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LARGER FUNGI ON SANDY GRASS HEATHS AND SAND DUNES IN SCANDINAVIA

BY

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Contents.

Introduction.

In connection with investigations (1944—50) in the flora and vegetation of sand-fields, sand-hills and sand-dunes in the southern parts of Sweden, I have succeeded in finding a number of larger fungi, previously considered very rare in Sweden. Some of them are new to Sweden.

Several of them belong to the biological group of fungi often classified as s t e p p e f u n g i. These have their centre in the climatically conditioned steppe regions and many of them are only found here, e.g., *Battarea Stevenii*, and several *Secotium*-species. Others occur also within the e x t r a - z o n a l steppe regions, e.g., within certain parts of central and north-western Europe.

Throughout their entire area of distribution these species grow — together with a great quantity of other species not indigenous to Sweden — on more or less sandy, dry habitats devoid of any dominating shrub or tree layer. An adequate classification of fungi confined to such habitats is o b l i g a t e s a n d - f u n g i.

The obligate sand-fungi, however, do not only consist of steppe-species but also of species which never occur in the real steppe-regions. To this group belong, among others, those that occur on the marine sand-dunes skirting the Atlantic, North Sea and Baltic coasts.

The total number of obligate sand-fungi, the greater part of which belongs to the *Gastromycetes* appears to be comparatively small, but it is impossible to give an approximate figure. In Sweden the number of obligate sand-fungi is small, consisting of not more than 15 to 20 species.

In contrast to the obligate sand-fungi are placed the f a c u l t a t i v e s a n d - f u n g i, which appear sporadically on sand-fields and sand-dunes, but especially occur in other types of vegetation, in woods, meadows, etc.

The taxonomy, ecology and distribution of a quantity of sand-fungi have already been dealt with in Scandinavian as well as extra-

Scandinavian literature. But there are few treatises dealing exclusively with sand-fungi.

As our knowledge of the obligate sand-fungi appearing in Scandinavia is especially limited, a review will be given here, based partly on my own field observations and partly on my studies of the relevant literature. The following species will be the subject of a more or less thorough investigation. Some facultative sand-fungi marked with an asterisk will also be dealt with.

Ascomycetes

Corynetes arenarius
*Geoglossum Cookeianum**
Peziza ammophila
*Sepultaria arenicola**

Basidiomycetes

Hymenomycetes

Laccaria trullisata ssp. *maritima*
Inocybe lacera var. *halophila*
— *maritima*
Inocybe serotina
Psilocybe ammophila

Gastromycetes

Phallus Hadriani
Geaster Drummondii
— *fimbriatus**
— *minimus*
— *nanus*
Disciseda Bovista
Disciseda candida
— *pedicellata*
Tulostoma brumale
— *granulosum*
*Lycoperdon pusillum**
*Scleroderma Bovista**

Methods.

Ecological data, referring to sociological and edaphic conditions are given for several species. The plant-communities have been analysed by means of squares 1 m^2 in size. The degree of cover has been rated for all species according to the scale of HULT-SERNANDER-DU RIETZ ($5 = 1—{}^1/_2$, $4 = {}^1/_2—{}^1/_4$, $3 = {}^1/_4—{}^1/_8$, $2 = {}^1/_8—{}^1/_{16}$, $1 = {}^1/_{16}$) (DU RIETZ 1921, p. 225).

In connection with the sociological analyses, soil samples have been taken which after drying in the air have been determined with regard to pH, electric conductivity (indicated as $\varkappa_{20} \cdot 10^6$), content of lime ($CaCO_3$), humus and mechanical composition.

For measurement of the hydrogen ion concentration and electric conductivity a mixture of soil and distilled water (free from carbonic acid) in the proportions 1 : 4 has been shaken for two hours after which it was allowed to stand for 22 hours in the cold. The measurements have been made on an aqueous suspension of soil. The pH-values have been obtained electrometrically. The electric conductivity has been determined with a Wheatstone's bridge and a dipping electrode with the cell capacity = 0.6828. The contents of $CaCO_3$ have been determined volumetrically with a Passon apparatus (cf. PIPER 1950). The mechanical analyses have been performed with a shaking apparatus. For classification the scale of ATTERBERG (1912) has been used.

The spores and capillitium were mounted partly in 10 per cent KOH, partly in a solution of 50 c.c. lactic acid and 50 c.c. water with 0.1 gr. Aniline Blue. The sculptures are included in the spore measure.

Sand-fungi in Scandinavian literature.

As early as in the eighteenth century the first reports are found on sand-fungi in Scandinavia (LINNAEUS 1745, 1753, OSBECK 1762, LILJEBLAD 1796). These data are mainly of floristic and taxonomical interest. OSBECK (l.c.) presented, however, certain practical biological viewpoints concerning »Moving-sand fungus, *Peziza arenaria*» (orig. Swedish) which should be considered as an expression of eighteenth century utilitarianism.

Even if the mycologists of the nineteenth century had especially a taxonomical interest in fungi, certain phytogeographical and biological view-points were introduced in the works by ELIAS FRIES (1818, 1860—63) and by WAHLENBERG (1826). They provided interesting information about the distribution and biology of certain sand-fungi. In the doctor's thesis by E. P. FRIES (1857) on »Notes on the geographical distribution of Fungi» (orig. Swedish) — mainly a work of compilation — the phytogeographical viewpoints dominate, as is shown by the title. Concerning sand-fungi he wrote: ». . . Sand fields are always very poor in species, but the few that do occur there are peculiar to them, e.g. *Inocybe maritima* and *Peziza arenaria*.»

Not until the twentieth century have sand-fungi been the subject of more thorough phytogeographical and ecological studies. In his work on the Danish sand-dunes WARMING (1907—1909) gave the following characteristic of the fungus flora in Denmark's sand-dunes (orig. Danish): »Cap fungi also occur in the open sand bottoms, especially in the damp layers, and where there are deposits of dung of sheep and other animals; but they obviously do not play a very important part; they are almost always small, brown species, scattered in the sand with the stalk sunk down in it and often thickly covered with grains of sand, which are blown over them and can be completely sunk in the fleshy fruit-body. Now and then larger species are found, among them, curiously enough, the stinkhorn, which otherwise belongs to the woods. [Not the wood species *Phallus impudicus*, but the sand species, *P. Hadriani*, note of O. ANDERSSON].

It is probably the humidity of the air, which enables this fungus, as well as certain flowering plants that are discussed at a later stage, to thrive in the sand-dunes. In addition puffballs are found (*Bovista*, *Lycoperdon* and *Scleroderma*).»

WARMING gave also a list of the species occurring in the Danish sand-dunes. Only a small number of these are obligate sand-fungi.

As characteristic of the sand-dunes along the Gulf of Finland THESLEFF (1920) mentioned among others, *Inocybe lacera, maritima*, *Laccaria laccata* and *Deconica* (=*Psilocybe*) *atrorufa*.

TH. C. E. FRIES (1921) gave valuable ecological and phytogeographical data concerning certain sand-fungi in his monograph on the Swedish Gasteromycetes.

The hitherto most important contribution to the knowledge and distribution of ecology of certain Swedish sand-fungi has been made by SANDBERG (1940).

Recently RYDBERG (1949) reported some data concerning the characteristic genus *Disciseda* in Sweden.

Sand-fungi in extra-Scandinavian literature.

A certain amount of information on sand-fungi has been reported from the rest of Europe, Asia, America and Australia. The majority of these papers are to an overwhelming degree of a taxonomical and floristic category, and are often included in more important works.

As typical for the Hungarian puszta HOLLÓS (1904) mentioned the following sand-fungi: *Peziza arenosa* (=*Sepultaria arenicola*), *Peziza ammophila, Tulostoma granulosum, T. valvulatum, Battarea phalloides, Montagnites radiosus, Disciseda debreceniensis* (=*D. Bovista*), *Geaster Drummondii, G. floriformis, Mycenastrum Corium* and *Secotium agaricoides*. HOLLÓS has also found some of these species in the Caucasus.

From the sandy soils surrounding Budapest MOESZ (1942) reported approximately 30 species, of which the following are especially worthy of mention: *Sarcosphaera* (=*Peziza*) *ammophila, Psilocybe ammophila, Tulostoma fimbriatum* (=*granulosum*), *T. mammosum* (=*brumale*), *Disciseda candida* and *D. debreceniensis*.

From Hungary there is also another work by DE UBRISZY (1943) in which certain analyses of the fungus flora in the vegetation types »*Festucetum vaginatae*» and »*Brometum tectorum*» are discussed.

From Latvia, STOLL (1925—26) has given a detailed description of the fungus flora on the drift sands at Langasciem in the neighbourhood of Riga.

Certain sand-fungi of the inland sand-dunes at Eberstadt in Germany have been dealt with by KALLENBACH (1931).

From Poland, TEODOROWICZ (1936) mentioned several obligate sand-fungi and discussed their taxonomy, distribution and ecology.

WHELDON published a list of the species growing on the sand-dunes of Lancashire in England. In »Observations on the biology of some sand-dune Fungi» WAKEFIED (1918) reported her observations concerning several cap fungi, which occur on the sand-dunes of the South Wales coast. WHELDON (1918) completed his list of species with certain biological data in »Observations on the Fungi of the Lancashire and Cheshire dunes.»

The majority, however, of the species mentioned by WAKEFIELD and WHELDON are not obligate sand-fungi but should be assigned to the facultative. The same is true of the majority of the species mentioned by HEIM (1934) from the sand-dunes on the east coast of Spain. From England PEARSON (1943, 1946) has reported many obligate sand-fungi.

Data concerning sand-fungi and their occurrence in Asia have been furnished by SOROKIN (1890), AHMAD (1939) among others, in North Africa by MAIRE (1909), by MAIRE and WERNER (1937), in South Africa by BOTTOMLEY (1948), in the U.S.A. by LLOYD (1902—1919), LONG (1907), LONG and STOUFFER (1948), KAMBLY and LEE (1936), COKER and COUCH (1928), SEAVER (1942), in South America by ROB. E. FRIES (1909), in Australia and N. Zealand by CLELAND (1934—35) and CUNNINGHAM (1925, 1927, 1944).

The species.

Corynetes arenarius (ROSTR.) DUR.

Description. *Fruit-body* 1—4 cm. high, 0.5—2 cm. broad, irregularly club-shaped, more or less compressed. The fertile part constitutes about $^1/_2$ of the entire fruit-body, black. Stem only slightly more slender than the upper part, brownish-black. The base of the stem provided with a club- or bag-shaped formation, consisting of mycelium strands and grains of sand attached. *Fruit-bodies* single or thickly clustered (see Plate I).

Asci 110—160×12—18 μ.

Paraphyses club-shaped, crooked at the top, septate, dark brown.

Spores 8, not or seldom septate, hyaline, straight or somewhat crooked, 25—30—35×4—6(—6.5) μ.

History. This species, which was described by ROSTRUP (1892) from material gathered in Greenland, was reported by him as being new for Denmark in 1892 and for Norway in 1904. *Corynetes arenarius* has also been observed in several localities in Denmark (LIND 1913), Holland (WESTERDIJK en VAN LUYK 1917, VAN LUYK 1919 and others), Norway (IMAI 1940) and in Germany (SCHADE 1939). RAMSBOTTOM (1926) also mentioned it for northern Scotland. NANNFELDT (1942) discussed *Corynetes arenarius* in his monograph on the Geoglossaceae of Sweden, but pointed out that it has not been observed in Sweden, and should, therefore, be searched for here. Three years later the first Swedish find was made, namely in Värmland by GRANQUIST (1950) and in 1945 the present writer found the species in Scania.

Ecology. In Scania (see below) *Corynetes arenarius* occurs on the sheltered side of the high inner sand-dunes, exposed to the north in a sparse vegetation, consisting of *Ammophila arenaria, Empetrum nigrum, Corynephorus canescens, Rhacomitrium canescens, Cladonia*

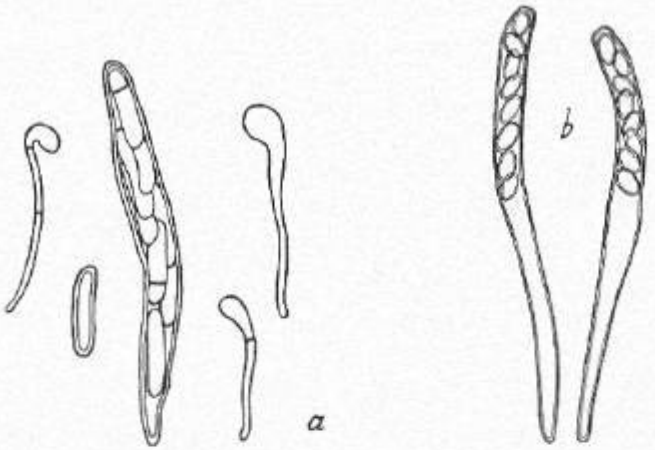

Fig. 1. a. Ascus, spore and paraphyses of *Corynetes arenarius*. (× 400). — b. Asci of *Peziza ammophila*. (× 275).

rangiformis, *C. silvatica* and many others. The substratum has a moderately acid reaction. *Calluna vulgaris* and *Arctostaphylus uva ursi* which are recorded for the Värmland locality also indicate a rel. low pH. It is impossible to draw any direct conclusions concerning this factor as well as other edaphic conditions, since material for comparison concerning the chemical and physical nature of the substratum from other localities is missing. DURAND (1908) mentioned *Corynetes arenarius* among the species of Geoglossaceae, growing on sand usually without humus. Yet it cannot live on a substratum entirely without humus. The tiny remains of roots and moss rhizoids, encrusted in the club-shaped sand-bag at the base of the stem, probably constitute its most important organic source of nutrition.

