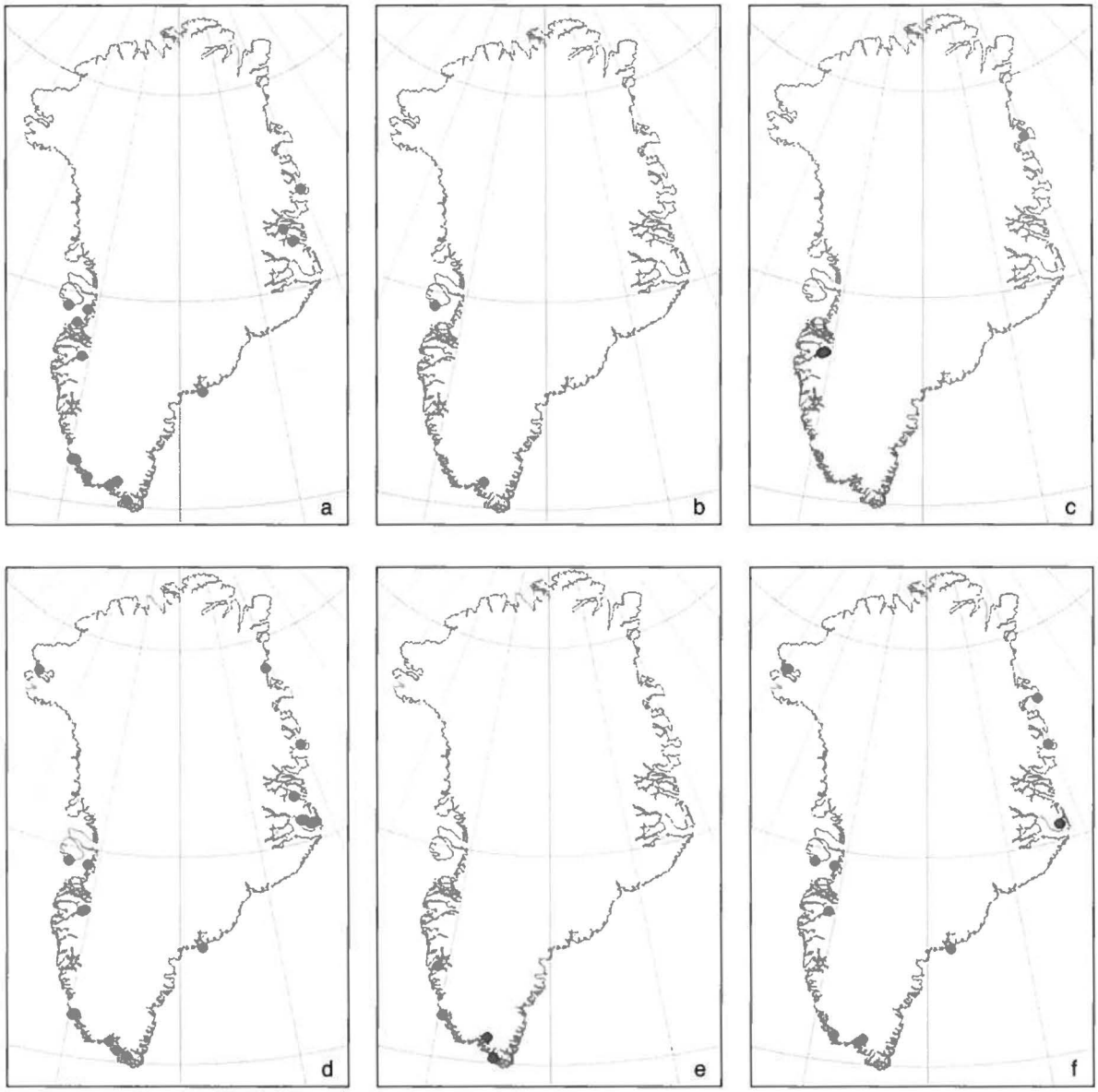


Fig. 12. Location of *Lycoperdon* records (black dots) in Svalbard. A. *Lycoperdon frigidum*. B. *L. molle*. C. *L. niveum*.

such as Swedish and Finnish Lapland and Canada (Demoulin 1971a). There are also recent records from Iceland (Jeppson, unpublished). It is usually a species of forested situations. In Greenland it seems to be restricted to the S and SW and in one of the localities (Qorqut) it was reported to grow in a dense shrub with *Alnus crispa* and *Salix glauca*.