Scandinavian Distribution.

Sweden.

Skåne. Löderup, Sandhammaren, 15.X.1945, OLOF ANDERSSON. — *Värmland*. Segerstad, Tranmyren at Rudsviken shore of lake Vänern, GUNNAR GRANQUIST 1943 (U.).

Norway.

Vest-Agder. Mandal, Risörbank, on sand, R. FRIDTZ (O.).

Denmark.

Jutland. Gaardbogaard, 2.VIII.1890, O. ROSTRUP (K.). — Skagen, 2.X.02, MARIE KRØYER (LIND 1913). — Borris Hede, 1908, Ø. WINGE (K.). — Between Kandestederne and Bunker, 5.IX.1929, N. HYLANDER (U.). — Raabjerg Mile, 5.IX.1929, K. WINSTEDT (K.). — Mols, ANDERS MUNK.

Sjælland. Hornbæk, 7.X.1893, O. ROSTRUP.

Extra-Scandinavian Distribution. — Outside Scandinavia *Corynetes arenarius* is known from Germany, England, Scotland and Holland, where it reaches its southernmost limit in Europe. It has a small area in Greenland and in north-eastern America, too.

Geoglossum Cookeianum NANNF.

This species has been critically treated by NANNFELDT (1942) and given a detailed diagnosis. *Geoglossum Cookeianum* seems to be quite rare in Scandinavia (NANNFELDT l.c.). It was previously reported from Gotland, Småland, Östergötland and Uppland. In the year 1945 it was found in south Halland at Malen by the present writer. Here it grows on the flat sandy soil, inside the outer sand-dunes in a dense vegetation, dominated by *Thymus Serpyllum* (see Plate I B). Reports from other localities concerning the substratum, on which *Geoglossum Cookeianum* grows, are few and insufficient. For this reason it is impossible to draw any general conclusion concerning the correlation between *Geoglossum Cookeianum* and the nature of the substratum. Presumably it must be assigned to the facultative sand-fungi.

In contrast to *Corynetes arenarius* it has a more southerly distribution. Its most northerly occurrences are those in Sweden. The area of distribution is limited to Europe and embraces England, France, Italy, Germany, Denmark and Sweden.

In addition to the localities given by NANNFELDT (l.c.) the following new ones will be mentioned.

Sweden.

Blekinge. Sölvesborg, close to the ship-yard, on somewhat mossy sandy soil, with *Festuca ovina, Helichrysum arenarium, Hieracium pilosella, Thymus Serpyllum* and single pines, 2.X.1946, S. LUNDELL & S. WIKLAND (nr. 1783, LUNDELL & NANNFELDT 1949).

Halland. V. Karaby, at the mouth of the river Stensån, on sandy soil, amongst *Thymus Serpyllum*, 7.X.1945, OLOF ANDERSSON.

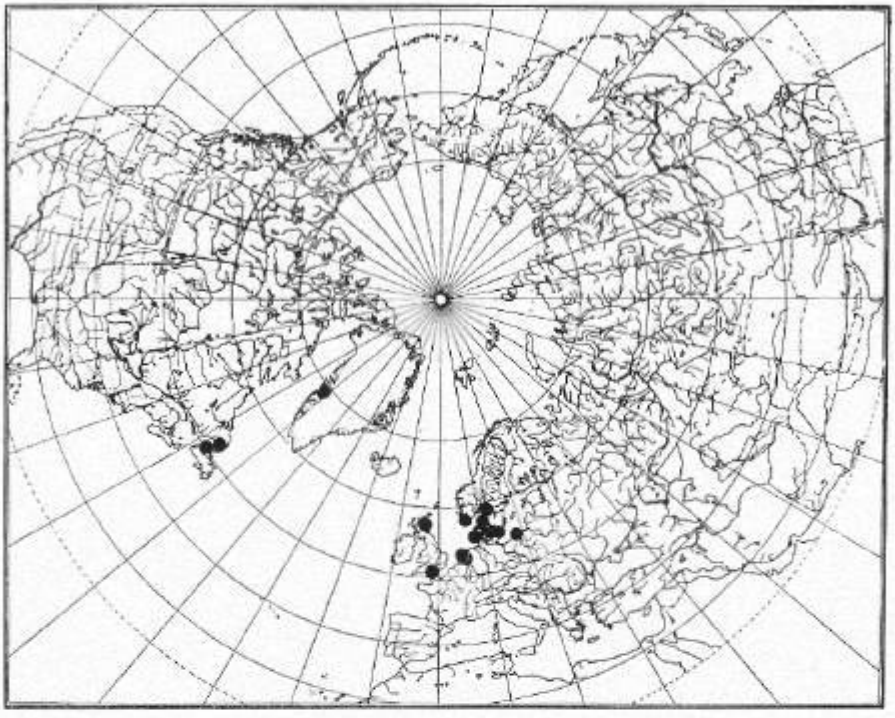

Fig. 2. The total area of distribution of *Corynetes arenarius*.

Gotland. Hejdeby, W of the church, 7.X.1946, BENGT PETTERSSON (U.). — Vamlingbo, Bustre, moving sandfield, 27.IX.1947, BENGT PETTERSSON (U.). — Hablingbo, St. Burge, the *Litorina*-vallum, 30.IX. 1948, BENGT PETTERSSON (U.). — Lummelunda, Etebols, 17.X.1948, E. TH. FRIES (U.). — Stenkyrka, Holge, pine-wood, 15.IX.1948, E. TH FRIES (U.). — Dalhem, Vidunge, sandy pine-wood, 13.IX.1949, E. TH FRIES (U.).

Uppland. Älvkarleby, Billudden, Billskaten, 7.X.1945, N. FRIES, G. SANDBERG and J. A. NANNFELDT (nr 8062); »Insjöängen», on sand, 7.X.1945, N. FRIES, G. SANDBERG and J. A. NANNFELDT (nr 8068). — Almunge, 1.5 km SW of Länna stn, roadside, 11.IX.1948, A. MELDERIS.

Peziza ammophila (DUR. et LÉV.) COOKE.

Description. — *Apothecia*, when young, almost club-shaped, first entirely closed, then with a round opening; in grown condition 2—6 cm.

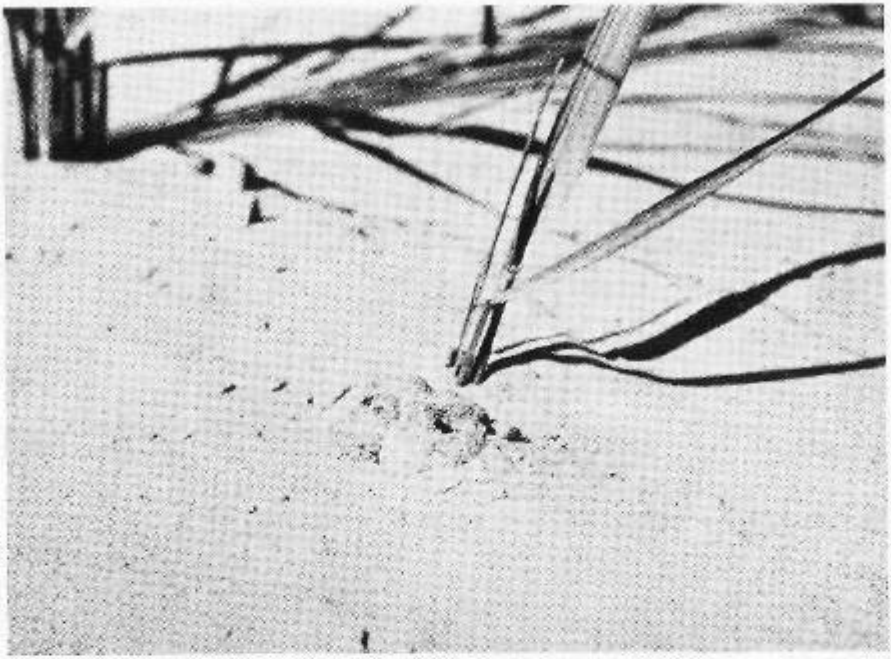

Fig. 3. A young specimen of *Peziza ammophila*, immersed in the sand, forming »a hole» in the ground.

broad, 1.5—3.5 cm. high, deeply bowl-shaped, finally shallow bowl-shaped; the edge bursting out into triangular lobes. The outer side smooth, pale brown. Meat very brittle. Apothecia more or less sunk down in the sand, with a 3—5 cm. long extension, similar to a root, consisting of the mycelium and of the coagulated grains of sand.

Hymenium at ripening dark brown.

Asci thin-walled, cylindrical, J+, 210—260×12—16 μ, with 8 spores lying in a row, pointing in the direction of the ascus' length or set obliquely; in the latter case often bulging out the ascus wall.

Paraphyses thread-like, somewhat thicker towards the top, septate, hyaline.

Spores ellipsoidical, hyaline, smooth, as young with granular content, 14—18×8—10 μ.

Taxonomical notes. — Whether the root-like extension shall be interpreted as a »genuine stem» or as a »false» one has caused certain discussion. Hollós (Moesz 1912) considered it as a sand-formation stuck

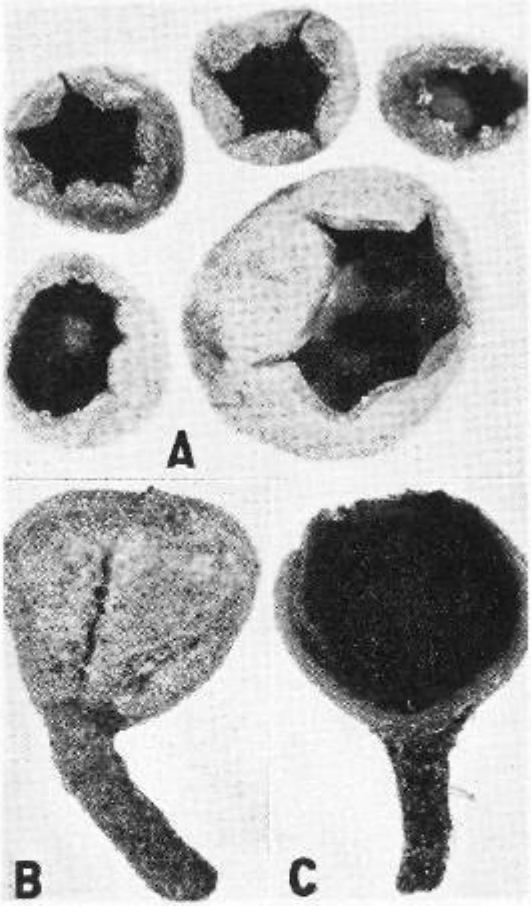

Fig. 4. Specimens of *Peziza ammophila*, showing i.al. the root-like extension (from SEAVER).

together by the mycelium. LINDTNER (1938) also considered it to be a formation of grains of sand and hyphae. I myself, after investigating the material in different stages, was unable to find that the fruit-body's fleshy tissue continued into the root-like extension, and therefore I adhere to the interpretation of HOLLÓS and LINDTNER.

The reports on the size of the spores vary somewhat in different authors. COOKE (1879) and OUDEMANNS (1891) gave 20×9 μ, MOESZ (1912) 14—18×9—11 μ as the greatest measurement. The Swedish material investigated shows a maximum spore length of 18 μ.

COOKE (1879) placed the species in the subgenera *Sarcoscypha* and *Macropodes* of *Peziza*, OUDEMANNS (l.c.) and HOLLÓS (l.c.) in *Geo-*

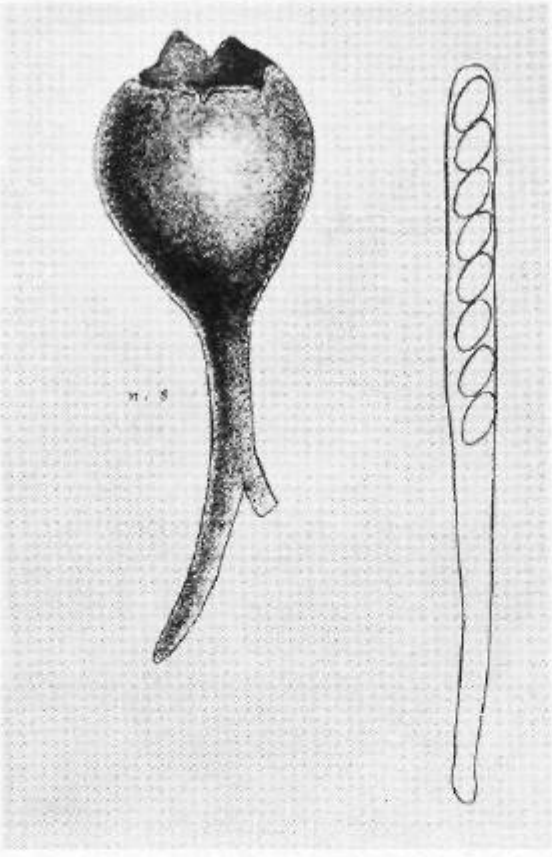

Fig. 5. *Peziza ammophila* from Algeria (after COOKE 1879).

pyxis. TEODOROWICZ (1936) ascribed it to *Tarzetta* because the asci reacted clearly to iodine. SEAVER (1930) placed the species in the genus *Sarcosphaera*. This, however, had been done a long time before by MOESZ (l.c.), who considered that it was closely related to *Sarcosphaera coronaria*. Professor NANNFELDT, Uppsala, however, holds that the placing of the species in the genus *Peziza* s.str. (=*Aleuria* [sensu BOUD.]) is the most natural (NANNFELDT, in letter). PATOUILLARD had come to the same conclusion, according to a remark in his copy of BOUDIER »Histoire et Classification des Discomycetes d'Europe (in NANNFELDT's possession) where he referred the species to the genus *Aleuria*.

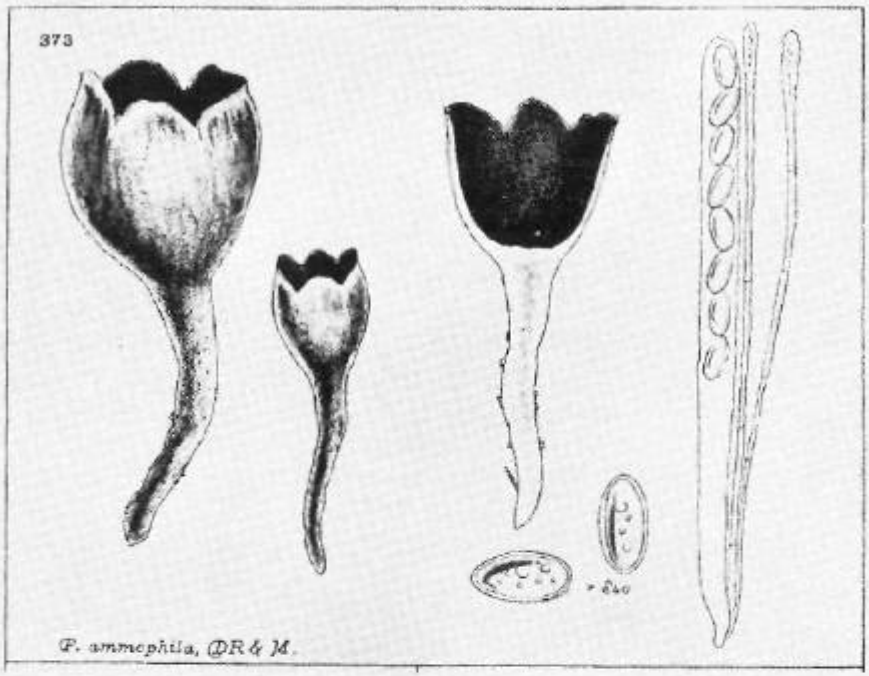

Fig. 6. *Peziza ammophila* from Scotland (after COOKE 1879).

History. — *Peziza ammophila* was described from material found in Algeria. The first European locality mentioned is St. Andrews in Fife in Scotland, where it was observed in 1876 (TRAIL 1893). In Scandinavia it has been known from Denmark since 1908 (FERDINANDSEN and WINGE 1908). In the autumn of 1945 it was observed by the present writer for the first time in Sweden, namely at Sandhammaren. In 1947 it was discovered at one more place, namely at Löderup's beach, about 3 km. west of Sandhammaren. These three sites are the only known ones in Scandinavia.

From North America it was reported by COOKE (1878) under the name *Peziza funerata* in RAVENEL's American Fungi, described from specimens found in Gainesville, Florida: »Immersa. Cupulis campanulaeformibus, fuscis, margine reflexis, subcrenatis, vel sublobatus, tenuis, fragilis; ascis cylindraceis, sporidiis ellipticis.» COOKE (1879 fig. 100) reproduced *Peziza ammophila* after DURIEU and LEVEILLE's picture in Flore d'Algérie and gave the following description: »Stipitata turbi-

nata, radicata, ochracea, ore lacerato, triangulari-dentato, margine contracto. Ascis cylindraceis. Sporidiis ellipticis, hyalinis. — On the ground. Algeria.») In the same work (fig. 373) COOKE illustrated *Peziza ammophila*, which he ascribed to the sub-genus *Macropodes*, after material collected at St. Andrews in Scotland. In connection with the picture he gave a detailed diagnosis, which in certain sections agreed with the former: (»Stipitata, turbinata, fragilis, radicata, ore lacerato, triangulari dentato; intus fusco, demum umbrino, extus pallido, arenoso: stipite elongato, radicato, fragilissimo. Ascis cylindraceis. Sporidiis ellipticis, hyalinis. Paraphysibus leniter incrassatis . . . Britain, France, Algeria.»). In spite of the diagnoses being in agreement on several points, COOKE had not perceived the similarity between *Peziza funerata* from Florida and *Peziza ammophila* from Algeria, England and France.

In Mycologia (1930) SEAVER dealt with the species, which he called *Sarcosphaera ammophila* and identified with COOKE's *Peziza funerata*. Previously SEAVER had been doubtful of the identity of the species, which is seen in a letter (1921) to Prof. H. C. BARDSLEY, who had sent him material from New Smyrna: (»Your species would probably fit better in the genus *Sarcosphaera* than in *Sepultaria* on account of the absence of the hairs on the cap. I do not know the species, although I have been working the group for North America.») In a later letter, however, he had made up his mind and wrote: (»It is *Peziza funerata*, which was described by COOKE from material collected in Gainesville, Florida.») In the first work quoted he gave a detailed description and further mentioned an American locality and, although with a certain hesitation, also a place from Melbourne in Australia. As type locality he gave Florida, which shows that he together with COOKE were unaware of the identity between *Peziza funerata* and *Peziza ammophila*. SEAVER's attention was drawn to this circumstance by KALLENBACH (SEAVER 1940), who wrote: (»Die Bilder sehen genau aus wie die von mir zum erstenmal im Binnensandgebiet Europas festgestellte *Geopyxis ammophila*.») A comparison of illustrations and diagnoses of material from places in Europe, Africa and America shows that not the least doubt exists of the correctness of KALLENBACH's remark. KALLENBACH had previously (KALLENBACH 1931) reported it from the Rhine area and given a detailed description of the habitat.

Ecology. — Along the North Sea and Baltic coasts *Peziza ammophila* grows on the low dunes, »white dunes», in a vegetation poor in species, which is dominated by *Ammophila arenaria* and *Elymus*

arenarius (Trail l.c., Stoll 1925, Ulbrich 1928, Teodorowicz 1936). The remaining important phanerogamic constituents in this vegetation are *Festuca rubra* var. *arenaria* and *Agropyron junceum*. These species characterize the vegetation in the places in which *Peziza ammophila* occurs in Sandhammaren and Löderup (see table 1 and plates II and VI). *Lathyrus maritimus*, *Minuartia peploides*, *Cakile maritima* and *Salsola Kali* — the real constituents of the sea-strand vegetation — are extremely sparsely represented. The vegetation here is especially scanty and covers about one-third to one-half of the ground. The substratum is typical drift sand (see fig. 3 and plate VI). Its pH lies at the neutral point. The electric conductivity lies between 21 and 39.

It also occurs in Eberstadt, in Germany, in a typical xerophyte vegetation, which has, however, quite another composition of species (Kallenbach l.c.). Its most important constituents are *Corynephorus canescens*, *Festuca duriuscula*, *Koeleria glauca*, *Helichrysum arenarium*, *Euphorbia Gerardiana*, *Poa badensis*, and *Alyssum montanum*. In its composition of species this vegetation strongly recalls that which in Scania is dominated by *Koeleria glauca* (Andersson and Waldheim 1946). From the Hungarian places there are unfortunately no descriptions of the vegetation in which *Peziza ammophila* occurs. Even from the American localities the information about the vegetation in which it grows is extremely scanty. In Florida it is found in the naked sand in orange plantations (Seaver 1930) as well as with *Aristida stricta* and *Opuntia* sp. (West 1932), both extreme xerophytes. The latter author also pointed out that the place is sandy soil, which has lain fallow for 10 years. From this information, scanty though it be, it would appear that the species within its *entire* area of distribution is strictly ecologically specialized, i.e. as it only grows on sand, with a preference for somewhat moving, well ventilated sand, without humus or, at least, with very little humus.

Scandinavian Distribution.

S w e d e n.

Skåne, Löderup, Sandhammaren, 15.X.1945, Olof Andersson; Löderup's beach 26.VII.1947, Olof Andersson & Ann-Marie Brüdigam.

D e n m a r k.

Jutland, Tannishus, few, almost entirely sand-covered specimens in loose *Psamma*-downs, August (Ferdinandsen & Winge l.c.).

Extra-Scandinavian Distribution. — *Peziza ammophila* has an extensive area of distribution in the northern hemisphere with great disjunctions (cf. map, fig. 7). The disjunctions should be ascribed to the strict ecological specialization.

The European places where it has been found are concentrated to the coasts of the North Sea, the Mediterranean, and the Baltic together with the Hungarian puszta. It can also be presumed to occur in southern Russia and in the extensive sand areas of Central Asia, but these are unfortunately a terra incognita from the mycological viewpoint.

Reports of its occurrence in Australia (SEAVER l.c.) and the Cape (RAMSBOTTOM 1926) have been impossible to authenticate. Its occurrence in the southern hemisphere, however, is not unthinkable, as many sand fungi are bihemispheric.

[*Peziza arenaria* OSB. On page 8 it was mentioned that OSBECK (l.c.) gave certain practical viewpoints on the Drift sand fungus, *Peziza arenaria*, but it has never been satisfactorily explained which species OSBECK was referring to. The assumption has been advanced that *Peziza arenaria* and *Peziza ammophila* are identical. As the type material has been lost it is impossible to establish *Peziza arenaria*'s identity. The description is far too scanty for any conclusions to be drawn from it, although in certain cases it fits for *Peziza ammophila*.

». . . *Peziza* (*arenaria*) acaulis, junior globosa campanulata margine integra; senior magis dilatata lacerata. Tab. VII.

a *Peziza subfusca* major? RAJ. Synops. stirpium edit. 3. p. 17.

Habitat in arena volatili in via inter Hasslöf & Växtorp Hallandiae meridionalis, mense Septembri.

The size of the fungus varies very much, according to age. The smallest are not larger than sugar-peas, hollow with a little round opening at the top, as shown in fig. 1. Then it broadens out, and resembles fig. 2. Finally it becomes wider at the top than at the bottom, bursts irregularly in width, and when it reaches such a width, it will often grow with 2 or 3 others, as seen in fig. 3. . . . «]

Sepultaria arenicola (LÉV.) MASSEE.

This species, which I myself have not found, must be regarded as a facultative sand-fungus. In general it occurs on or rather in gravel-walks (NANNFELDT in URSING 1949), but it also grows in pure sand. KALLENBACH (l.c.) mentions it together with *Peziza ammophila* from Germany. (See also HOLLÓS 1904 and MOESZ 1942).

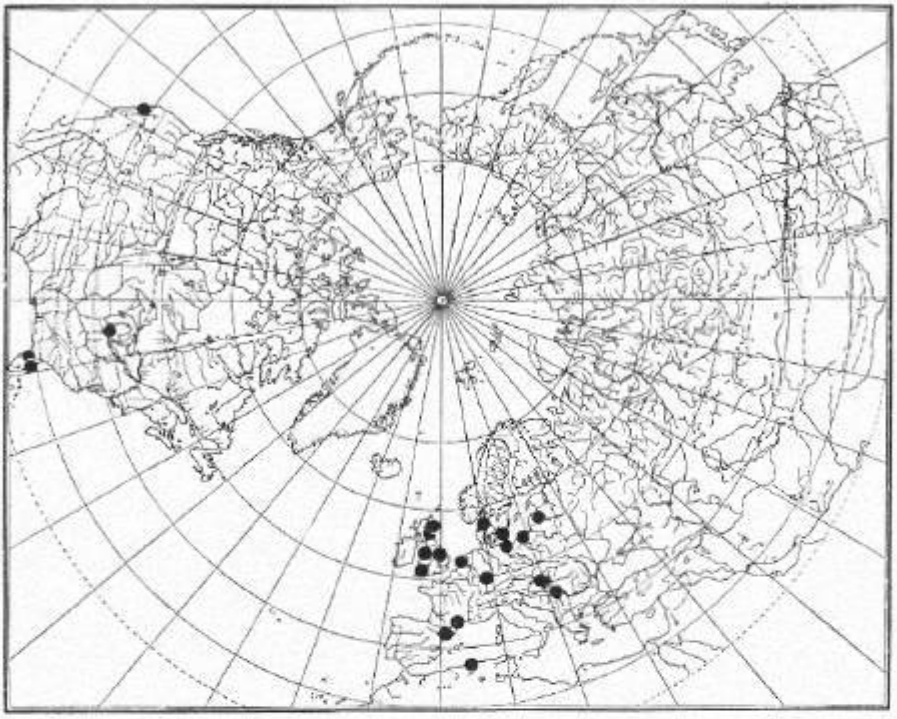

Fig. 7. The area of distribution of *Peziza ammophila*.