L. umbrinum was previously reported from Green-



land by Lange (1948) but these records refer to other taxa in the *molle*-group a.o.

It was not found among the samples from Svalbard.

Material examined

Greenland: Narsarsuaq, Qassiarsuk (Brattahlid), 6110' N, 4525' W, 13 VIII 1971, P.M. Petersen. Umanap Sullua, Qorqut, 6416' N, 5054' W, 16 VIII 1987, H. Knudsen. Area N of Serfarsuit, 6850' N, 5045' W, 7 VIII 1972, P.M. Petersen.

Conclusions

The genus *Lycoperdon* is represented in Greenland and Svalbard by ten and three taxa respectively. In the area under study the greatest number of species was met with in the southernmost and southwestern parts of Greenland. A majority of these southern species have wide distributions in temperate regions and seem to reach northern outposts in south Greenland. They coincide morphologically with their Eurasian and North American counterparts. A few taxa belonging to

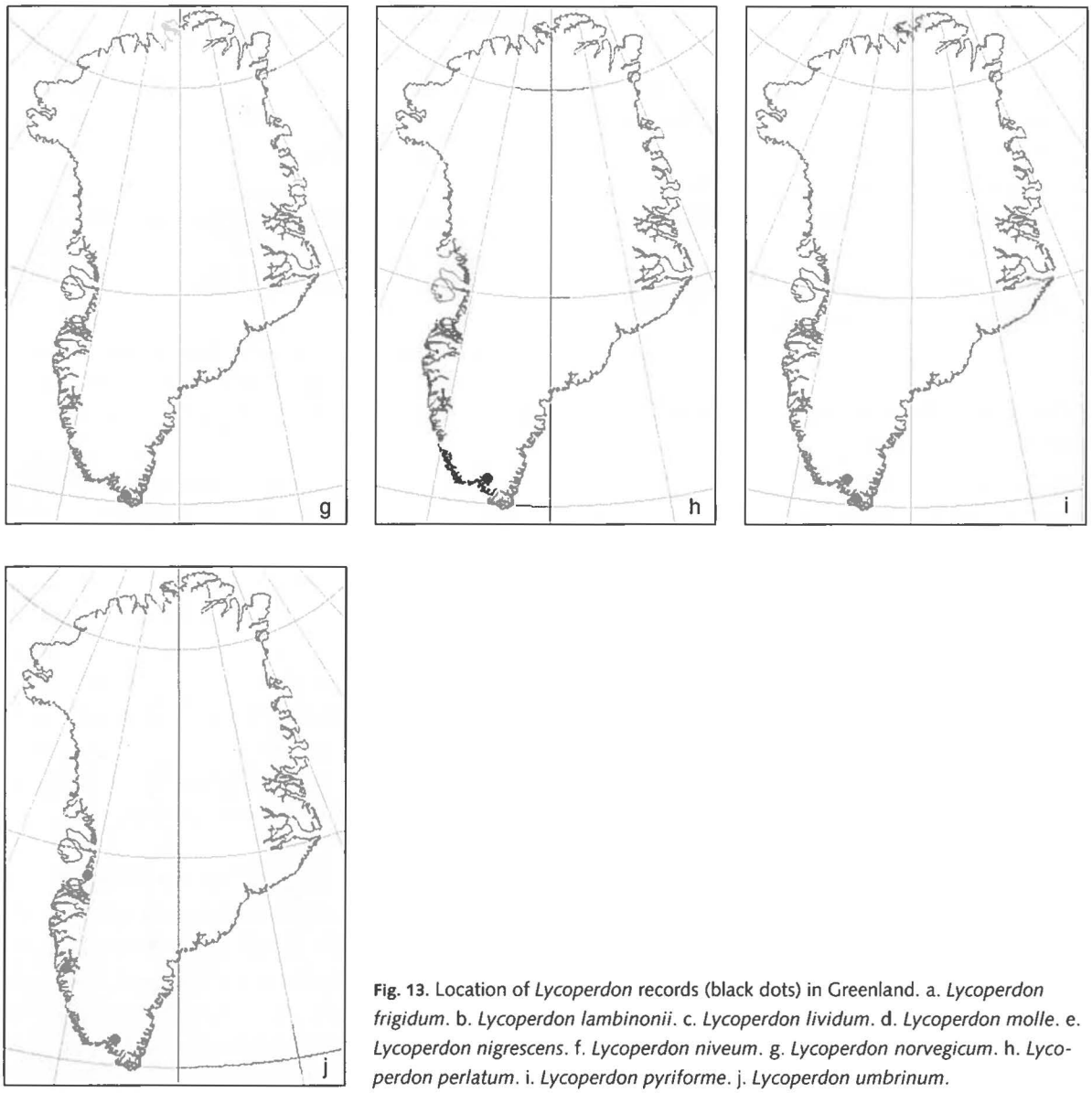


Fig. 13. Location of *Lycoperdon* records (black dots) in Greenland. a. *Lycoperdon frigidum*. b. *Lycoperdon lambinonii*. c. *Lycoperdon lividum*. d. *Lycoperdon molle*. e. *Lycoperdon nigrescens*. f. *Lycoperdon niveum*. g. *Lycoperdon norvegicum*. h. *Lycoperdon perlatum*. i. *Lycoperdon pyriforme*. j. *Lycoperdon umbrinum*.

the complex around the widespread and polymorphous *L. molle* constitute a true arctic-alpine element: *L. frigidum, L. niveum* and some forms of *L. molle* s.l. itself. They occur along with the southern species in the S and SW of Greenland but have wide distributions comprizing most of Greenland as well as Svalbard. They also seem to be widely distributed in Arctic-alpine areas elsewhere. In the complex around *L. molle* s.l. there might still be taxa that could be separated, but awaiting extensive molecular data it would be premature to describe new species in this difficult group.

Distribution patterns in Greenland and Svalbard

The Greenland material originates from subarctic, low arctic and high arctic types of habitats whereas the Svalbard samples are all from high arctic environments.

1. Subarctic species occurring only in the southernmost part of Greenland (no records from Svalbard): *Lycoperdon perlatum, L. pyriforme* and *L. norvegicum*.