Laccaria trullisata (Ellis) Pk ssp. ***maritima*** (Teod.)

Description. — *Cap* 2—4 cm., convex or flat, then shaped like a shallow funnel, with a thin, uneven edge, fibrous on the inside, rather scaly, light brick to meat-coloured.

Gills of different length, broad, distended, 0.5—1 mm. thick, fastened to or running down with a tooth in the stem, violet, then white.

Stem 1—4 cm. long, the upper part often somewhat compressed, fibrous, grooved, with root-like, clumsy extensions at the base, covered with mycelium, to which the grains of sand are fastened.

Spores fusoid or cylindrical, with a fairly thick wall 16—18× 8—10 μ.

Basidia 4 sporous.

Cystidia missing.

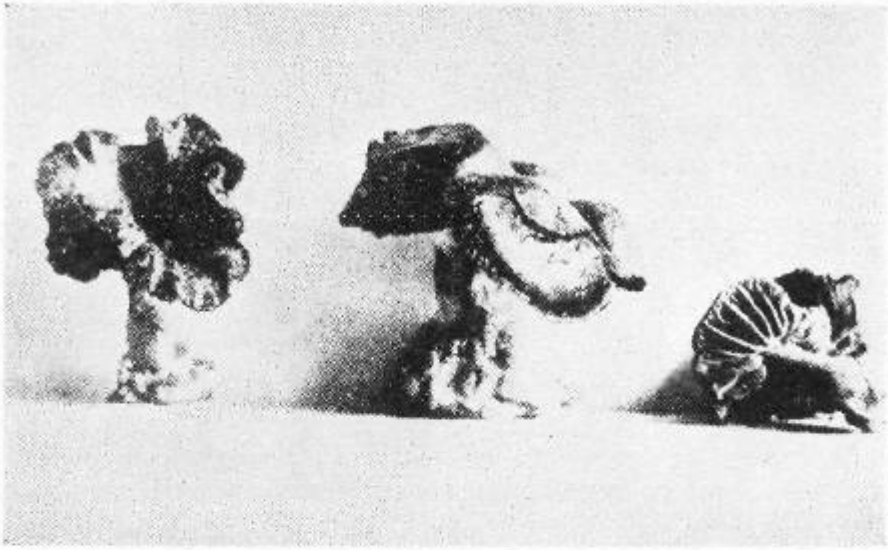

Fig. 8. *Laccaria laccata* var. *maritima* from Poland (after TEODOROWICZ).

Taxonomical notes and history. — The taxonomical position of the genus *Laccaria*, and especially its best known species, *L. laccata*, has been much discussed. Certain authorities have placed *Laccaria* in a larger genus, e.g. *Clitocybe* (FRIES, LANGE), *Hygrophorus* (KARSTEN) or *Collybia* (QUELÉT). Others again, have classified it as an independent genus. SCHROETER called it *Russuliopsis*. Its most important characteristics, which differentiate it from the above-mentioned genera, are considered to be the asperulate, round or almost round spores. BERKELEY (1860) places *L. laccata* with *Clitocybe* but maintains: »Spores subglobose: a very uncommon character amongst Agarics.» Nowadays *Laccaria* is generally considered as an independent genus.

Within the genus *Laccaria*, however, there has been placed a species, first described from America by ELLIS (1874) sub nom. *Agaricus (Clitocybe) trullisatus*, which shows in its habitus a great similarity with the pale brick-red colour variety of *L. laccata* but differs in microscopic characteristics. *Laccaria trullisata* has large and fusoid or cylindrical spores. It has now also been discovered in Sweden. The European material may possibly represent a special ssp. *maritima* but for the sake of simplicity, the designation *L. trullisata* will be hereafter employed.

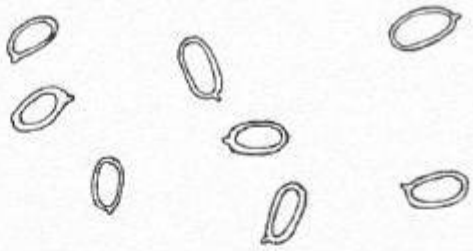

Fig. 9. Spores of *Laccaria laccata* var. *maritima* from Löderup. (× 600).

As mentioned above *L. trullisata* bears an amazing similarity to *L. laccata* and the two species have probably been confused. This would also seem to be the case with *L. laccata* from the sand dune region of south-eastern Finland. THESLEFF (l.c.) wrote: »Where *Elymus* and other species have bound the sand, *Cricunopus* (=*Boletus*) *luteus*, *Laccaria laccata* (!) and *Polystictus* (=*Polyporus*) *perennis* are noted.» The *Hygrophorus maritimus*, recently described by TEODOROWICZ (1936) from Poland, belongs to *L. trullisata*'s form group and is identical with the Swedish form. TEODOROWICZ (l.c.) maintained that *Hygrophorus maritimus* shows considerable similarities to *L. laccata*, but that it is distinguished from the latter especially by the shape and size of the spores. He compared it instead with *Hygrophorus chlorophanus* FR., to which NÜESCH determined TEODOROWICZ' material. TEODOROWICZ, however, found essential differences between *Hygrophorus chlorophanus* — according to the literature — and his own material. On this basis he set up a new species, *Hygrophorus maritimus*.

The gills in *L. trullisata*, as in other *Laccaria* species certainly show a definite hygrophoroid structure, but this characteristic and the similarity in the spore shape are not sufficient evidence for classifying the species among the Hygrophori. It appears to be most naturally and closely related to *Laccaria*.

SINGER (1942) considered the placing of the species in *Laccaria* to be the most natural. He gave the following description of the microscopical characteristics: »Spores 15—22×5—10 μ, fusoid or cylindrical, smooth, internally granulate, rather thin-walled; basidia 45—65×9—14 μ, 4-spored; cystidia not seen; gill trama non-amyloid, septae with clamp connections; hyphae of the cuticle tangentially arranged but somewhat interwoven, subintermixed; pigment intracellular», and he made the following conclusion, »This species has evidently all characters of the genus Laccaria, except for the spore shape and ornamen-

tation . . . Thus the diagnosis of this genus has to be enlarged: The spores are either subglose and spinose or gigantic (i.e., over 15 µ long and smooth.»

A comparison between SINGER's description of the microscopical characteristics of the American species and TEODOROWICZ's and my own of the European form shows that certain differences concerning the spore size exist.

Unfortunately I have not had the opportunity of examining American material in order to determine whether it is fully identical with the European. For this reason I have been compelled to turn to different authors' descriptions for comparison. According to the descriptions by ELLIS (1874) and MURRILL (1907—16) there is no difference in habitus. Since there is quantitative differences in the spore size, I consider it justifiable to classify the European form, for the present, as a subspecies under *L. trullisata*. As 'TEODOROWICZ' description was the first from Europe, it would be most correct to call it *L. trullisata* (ELLIS) PK ssp. *maritima* (TEOD.).

PEARSON (1943, p. 41), when discussing *Omphalia rosella* from Scotland wrote that he had »gathered specimens of an agaric growing on sand looking remarkably like *Laccaria laccata* but with smooth guttulate spores measuring 16—18×6—8 µ which may be a form of *Omphalia demissa* Fr.» Probably these specimens belong to *Laccaria trullisata* and not to *Omphalia demissa*. The size of the spores and the habitat favour that belief.

In this connection it can also be pointed out that a form belonging to *L. trullisata*'s form group has been observed in Greenland on sand (MORTEN LANGE in letter). LANGE has informed me that the Greenland form has ellipsoidical, 12—14(—15.5)×7—8.5(—10.5) µ large spores with a smooth (or almost smooth?) wall. The spore shape, the colour of the fungus and several habitual characteristics together with the same habitat points to *L. trullisata*. It differs, however, from the typical *L. trullisata* by having smaller spores and a smaller cap diameter. These characteristics, however, are quantitative and should not be ascribed too great importance when making a taxonomical delimitation. The taxonomical rank of this form, however, must be decided by LANGE.

Ecology. — In the Swedish localities *L. trullisata* is confined to marine sand-dunes. In Poland it occurs in similar habitats. TEODOROWICZ (l.c.) referred to a symbiotic relation with *Salix daphnoides* but I have never observed such a relationship in the Swedish localities.

Fig. 10. *Laccaria laccata* var. *maritima* among *Ammophila arenaria* in Poland (after TEODOROWICZ).

Scandinavian Distribution.

Sweden.

Skåne, Löderup, between Sandhammaren's lighthouse and Löderup's beach, 1.X.1946, OLOF ANDERSSON.

Halland, Laholm, Mellbystrand, 12.IX.1946, OLOF ANDERSSON & ANN-MARIE BRÜDIGAM.

Extra-Scandinavian Distribution. — From the preceding it is clear that *Laccaria trullisata* is only known from a few localities in Poland, Scotland, Greenland(?), and U.S.A.

Inocybe lacera var. *halophila* (HEIM)

Description. — *Cap* 1.5—4 cm., umbonate or semiglobate, chestnut brown or ochre brown covered with scaly and compressed fluff, often bursting upwards concentrically.

Gills deeply ventricose, free or somewhat widely grown, brown with darker edge.

Stem often short, narrow, stiff, somewhat striate, brown or pinkish, darker to the middle, thickened towards the base.

Flesh green in the cap and the apex of the stem, in the rest of the stem brown.

Spores almost cylindrical, slightly pointed at one end, smooth, 5.8—6.5×12—16 μ.

Cystidia, in groups first globe-shaped, then extended, crested with lime crystals.

Taxonomical notes. — HEIM (1931) interpreted this variety as a distinct species, *I. halophila*. Whether this is well-grounded is open to discussion. The characteristics reported by HEIM (l.c.) are scarcely sufficient for the separating of a new species from *I. lacera*. As a difference HEIM brings forward the ecological peculiarities of *I. halophila*: ». . . finally its habitat strictly limited to the sands.» Naturally a plant's reaction has taxonomical importance, but to it alone should not be ascribed the value of a s p e c i e s d e l i m i t a t i o n. From the investigations by TURESSON and many others numerous phanerogamous plants are known which include different ecotypes. Why should the same not be the case with fungi? *I. halophila* can perhaps be separated as a sand-dune ecotype of *I. lacera*. Unfortunately such a supposition cannot be ascertained by culture tests and the discussion must rest here. It seems most natural to me, however, to place *I. halophila* as a variety under *I. lacera*. That has already been done previously by EKLUND (1944). PEARSON (1943, p. 46), who considered it to be a species, remarked that it is doubtful, whether *I. halophila* really is distinct from the very variable *I. lacera*.

History. — In Sweden *I. lacera* var. *halophila* was found in Sandhammaren and Mellbystrand in 1946. The sand-dune variety of *I. lacera*, however, seems to have been observed previously in Scandinavia. Thus PETERSEN (1907—11) wrote (orig. Danish): »It (*I. lacera*) is extremely common in the drift sand along the west coast of Jutland and varies here in that the flesh in the stem is not reddish, and the gills finally remain yellow-brown.» When discussing *I. lacera* LANGE (1938) maintained that he saw on the North Sea sand-dunes a form of *I. lacera* which he believed was possibly identical with *I. halophila* HEIM. Whether THESLEFF's *I. lacera* from the dunes along the Gulf

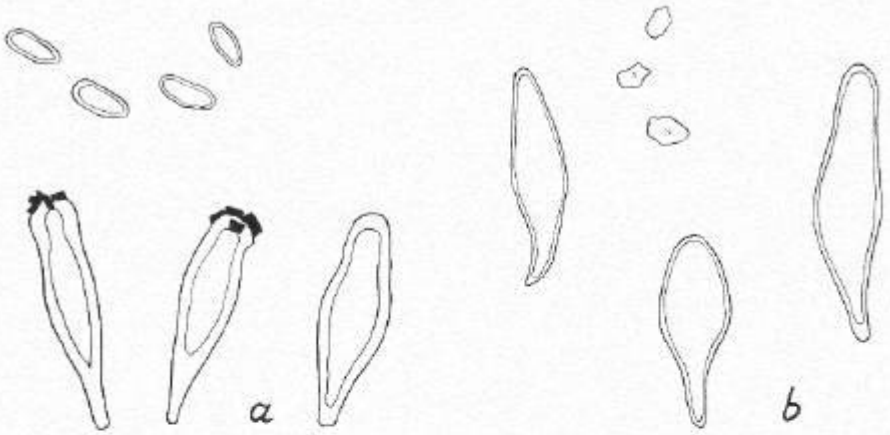

Fig. 11. a. Spores and cystidia of *Inocybe lacera* var. *halophila*. (× 575). — b. Spores and cystidia of *Inocybe maritima*. (× 575).

of Finland can be identified with *I. lacera* var. *halophila* is impossible to say as no material has been preserved. Later it was reported from Finland by EKLUND (l.c.). It was also found in Scotland, on Culbin sands, Moray Firth (PEARSON l.c.).

Ecology. — HEIM (l.c.) stated that *I. lacera* var. *halophila* grows together with *Psilocybe ammophila* in its type locality, Biville in France. In Sandhammaren it occurs in an *Ammophila arenaria* vegetation, in which appears *Psilocybe ammophila* (see page 33). A certain ecological agreement thus exists between the French and Scandinavian habitats. Presumably *I. lacera* var. *halophila* is a characteristic species in the *Ammophila arenaria*-vegetation along the coasts of the Baltic, the North Sea and the Atlantic.

Scandinavian Distribution.

Sweden.

Skåne. Löderup, Sandhammaren, 28.VI.1946, OLOF ANDERSSON.
Halland. Laholm, Mellbystrand, 12.IX.1946, OLOF ANDERSSON & ANN-MARIE BRÜDIGAM.

Finland.

Alandia. Gyltö; Jurmo (EKLUND l.c.).

D e n m a r k (See above).

Extra-Scandinavian Distribution. — (See above).

Inocybe maritima Fr.

Description. — *Cap* campanulate-convex, 2—4 cm, fibrous, brown-blackish brown, hygrophanous.

Gills thick, adnate or running down somewhat, cinnamon-coloured—greyish or ochre-olive coloured.

Stem cylindrical, fibrous, light brown, thickened at the base.

Spores angular, slightly nodulose, nodules few, 7.5—10—15×6—8 μ.

Cystidia on gill edge and face, ventricose, 48—72×16—22 μ.

Taxonomical notes. — Macroscopically *I. maritima* shows great similarity to *I. lacera*. On the other hand, there exist essential differences in the microscopic characteristics, e.g. in the shape of the spores and cystides. Whereas *I. lacera* has long, almost bean-shaped spores, those of *I. maritima* are angular, slightly nodulose. The fig. 392 in Cooke's Illustrations (1884—86) seems to be another species. The spores depicted are too nodulose. The spore measurements given by Cooke coincide to a considerable degree with those reported by Heim (1931), 9—11—15×6—9 μ. Full agreement is not found in the measurements of cystidia. In the material investigated by Heim the cystides are 45—60—93×18—29 μ. Boedijn (1925) gave as measurements for the cystides 75—100×15—19 μ. The Swedish material shows the variation 48—72×16—22 μ. This difference must depend on the Swedish material not being sufficiently large to reflect the whole variation of the cystidia in the species.

History. — This species, which was reported from Halland by Elias Fries (1818, 1849 and 1862, cf. also Lundell 1936), was found in Sandhammaren in 1945 (by Torsten Håkansson, Lund). Sandhammaren is most likely the second, possiby the third, Swedish locality for *I. maritima*. In Mon. Hym. Suec. (1863) Fries wrote: »In arenosis maritimis humidis juxta mare occidentale fere ubique per totam aestatem; primo ad Halmstad legi. Nuperrime quoque in via arenosa prope Upsaliam . . .» In the Upsala region, which is one of the best investigated places from a mycological viewpoint, *I. maritima* has, however, not been rediscovered.

Fig. 12. The area of distribution of *Inocybe maritima*. (The species is also known from England but no localities are mentioned).

Ecology. — Within the larger part of its area of distribution *I. maritima* seems to prefer dunes (BLYTT 1905, STOLL 1926, TEODOROWICZ 1936). HEIM wrote: »Dans les dunes du littoral de l'Ocean . . ., de la Manche . . ., de la Mer Baltique», but continues, »et probablement dans les forets sablonneuses de conifères . . .» This report is in agreement with that of FRIES: ». . . et amic. LINDBLAD *in pinetis* (underlining O. ANDERSSON) arenosis Germaniae observavit.» CORBIÈRE (1924—29) also wrote: »Bois de conifères . . .» The pine-woods on sandy soils in Germany, France and England consist most often of woods planted on previously wood-free dunes, for which reason it is possible to believe that *I. maritima* succeeded in keeping its foothold in favourable places from that period when the dunes were only covered with a sparse grass vegetation. *I. maritima* should be classified as an o b l i g a t e s a n d f u n g u s.

Scandinavian Distribution.

Sweden.

Halland. Halmstad (FRIES 1818).

Skåne. Löderup, Sandhammaren, on sandy soil, IX.1945, T. HÅKANSSON.

Norway.

Rogaland. Jæderen, Ogne, in moving sand (BLYTT l.c.).

Extra-Scandinavian Distribution. — As appears on the map (fig. 12) the area of distribution also includes Estonia (STOLL l.c.), Poland (TEODOROWICZ l.c.), Germany (GRAMBERG 1923), Holland (BOEDIJN l.c.). It is also reported from England (REA 1922, HEIM l.c.) but no localities are known to me. Its occurrence in America has not been clearly ascertained.

Inocybe serotina PECK

Description. (according to LANGE 1938, PEARSON l.c.). — *Cap* 4—8 cm., convex, obtusely umbonate, margin abruptly inturned at first, rimose with arachnoid fibrils, white turning ochre or rusty brown.

Gills crowded, adnexed or free, ventricose, white at first then snuff brown.

Stem 3—10 cm., thickened above and below, base sometimes with a submarginate bulb, white near apex and with striate rusty fibrils below or rusty brown all over except at white base.

Flesh white.

Spores 11—18×5—8(—10) μ.

Cystidia on gill edge and gill face, subcylindrical, balloon-shaped or ventricose 40—80×10—32 μ.

Ecology and distribution. — This species has only been observed in Scandinavia, at Blaavandshuk, Jutland, Denmark (LANGE 1938, 1940—41). It belongs to the same ecological group as *Peziza ammophila*, *Phallus Hadriani*, *Laccaria trullisata* ssp. *maritima*, *Psilocybe ammophila* and *Inocybe lacera* var. *halophila*, and *I. maritima* as it occurs on sand-dunes. It is also known from Holland (HEIM l.c.), England (PEARSON l.c.), and North America (ATKINSON 1918).

Psilocybe ammophila LÉV.

Description. — *Cap* 1—3 cm., campanulate, then expanded, in damp weather dark dirty brown, in dry weather pale yellow to yellow-brown.

Gills broad, ventricose, adnate, decurrent with a tooth, grey-brown to cinnamon brown, purple to cinnamon coloured.

Stem 2—6 cm., at the top somewhat striate, roughly of the same colour as the pileus, but somewhat lighter; stem-base sunk down 2—3 cm. in the substratum, surrounded by thickly packed grains of sand and root-strands.

Cystidia on the gill-edge, large, inflated, colourless, 43×15 μ.

Spores rounded off cylindrical, brown to purple-brown, 6.5—8× 10—12—14(—16) μ.

Taxonomical notes. — This species has been referred to different genera, *Hypholoma*, *Drosophila*, and *Psilocybe*. Its most natural position is in *Psilocybe*. MAIRE (1909) described a variety *ecaudata:* »A typo differt statura minore (pilei diam. 1—2 cm.), stipite aequali nec radicato, sporis basi non incrassati.» From Australia CLELAND (1934—35) described a species *Psilocybe subammophila*, which according to the diagnosis seems to be identical with *P. ammophila*. *Naucoria arenicola*, reported from South Africa by BERKELEY, may also be identical with *Psilocybe ammophila*.

History. — This species like *Peziza ammophila* was first described from Algeria. In Scandinavia, it has previously been observed in Denmark (PETERSEN 1907—11, J. LANGE 1939). In Sweden, however, the first find of *Psilocybe ammophila* was made by the present writer in 1945 on the sand-dunes of the Halland coast. In Norway, it is unknown in the literature, but there are specimens of it in the Oslo herbarium collected by EGELAND from the southern coast of Norway.

Ecology. — Ecologically *Psilocybe ammophila* agrees with *Peziza ammophila* and *Phallus Hadriani* (see table 1 and plates III, IV and VI). From Montpellier it was reported as growing together with *Elymus arenarius* (DE SEYNES 1863). In North Africa it was seen growing together with *Scirpus Holoschoenus* (MAIRE l.c.). According to TEODOROWICZ (1936) it is said to grow on rabbit excrement, which it dissolves. WAKEFIELD (1918) has carried out certain field observations concerning

Psilocybe ammophila and found that the buried base-part is always united with rotting leaves of *Ammophila arenaria*, buried in the sand. WAKEFIELD's observations are more correct than those of TEODOROWICZ. *Psilocybe ammophila* lives on humus, possibly forming mycorrhiza on the roots of the dune grasses and is not a coprophile species.

Scandinavian Distribution.

S w e d e n.

Skåne. Båstad, Malen, 10.X.1945, OLOF ANDERSSON. — Barkåkra, Vejbystrand, 9.X.1945, OLOF ANDERSSON. — Löderup, Sandhammaren, 15.X.1945, OLOF ANDERSSON; Löderup's beach, 27.VII.1947, OLOF ANDERSSON & ANN-MARIE BRÜDIGAM.

Halland. Ö. Karup, north of the mouth of the river Stensån, 10.X.1945, OLOF ANDERSSON.

D e n m a r k (See above).

No exact localities.

N o r w a y.

Rogaland. Jæderen, at Bruen, 14.VII.1916, J. EGELAND (O.).

Extra-Scandinavian Distribution. — As is seen from the map (fig. 13), *Psilocybe ammophila* is distributed over large parts of Europe and north-western Africa. Judging from the above discussion it possibly occurs in South Africa and southern Australia. The report of its occurrence in the U.S.A. (HARD, according to BRESADOLA 1930) has not been authenticated. According to SINGER (in letter) it is not known from America.

The majority of the European localities is situated along the coasts of the Baltic, the North Sea, the Atlantic, and the Mediterranean. From the central part of Europe it is only known in two localities, the inland dunes at Darmstadt (KALLENBACH l.c.) and in the Budapest district (MOESZ l.c.).

Phallus Hadriani (VENT.) PERS.

Description. — *Volva* subglobose-ovate, 3—4 cm. broad, 4—6 cm. long, surrounded by the substratum white, when exposed to the air swiftly acquiring a pink to deep violet colour. *Mycelial* cords of same colour.

Fig. 13. The area of distribution of *Psilocybe ammophila*.

Stipe cylindrical to fusiform, 10—15 cm. long, at the base somewhat pink-coloured, otherwise white, with a conic to campanulate pileus. Discus and its opening large, cylindrical, edge crenate.

Walls of the gleba chambers 2—5 cm. high, branched, extending to the volva in immature stage.

Spores oblong to elliptical, smooth, 3—4(—5)×1.5—2 μ.

Taxonomical notes and history. — Some authors list additional characteristics to those given above but these do not justify the denomination of a different species. The fruit-bodies of *Phallus impudicus* occur mostly isolated or two together, whereas *Ph. Hadriani* usually grows in clusters of 5 to 10 (see plate IV). As an important characteristic of *Phallus Hadriani*, it is pointed out that the upper part of the volva, when the receptacle expands, remains behind on the cap of the receptacle (see plate V A). This, however, does not always occur and

seems to be of a modificative nature, in all probability depending upon the changing conditions of dampness. If the egg under damp weather conditions has projected out of the sand and then dry conditions suddenly arise, the upper part of the volva often sticks to the pileus of the receptacle. With renewed rain the receptacle expands, often in an explosive manner. That is not, however, sufficient to burst the dried volva with the cap on the top, but this occurs at the point of least resistance, i.e., in the transitional zone between the dried apical part and the soft basal part.

Phallus Hadriani, which has been known for long time in Denmark (WARMING 1907—09, BUCHWALD 1930, FERDINANDSEN and WINGE 1943), was discovered in Falsterbo, Sweden in 1944 (by GUSTAF RUDEBECK). After that it has been observed in several Swedish localities (O. ANDERSSON 1945, NANNFELDT in NANNFELDT and DU RIETZ 1945). It has possibly been observed earlier in Sweden, for RIDELIUS' find (RIDELIUS in letter) of *Phallus impudicus* on Fårön in Gotland may have been *Phallus Hadriani*.

Phallus Hadriani was the first of the *Phallus*-species to be described in the world. It was described by the Dutch doctor, AADRIAN DE JONGHE, (latinized HADRIANUS JUNIUS) in »Phalli ex Fungorum genere . . .», 1st ed., 1564, 2nd ed., 1601 (cf. LÜTJEHARMS 1931, and fig. 37). He called it only *Phallus* without giving a species name. It appears, however, very clearly from his description that the sand species was intended, as he calls attention to the red colour of the volva: (»Ea ubi primum scrobe revellitur, pallidior est, mox paulatim purpurascit, intercurrentibus sparsim ceu venulis quibusdam sanguineis.») A further proof is the habitat, the Dutch sand-dunes, the *Ammophila arenaria*-vegetation of which JUNIUS describes. JUNIUS' work has been the subject of much discussion (cf. DE BARY 1864, LÜTJEHARMS l.c.).

The sand species is later discussed in works from the seventeenth, eighteenth, and nineteenth centuries (ULBRICH 1932). VENTENAT called it *Phallus Hadriani*, under which name it was treated by PERSOON (1801) as well as by FRIES (1829). In the literature of the nineteenth and twentieth centuries it appeared under the name *iosmos* and *imperialis*, sometimes as a species, sometimes as a variety under *Ph. impudicus*.