2. S-SW (subarctic-low arctic) species in Greenland (no records from Svalbard): *Lycoperdon nigrescens, L. umbrinum* and *L. lambinonii.*
3. Subarctic-low arctic species in Greenland and Svalbard: *Lycoperdon frigidum.*
4. Species with wide distributions in Greenland and Svalbard (subarctic-low arctic-high arctic): *Lycoperdon molle* s.l. and *L. niveum.*
5. Widespread xerophilous species (no records from Svalbard): *Lycoperdon lividum.*

Additional note on *Bovista aestivalis* (Bonord.) Demoulin

One species previously attributed to *Lycoperdon*, viz. *L. pusillum* Batsch reported from Greenland by Lange (1948) has turned out to belong to *Bovista aestivalis* – a widely distributed species in temperate regions, where it shows xero-thermophilous tendencies. The samples reported by Lange originated from Søndre Strømfjord in SW Greenland, from which area there are also records of the gasteromycetes *Lycoperdon lividum* and *Geastrum minimum* (cfr Lange 1948). In the present material there is an additional collection of *B. aestivalis* from Narsarsuaq in the southern, subarctic part of Greenland.

It was not found among the samples from Svalbard. Although rare in northern stations it is on record from subalpine localities in Norway and Iceland (Jeppson 2001).

In the field *B. aestivalis* can easily be mistaken for a *Lycoperdon*. Sectioned fruitbodies, however, reveal a compact subgleba instead of the lacunar structure characteristic of *Lycoperdon.* Microscopically it shows a heterogeneous capillitium: the apical part of the capillitium is of rather fragile *Lycoperdon*-type whereas in the centre it is subelastic-elastic with characters intermediate between *Lycoperdon* and *Bovista.*

B. aestivalis belongs to *Bovista* subgenus *Globaria* whose position in the genus is somewhat uncertain due to the presence of strong lycoperdoid characters. *Lycoperdon pusillum* itself was transferred into *Bovista* subgenus *Globaria* by Kreisel (1962) and later (Moyersoen and Demoulin 1996) divided it into at least two separate taxa in Europe: *B. furfuracea* Pers. and *B. dermoxantha* (Vitt.) De Toni, none of which is on record from the Arctic.