The first exact European locality reported for *Phallus Hadriani* was Lowestoft in England. The species from this place was reproduced by J. CURTIS in British Entomology (1833) in connection with the description of a hymenopter, *Borborus hamatus*, which CURTIS found

Fig. 14. The oldest picture of *Phallus Hadriani*. (From the paper of HADRIANUS JUNIUS).

on the gleba of *Ph. Hadriani*. He gives the following commentary to the picture: »The Plant figured had a scent somewhat like violets at a distance, when growing, but was very offensive when dried: it seems to differ materially from *Phallus foetidus* LAM. (*Ph. impudicus* LINN.); I found it in some abundance on the sandhills near Lowestoff, Suffolk, in the middle of October. Flies of all descriptions were much attached to this Fungus and, as well as bees and beetles, seemed very fond of the shining matter which dropped from the pileus.« On this picture and description BERKELEY (1860) based *Ph. iosmos*, which was reported by PHILLIPS and PLOWRIGHT (1875—76) from another English locality. BERKELEY confirmed the classification but wrote: ». . . doubtless the plant of CURTIS' Entomology, but it is very doubtful whether it is a species.«

SCHULZER (1866) reported *Phallus Hadriani* from Hungary. He even created a special genus for it, *Kirchbaumia*, and called the species *Kirchbaumia imperialis*. The launching of this genus clearly originated with a false interpretation from SCHULZER's side: »Wie *Phallus*, aber ein häutiges Velum partiale verbindet die Unterseite des Hutes mit dem Strunke, reisst dann, und bleibt in Fragmenten am Strunke, grösstenteils aber vorhangförmig am Hute.«. Such skin-like growths, which are not homologous with the Velum partiale in the Hymenomycetes, hanging down from the bell-shaped under-side of the cap occur in

Phallus Hadriani, but are not a constant characteristic. Presumably the material at SCHULZER's disposal was far too scanty for the setting up of this new genus. SCHULZER seemed later to have changed his mind, because he in a later work (KALCHBRENNER 1873) called the species *Ph. imperialis*. Its description is very striking, but on the other hand the illustration is scarcely true to nature. The whole fungus has been reproduced too large. The volva has been given a colour that is far too red, which among other things seems to have been the reason why certain authors (HOLLÓS 1904, ALEXANDRI 1934) have ascribed specimens with an only faintly pink-coloured volva to *Ph. impudicus*. HAZSLINSKY (1878) degrades *Ph. imperialis* to the variety *imperialis* under *Ph. impudicus*.

According to FISCHER's (1886) interpretation *Ph. impudicus* is a collective species, which except for the main form includes the varieties *imperialis* and *iosmos*. FISCHER wrote that var. *imperialis* was marked from the main form through the pink-coloured volva: (». . . The only important difference from *Ithyphallus impudicus* lies in the pink-coloured volva.») Curiously enough he does not give the colour of the volva in the main form! As the most important characteristic in *Ph. iosmos* he gave the dentate reticulations of the gleba chambers.

HOLLÓS (l.c.) agreed with FISCHER and distinguished from the main form var. *imperialis*. The former he described as characterized by a ball- or egg-shaped volva, white, rose-red or lilac colour, cloven in 2 to 3 lobes. For the delimitation of var. *imperialis* he did not give any argument of his own but only quoted earlier authors (KALCHBRENNER l.c., HAZSLINSKY l.c., FISCHER l.c.).

JACZEWSKI (1911) set up again *Ph. imperialis* with the support of finds made in Bessarabia: (». . . Il est assez difficile d'établir une délimitation rigoureuse des espèces d'*Ithyphallus*, les caractères microscopiques étant peu prononcés et en partie mal connus. Dans cette occurrence, les caractères d'ensemble, l'habitat ont ici une valeur prépondérante, comme pour la classification des *Hyménomycètes* charnus; ceci étant donné, il semble que l'on devrait considérer comme des variétés les formes qui présentent des transitions graduelles vers le type spécifique et comme des espèces bien définies, les formes bien tranchées. Or dans les cas qui nous occupe, aussi bien Bessarabie qu'au Caucase il m'a été impossible de constater aucune transition entre le type *impudicus* et le type *imperialis*, et dans tous les exemplaires se rattachant à ce dernier, j'ai toujours retrouvé les caractères tranchés, qui, selon

mon opinion, ont une valeur spécifique. J'ajouterai que ces différences, fort nettes, mais assez difficiles à rendre dans leur ensemble par la seule description, ressortaient plus particulièrement à Chabot où je retrouvais simultanément les deux espèces croissant côte à côte, mais ne fusionnant pas, et gardant leur individualité propre. Il est à remarquer encore que l'*It. imperialis* est presque sans odeur, contrairement à ce qui s'observe chez l'*It. impudicus*. . . . Toutes ces considérations me paraissent concorder pour le rétablissement de l'espèce de SCHULZER qui me semble même une *bonne espèce*».

ULBRICH (1932), who called the main group with white—whitish yellow volva var. *vulgaris*, placed against this the varieties *iosmos*, *imperialis*, and *americanus*, all of which have a pink-coloured volva. With this delimitation FISCHER (1933) later agreed. The differentiation of three varieties, all characterized by a pink-coloured volva, would appear to be scarcely justified. Nor did ULBRICH produce any obviously different morphological characteristics between *iosmos* and *imperialis*. The description of *imperialis* can just as well be applied to *iosmos* and vice versa. According to ULBRICH's description the most important difference would appear to have been that they occurred in different areas. A map, however, shows that the areas of both varieties overlap one another. The setting-up of a special var. *americanus* for the form appearing in America with pink-coloured volva and with somewhat smaller spores than both the others might possibly be justified, but in that case it should be ascribed the rank of a subspecies, because it is properly geographically limited. It would seem most suitable, however, to refer the American form, also, to *Ph. Hadriani*. LONG and STOUFFER (1948) refer the American form to *Ph. iosmos*.

In addition to ULBRICH (l.c.) and FISCHER (l.c.) other authors at later periods have considered *Ph. Hadriani* as a variety of *Ph. impudicus*. LÜTJEHARMS (l.c.) wrote for example (orig. French): (». . . In my opinion the characteristics which seem to separate these kinds are not very obvious. It is true that there is always found in the sandhills a *Phallus* with a white volva which, after exposure to the air, acquires a certain colour by which it may be distinguished from the typical form of the *Phallus impudicus*.«) The rose-coloured volva is not the only quality by which *Ph. Hadriani* differenties itself from *Ph. impudicus*. DOMINIK and MORAWSKI (1935) reported several differentiating characteristics and considered that for these reaons *Ph. Hadriani* is a good species. The following comparison shows the essential differences between both species.

Phallus Hadriani	*Phallus impudicus*
1. Mycelial strands pinkish to deep violet	1. Mycelial strands white to yellowish white
2. Volva subglobose-ovate	2. Volva globose-subglobose
3. Volva pinkish to deep violet	3. Volva white to yellowish white
4. Walls of the gleba-chambers clearly branched, often reaching out to the volva, 2—5 mm. high.	4. Walls of the gleba chambers not branched, not extending to the volva, 0.5—2.5 mm. high.
5. Spores 3—4(—5)×1.5—2 μ.	5. Spores 3—5(—6)×1.5—2.5 μ.

Ecology. — ULBRICH (l.c.) distinguished from a phytogeographical viewpoint four form groups of *Ph. impudicus*, the forest variety *vulgaris*, the sand-dune variety *iosmos* along the coasts of the Baltic and the North Sea, the European continental sand variety *imperialis*, and the American variety *americanus*. This division is no longer of value now as it has been shown that *iosmos*, *imperialis*, and *americanus* are identical and form the species *Ph. Hadriani*. The latter grows preferably in sandy habitats and within the whole of its distribution area occurs in xerophilous vegetation types.

Along the coasts of the Baltic and North Sea it appears as the characteristic species in the *Ammophila arenaria*-vegetation, which characterizes the low sand-dunes, »the white sandhills», and which have been described in connection with *Peziza ammophila* (WARMING l.c., STOLL 1925—26, BUCHWALD l.c., LÜTJEHARMS l.c., ULBRICH l.c., TEODOROWICZ 1936, EICHWALD 1937).

In the continental parts of Europe it grows in warm, preferably sandy, habitats in open plant communities, in planted *Robinia pseudacacia* - *Gleditschia triacanthos* - woods, or in *Vitis*-plantations.

There is very little information concerning the habitats within its American area of distribution. LONG (1907) wrote the following: (». . . In rich loose soil in open fields or near the margin of thickets, along creeks, etc., n e v e r in well shaded places»).

Phallus Hadriani has been considered by different authors sometimes as a saprophyte, sometimes as a mycorrhiza-fungus, sometimes as a parasite. No proof, however, is to be found of these assumptions. It seems incredible that *Phallus Hadriani* could be a pure saprophyte, since the small quantity of humus on the sandy habitats cannot suffice as an organic source of nutrition for the large fruit-bodies of *Ph. Hadri-*

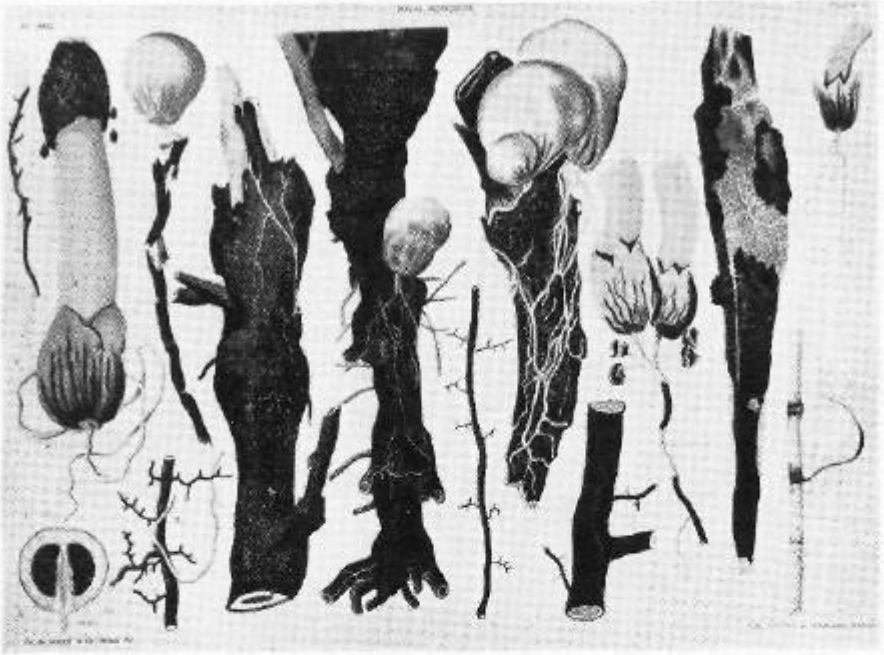

Fig. 15. *Phallus Hadriani* occurring on *Vitis* and *Agropyron repens*. (From the paper of ISTVÁNFFI 1904).

ani. Thus it must obtain its organic nutrition in another way, either through the formation of mycorrhiza or parasitism. For this reason I have followed the strands of the mycelium, which press closely along the roots of *Ammophila arenaria* and *Elymus arenarius* deep down in the sandy substratum, but have been unable to establish any closer connection between the mycelium and the plants named above. An attempt to produce mycorrhiza synthetically between these species and *Ph. Hadriani* is necessary in order to establish with certainty anything concerning the formation of mycorrhiza.

ISTVÁNFFI (1904) has observed that the mycelium of *P. Hadriani* lives sometimes saprophytically on tree-stumps in *Vitis*-plantations, sometimes parasitically on the roots of *Vitis*, *Gleditschia triacanthos*, *Robinia pseudacacia*, and *Agropyron repens*. His work also includes pictures of cross-sections of roots where the mycelium has forced its way in. Whether parasitism or the formation of mycorrhiza occurs in this case is difficult to judge. Information about the damage wrought by *Phallaceae* comes from Hawaii and Java (FISCHER 1933). FISCHER men-

tioned that *Phallus coralloides, celebicus* and *Colonnaria columnata* appeared as root-destroyers on the roots of sugar cane.

The question of *Ph. Hadriani*'s character as a parasite, a saprophyte, or a mycorrhiza-fungus is still open to discussion. I, myself, am inclined to believe that *Ph. Hadriani* is a mycorrhiza-fungus with certain xerophytic grasses, e.g., *Ammophila arenaria, Agropyron repens* and *Elymus arenarius* and certain lignicolous plants, e.g. *Vitis, Gleditschia triacanthos* and *Robinia pseudacacia*, but that it can also live as a saprophyte.

Scandinavian Distribution.

Sweden.

Skåne. Falsterbo, X.1944, GUSTAF RUDEBECK. — Ystad, Ystad's beach, 24.VI.1945, OLOF ANDERSSON. — Båstad, Malen, 7.X.1945, OLOF ANDERSSON. — Löderup, Löderup's beach, 15.X.1945, OLOF ANDERSSON. — Strövelstorp, Vegeholm, in sand-dunes, 23.VIII.1948, ALLAN NILSSON.

Halland. Ö. Karup, near the mouth of the river Stensån, 7.X. 1945, OLOF ANDERSSON. — Falkenberg, Falkenberg's beach, 2.X.1948, OLOF ANDERSSON.

Gotland. Fårön, Ulla hau, 30.VII.1931, K. G. RIDELIUS (in letter). — Gotska Sandön, BENGT PETTERSSON.

Denmark.

Jutland. Ulslø in Bordrup Plantage, 3.IX.1929, N. F. BUCHWALD. — *Sjælland.* Tisvilde Hegn, 11.X.1947, OLOF ANDERSSON and MORTEN LANGE, 31.X.1947 (MORTEN LANGE 1950).

Extra-Scandinavian Distribution. — ULBRICH's (l.c.) setting up of three section areas, the European, the Asiatic and the North American, for *Phallus impudicus* is no longer valid, owing to the delimitation which is now given to the species. The forest species *Ph. impudicus* is distributed in Europe, North Africa (?) and East Asia (?), but is not found in the U.S.A. The sand species *Ph. Hadriani*, however, is found in Europe, North Africa and the U.S.A.

As is seen on the map (fig. 16) *Ph. Hadriani* has an extensive distribution in Europe and the U.S.A. and a small area in north-western Africa. Its European area stretches from England in the west to the Caucasus in the East, from Sweden and Estonia in the north to Italy and Portugal in the south. It probably also occurs on the southern steppes of Russia,

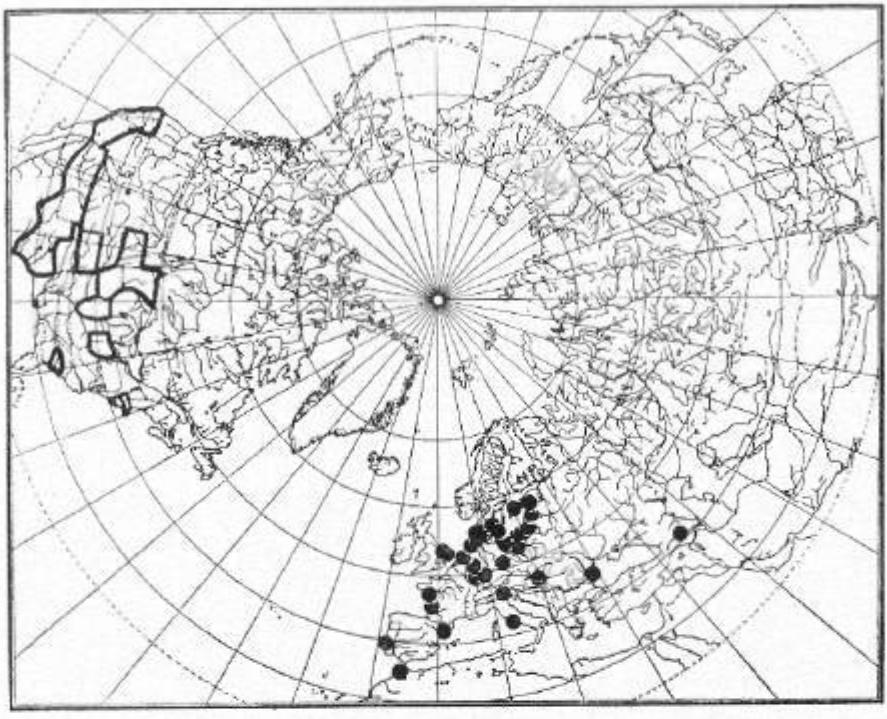

Fig. 16. The total area of distribution of *Phallus Hadriani*.

but neither herbarium specimens nor information from literature dealing with this subject could be found. The Tiflis locality is unreasonably isolated. Its North African area only includes Morocco and Algeria (MAIRE and WERNER 1937).

Its North American area stretches from the Pacific in the west to the Atlantic in the east, from south-east Canada in the north to Texas in the south, with the main point of its distribution west of the Mississippi.

Geaster Drummondii BERK.

Description — (See TH. C. E. FRIES 1921.)

Ecology and distribution. — This species, characterized by its hygroscopic exoperidium, is a typical steppe fungus. In Scandinavia it has only been known from three localities in the Uppsala region. The present writer found it in 1946 on sandy soil along a road near the sea in Oskarshamn (Småland).

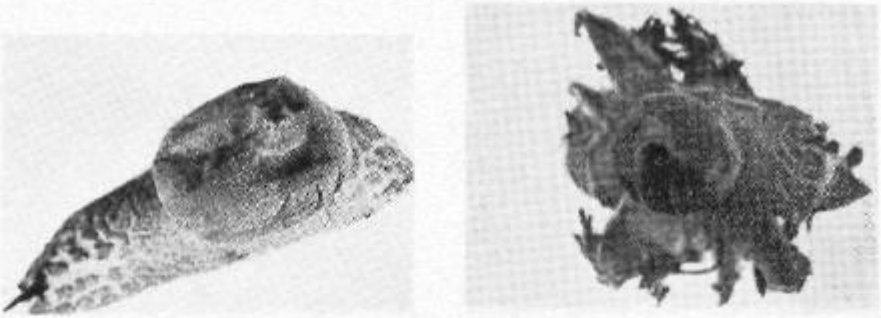

Fig. 17. *Geaster minimus* from Gotland. × 2.

In Europe it is reported from Hungary, Kaukasus and Germany (HOLLÓS l.c.). Outside Europe it is known from Australia and Tasmania (CUNNINGHAM 1946), South Africa (BOTTOMLEY l.c.), North America [New Jersey] and South America [Bolivia] (HOLLÓS l.c.).

Geaster fimbriatus FR.

Description. — (TH. C. E. FRIES 1921).

Ecology and distribution. — This species occurs generally in woods. The present writer, however, has found it in a characteristic *Koeleria glauca*-community in eastern Scania among *Tulostoma brumale*, *Geaster minimus*, *G. nanus* and *Disciseda Bovista*. It may consequently be characterized as a facultative sand fungus.

Geaster minimus SCHWEIN.

Description. — *Exoperidium* revolute, 1—3 cm. in diam., splitting approximately half-way into 7—10 acuminated rays, not *fornicate*; mycelial layer adnate with adhering sand particles and vegetable debris, not forming a basal cup; fleshy layer ochraceous — whitish, cracked, but not peeling off.

Endoperidium subglobose, 0.5—1.5 cm., when fresh sessile, when dry pedicellate, grey or buff, when young covered with whitish granules; apophysis generally well developed; peristome conical, fimbriate, outline surrounded by a definite groove.

Gleba umber brown. *Capillitium* threads paler than the spores 3—4 μ in diam.

Spores globose, 4.5—5 μ, brown, sparsely verrucose.

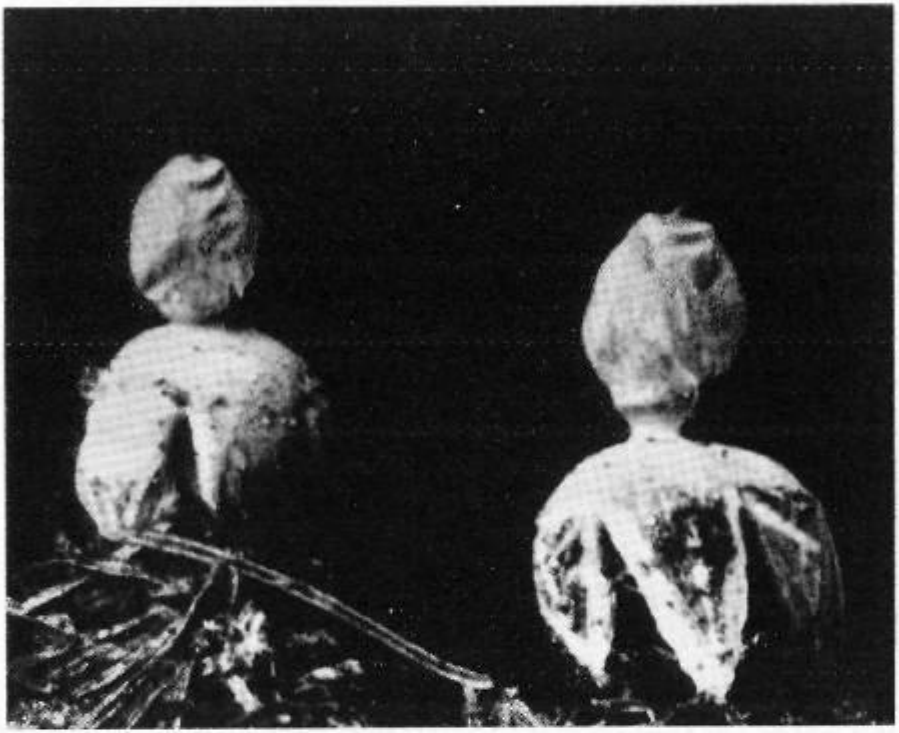

Fig. 18. *Geaster quadrifidus*. There is a striking difference between this species and *G. minimus*. (Cf. fig. 18 and the text).

Taxonomical notes. — The delimitation of this species has been much discussed. COKER (1923—24) and COKER and COUCH (1928) considered *Geaster minimus* and *Geaster quadrifidus* (=*G. coronatus*) to be identical. CUNNINGHAM (1944) was of the same opinion and treated them under the name *G. minus* (PERS.). According to CUNNINGHAM the species is very variable and the different »types» of exoperidium, expanded (»*G. minimus*»), fornicate (»*G. coronatus*»), hygroscopic (»*G. arenarius*») and saccate (tending to »*G. triplex*») represent only different forms of the same species. As to the peristome he wrote »seated on a flattened silky zone outlined by a depressed groove, or the zone may be incident and the groove absent». Concerning the spore size he said »two types can be distinguished, one with spores averaging 5—6.5 μ, the other 3.5—4 μ». In his diagnosis, however, he stated »spores 4.5—6.5 μ»! CUNNINGHAM's argument cannot be accepted, even if

one has a wide species concept. *G. minimus* and *G. quadrifidus* are alike in some characteristics, but essential features separate them. *G. minimus* has a smaller size, is not fornicate, has 7—10 exoperidium-rays. Its spores are larger 3.5—5 μ and darker. *G. quadrifidus* is fornicate and has only 4(5) exoperidium-rays. Its spore size is 2.5—3.5 μ. (For comparison see figs. 17, 18). In my opinion they are clearly distinct from each other. M. LANGE (1948b) as well as BOTTOMLEY (1948) found no reason for uniting the species.

History. — TH. C. E. FRIES (1912, 1921b) stated that this species has only been found once in Sweden, at Krokek in Marmorbruket in Östergötland. In recent years it has been discovered in several Swedish localities, in Uppland (SANDBERG 1940), Västmanland (DEGELIUS 1943), Lappland (HERTZ 1947), Bohuslän (ERLANDSSON 1948) and Gotland (SANDBERG in letter). To these can now be added also three localities in Scania.

Ecology. — We have very little information about the ecology of *G. minimus*. SANDBERG (1940) has, however, made certain sociological analyses and investigations of the soil at Billudden (Uppland). He concluded that *G. minimus* seems to be dependent on lime. SANDBERG's surmise is probably correct. The map of *G. minimus* in north-western Europe shows that it only occurs in districts where the rocky or loose strata contain lime.

The substratum of the Scanian places have a relatively high lime content. The substratum of its localities in Lappland consist of dolomite.

G. minimus occurs in Scania in typical sand-grass-heaths (Concerning their composition see pag. 72).

Descriptions of its habitats from abroad give us little information. Thus HOLLÓS (l.c.) [orig. German]: (»It grows on grassy soil, in *sandy* [underlining by O. ANDERSSON] places or in pine-woods between fallen leaves.»). EYNDHOVEN (1937b, 1942) mentioned »Dunes», »Dune-heaths» as places for growth and also mentioned a few plants which grow with it, e.g., *Hippophae rhamnoides*. M. LANGE (l.c.), who found *G. minimus* in Greenland described it as follows: »On south slope (20° S) on very dry loess, under isolated *Salix glauca*, in sparse ground vegetation (*Calamagrostis purpurascens, Carex supina*) and a poorly developed leaf layer.» According to BOTTOMLEY (l.c.) it grows amongst debris under bushes and in open ground. All the South African localities lie, however, in arid regions.