Additional material studied

Bovista aestivalis (Bonord.) Demoulin. **Greenland**: Narsarsuaq, 23 VIII 1988, T. Borgen. Kangerlussuaq 14 VIII 1946 and 23 VIII 1994 (2 coll.), M. Lange.

Lycoperdon altimontanum Kreisel. **Nepal**: Central Nepal, Kyanchin Gomba, 10 IX 1971, J. F. Dobremez, det. H. Kreisel (herb. Kreisel, holotypus)

Lycoperdon asiaticum Kreisel. **Mongolia**: N Mongolia, Zuun Mod Taiga, ca. 1800 m.m., 11 VII 1973, K. Kloss, det. H. Kreisel (herb. Kreisel, holotypus)

Lycoperdon frigidum Demoulin. **Norway**: Hordaland, Ulvik, Blåisen ved Finse, 6 IX 1951, P. Wendelbo, det V. Demoulin (O, herb. Kreisel). Oppland, Lom, V. del av Blåhøi, i Dryas, 30 VIII 1957, F.-E. Eckblad, det V. Demoulin (paratype, herb Kreisel). Lom, Soleggen, 20 VIII 1957, F.-E. Eckblad, det. V. Demoulin (O). Lesja, V. for Tannseter ved Flisevatn, 11 VIII 1960, R. Berg, det V. Demoulin (O). **Iceland:** N Múlasýsla, Skjöldólfsstaðir, 9 VIII 1974, M. Jeppson, det. V. Demoulin (herb. MJ). Eyjafjarðarsýsla, Árskógsstr., Kötlufjall, 27 VIII 1968, H. Hallgrímsson, det. V. Demoulin (ANMH).

Lycoperdon niveum. **Nepal:** Kumbu, Moränen des Lobuche-Gletschers bei Lobuche 4950-5000 m.s.m, IX 1962, J. Poelt, det. H. Kreisel (herb. Kreisel, part of holotypus). Jengla La, pelouse alpine sèche, 5000 m, 6 V 1974, J. F. Dobremez, det. H. Kreisel (herb. Kreisel). Kemi La, pelouse alpine sèche, 5200 m, 14 V 1974, J. F. Dobremez, det. H. Kreisel (herb. Kreisel). **Iceland:** Eyjafjarðarsýsla, Kræklingarhlíð, 10 VIII 1962, H. Hallgrímsson, det. V. Demoulin (AMNH). N. Múlasýsla, Efri Jökuldalur, Eiriksstaðir, 9 VII 1993, M. Jeppson (herb. MJ).

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References

Borgen, T. 1993: *Svampe i Grønland*. – Atuakkiorfik, Nuuk: 112 pp.

Bowerman, C. A. and Groves; J. W. 1962: Notes on fungi from Northern Canada. V. Gasteromycetes. – *Canadian Journal of Botany* 40: 239-254.

Demoulin, V. 1971a: *Le Genre Lycoperdon en Europe et Amérique du Nord*. – Dissertation de l'Université de Liège.

Demoulin, V. 1971b: *Lycoperdon norvegicum* sp. nov. A new gasteromycete with boreo-continental distribution in Europe and North America. – *Norwegian Journal of Botany* 18: 161-167.

Demoulin, V. 1972: Espèces nouvelles ou méconnues du genre *Lycoperdon* (Gastéromycètes). – *Lejeunia nov. sér.* 62: 1-28.

Eckblad, F.-E. 1971: The Gasteromycetes of Finnmark (Northernmost Norway). – *Astarte* 4: 7-21.

Elborne, S. A. and Knudsen, H. 1990: Larger fungi associated with *Betula pubescens* in Greenland. – *Meddelelser om Grønland, Bioscience* 33: 77-80.

Fries, Th. C. 1914: Zur Kenntnis der Gasteromycetenflora in Torne Lappmark. – *Svensk Botanisk Tidskrift* 8(2): 235-243 + pl. 5.

Gaarder, G. and Jordal, J. B. 1996: Botaniske undersøkelser av kulturlandskap i Grimsdalen i Dovre, Dalsida i Lesja, Fryadalen i Nord-Fron, og av barskog i Formolia og Uladalen i Sel, Oppland fylke. – Miljøfaglig utredning, rapport 1996: 3.

Gulden, G. and Torkelsen, A.-E. 1996. Fungi I. Basidiomycota: Agaricales, Gasteromycetales, Aphyllophorales, Exobasidiales, Dacrymycetales and Tremellales. In: Elvebakk, A. and Prestrud, R. (eds): *A catalogue of Svalbard plants, fungi, algae and cyanobacteria*: 173-206. – *Norsk Polarinstitutt Skrifter* 198.

Hallgrímsson, H. 1993: *Íslenskt sveppatal V: Kólfsveppir*. Draft made for the Extra Nordic Mycological Congress in Iceland 1993. – Náttúrufræðistofnun Nordurlands. Akureyri.

Hansen, L. and Knudsen, H. (eds) 1997. *Nordic Macromycetes vol. 3, Heterobasidioid, aphyllophoroid and gastromycetoid basidiomycetes*. – Nordsvamp, Copenhagen: 444 pp.

Jeppson, M. 1988: Nýr físisveppur (*Lycoperdon lividum*) fundinn á Íslandi (Íslenzkir belgsveppir VII). – *Náttúrufræðingurinn* 58: 97-100.

Jeppson, M. 2001: *Bovista aestivalis* (Lycoperdaceae) – a survey of its occurrence in North Europe. – *Windahlia* 24: 49-61.

Kallio, P. and Kankainen, E. 1964: Notes on the macromycetes of Finnish Lapland and adjacent Finnmark. – *Report Kevo Subarctic Research Station* 1: 178-235.

Kallio, P. and Kankainen, E. 1966: Additions to the mycoflora of northernmost Finnish Lapland. – *Report Kevo Subarctic Research Station* 3: 177-210.

Kreisel, H. 1962: Die Lycoperdaceae der DDR. – *Feddes Repertorium* 64: 89-201.

Kreisel, H. 1964: Vorläufige Übersicht der Gattung Bovista Dill. Ex Pers. – *Feddes Repertorium* 69: 196-211.

Kreisel, H. 1967: Taxonomisch-Pflanzengeographische Monographie der Gattung *Bovista*. – *Beiheft Nova Hedwigia* 25.

Kreisel, H. 1969: Gasteromyzeten aus Nepal. – *Khumbu Himal* 6: 25-36.

Kreisel, H. 1976: Gasteromyzeten aus Nepal II. – *Feddes Repertorium* 87: 83-107.

Kreisel H. and Hausknecht, A. 1998: *Lycoperdon frigidum* und *Calvatia arctica*, neu fur Österreich. – *Österreichischer Zeitschrift für Pilzkunde* 7: 129-133.

Lange, M. 1948: The Gasteromycetes of Greenland. – *Meddelelser om Grønland* 147: 1-32.

Lange, M. 1976: Some Gasteromycetes from North East Greenland. – *Kew Bulletin* 31: 635-638.

Lange, M. 1987: Arctic Gasteromycetes. The Genus *Bovista* in Greenland and Svalbard. In: Laursen, G.A., Ammirati, J.F. and Redhead, S.A. (eds): *Arctic and Alpine Mycology* 2: 261-271. – Plenum Press, New York.

Lange, M. 1990: Arctic Gasteromycetes II. *Calvatia* in Greenland, Svalbard and Iceland. – *Nordic Journal of Botany* 9: 525-546.

Lange, M. 1996: Arctic Gasteromycetes III. Additional notes on *Bovista* and *Calvatia* from South Greenland and from Tyumen region, Siberia. In: Mukhin, V. A. and Knudsen, H. (eds): *Arctic and Alpine Mycology* 5: 82-85. – Yekaterinburg Publishers, Yekaterinburg.

Matthiassen, G. and Granmo, A. 1995: *The 11th Nordic Mycological Congress in Skibotn, North Norway 1992*. – Universitetet i Trondheim. Vitenskabsmuseet: 77 pp.

Moyersoen, B and Demoulin, V. 1996: Les Gastéromycètes de Corse: Taxonomie, Écologie, Chorologie. – *Lejeunia* NS 152: 128 pp.

Ohenoja, E. 1971: The larger fungi of Svalbard and their ecology. – *Report Kevo Subarctic Station* 8: 122-147.