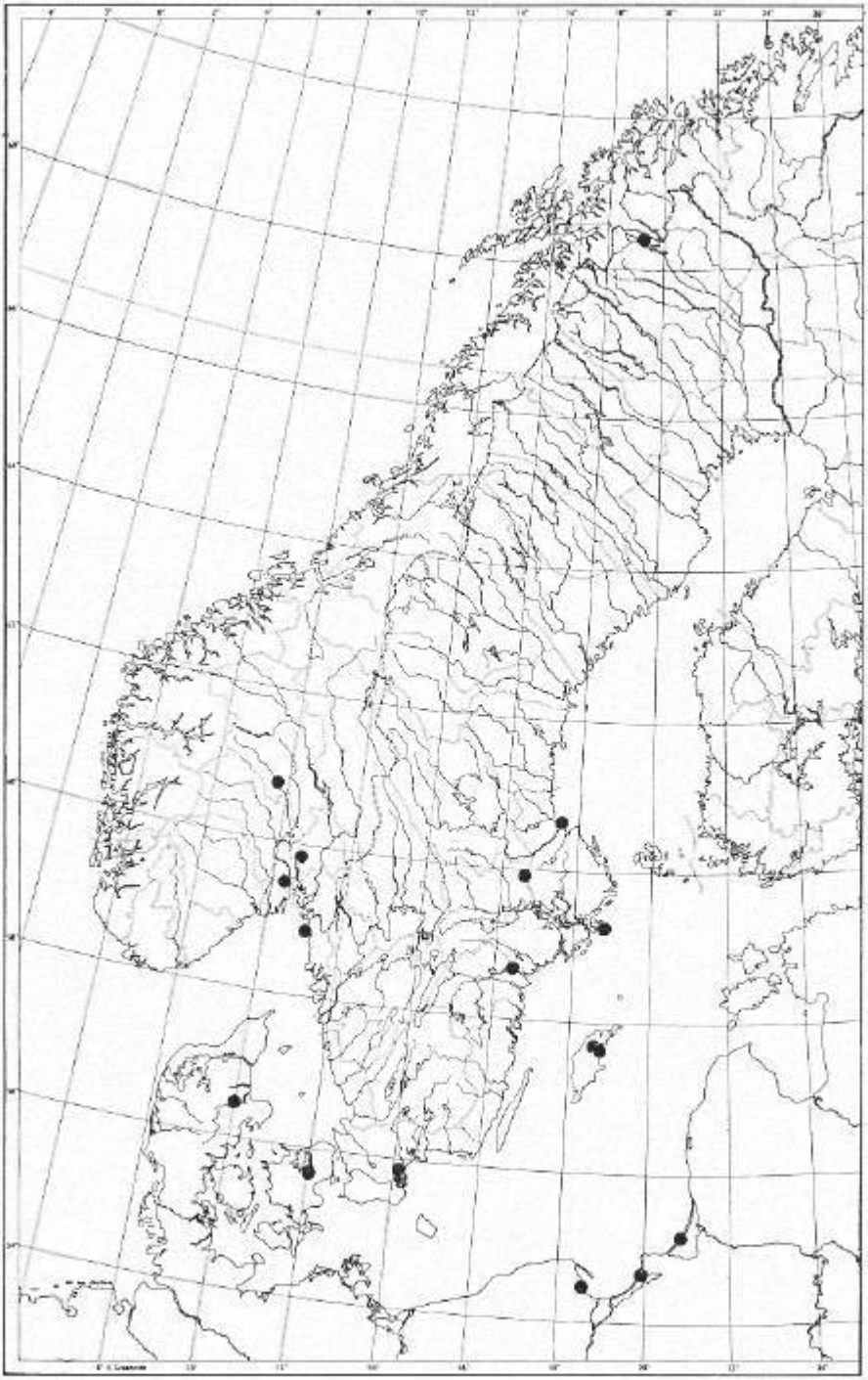

Fig. 19. *Geaster minimus* in Scandinavia.

Scandinavian Distribution.

Sweden.

Skåne. Vitaby, Vitemölla, in the summer 1947, FENNIA FRIES (S.); in sand-dunes, Aug. 1947, ROB. E. FRIES (S.). — Ravlunda, Haväng-Knäbäck, sand-hill, amongst *Anthericum Liliago, Astragalus arenarius, Tulostoma brumale* and *Geaster nanus*, 20.VII.1946, OLOF ANDERSSON (L.). — Vittskövle, »Vittskövle Driva», amongst *Anthericum Liliago, Astragalus arenarius* and *Tulostoma brumale*, 16.VII.1945, OLOF ANDERSSON (L.).

Gotland. Boge, Tjelders, 15.VIII.1910, GUNNAR ROMELL (S.). — Hejnum, »Hejnum hällar», lime rock at »Räumhajdsgalten», NE of the church, 30.V.1946, BO PETERSON (S.). — Gothem, at the mouth of the river Gothemsån, in *Thymus Serpyllum*-community 1946, GUSTAF SANDBERG (in letter).

Östergötland. Krokek, Marmorbruket, 1. IX. 1890. VIII. 1892, G. MALME (U.).

Bohuslän. Kärnö, Syd-Koster, Kilesand, sandy beach, 5.VII.1947, STELLAN ERLANDSSON (S.).

Västmanland. Sala, near Ulricelund, open area in *Corylus Avellana-Populus*-grove at Västeråsvägen, 24.IX.1942 (S., U.); Gruvan, Aspenstorp, amongst pine-needles, at the edge of pine-wood with foliiferous woods and shrubs 17.IX.1942, GUNNAR DEGELIUS (S.).

Uppland. Djurö, Runmarö, Nore, 3.XI.1946, R. RYDBERG (S.). — Älvkarleby, Billan, on a sandy area with *Juniperus*, on calcareous sand, VIII.1929, 6.X.40, G. SANDBERG (S., U.); Billudden, at the south part of the Sågarboviken, 30.IX.1945, ibid. (U.); Billudden, Billskaten, 29.IX. 1946, R. SANTESSON (U.).

Torne lappmark. Kiruna, Ortovare (HERTZ l.c.).

Denmark.

Sjælland. Boserup at Roskilde (FERDINANDSEN and WINGE 1943).

Jutland. Randers, Volk molle (FERDINANDSEN and WINGE l.c.).

Norway.

Opland. Sondre Aurdal in Bangslien, 1869, CHR. SOMMERFELT (U.).

Extra-Scandinavian Distribution. — *Geaster minimus* has a world-wide distribution, but as the synonymy is very confused our knowledge of its total area is greatly limited. From Europe it is known in Poland (TEODOROWICZ 1936), Germany (GRAMBERG 1923), Holland (EYND-

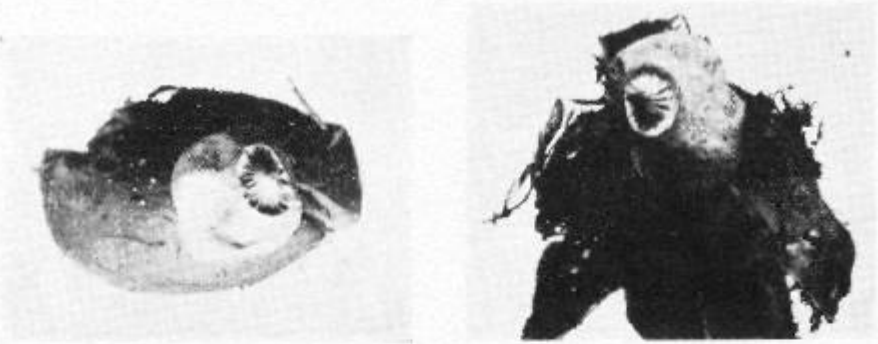

Fig. 20. *Geaster nanus* from Ravlunda, Haväng. × 2. (Note the sulcate mouth!)

HGVEN 1937), France (HOLLÓS 1904), Switzerland (HOLLÓS l.c.), Austria (HOLLÓS l.c.), Czechoslovakia (SMÝR 1926), Hungary (HOLLÓS l.c.), and Jugoslavia (HOLLÓS l.c.).

According to LLOYD (1902), COKER and COUCH (l.c.) *G. minimus* is widely distributed in the United States. It also occurs in Canada, Jamaica and Mexico. In South America it is only known from Ecuador. *Geaster minimus* is the only species of the genus that hitherto has been found in Greenland (M. LANGE l.c.). From Asia only a few records are known. Tiflis (HOLLÓS l.c.), Japan and India (BOTTOMLEY l.c.). I myself have seen specimens from China (in the Herb. of Helsingfors sub nom. *G. granulosus*).

CLELAND (1934) and CUNNINGHAM (1944) reported it from South, Central and Western Australia, Tasmania and N. Zealand.

From Africa *G. minimus* is hitherto only known in South Africa (BOTTOMLEY l.c.).

Geaster nanus PERS.

Description. — *Exoperidium* 1.5—3 cm., split up to the middle into 5—8 acuminate rays; *fleshy layer* adnate, smooth or sometimes cracked, ochraceous to umber brown; *mycelial layer* persistent with adhering sand particles and vegetable debris.

Endoperidium 0.5—1 cm., subglobose or oval, pedicellate with a pronounced apophysis, light umber brown with a whitish farinose covering; *peristome* well-defined, depressed, with a sulcate mouth.

Gleba dark umber brown. *Capillitium* threads 5—7 μ in diam.

Spores spherical, verrucose, brown, 4.5—6 μ.

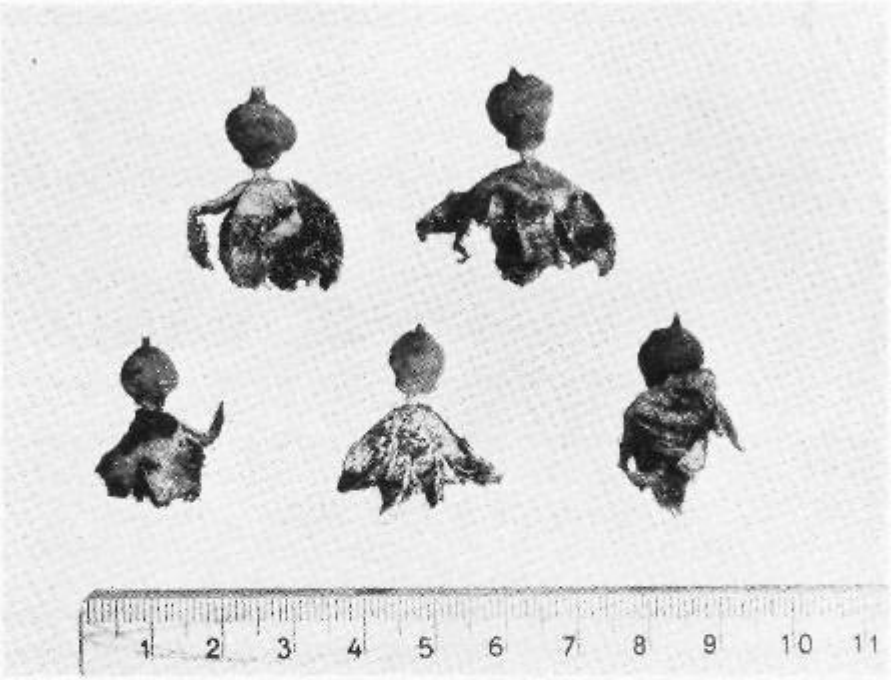

Fig. 21. *Geaster nanus* from Ravlunda, Skepparp.

Taxonomical notes. — *G. nanus* is well separated from *G. minimus* by its sulcate mouth and larger, strongly verrucose spores. GUNNINGHAM (1944) excluded *G. nanus* as a separate species and referred it to *G. pectinatus*. In accordance with HOLLÓS (l.c.), COKER and COUCH (l.c.), and BOTTOMLEY (l.c.) I consider *G. nanus* as a distinct species though it cannot be denied that the species are nearly related. COKER and COUCH (l.c.) do not know the diagnosis of PERSOON as they call it *G. Schmidelii* VITT. and mention only a synonym *G. Rabenhorstii* KUNZE.

History. — The first find of *G. nanus* in Sweden was made by H. KUGELBERG in the year 1889 (TH. C. E. FRIES 1921). It has been observed in Öland, Gotland, Uppsala, and Bohuslän. In recent years it has been discovered in Scania.

Ecology. — From an ecological point of view *G. minimus* and *G. nanus* are closely related, as they both are local characteristic species in the Scanian sand-grass-heath (see page 72). The map shows that

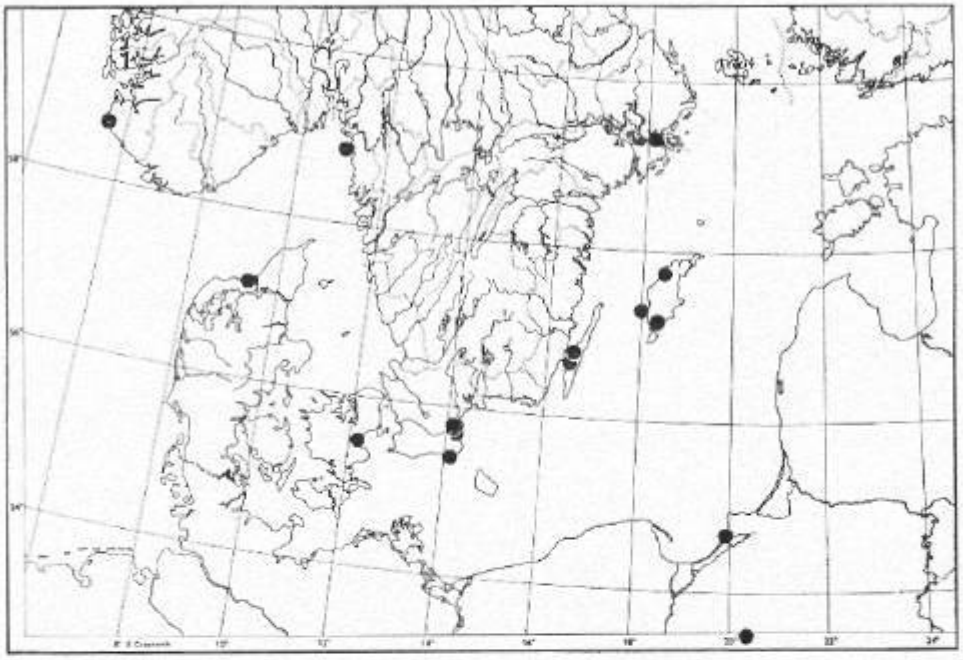

Fig. 22. *Geaster nanus* in Scandinavia. (The Uppsala-locality not mapped).

G. nanus, as well as *G. minimus*, are confined to districts where the rocky or loose strata contain lime.

From abroad there are no special descriptions of the habitat of *G. nanus*, but the information given provides an indication of the general characteristics of the habitats. According to HOLLÓS (l.c.) it grows »in the sandy heaths of the Hungarian plains, between grass and wooded places, mostly in the moss.» In Switzerland (FAVRE et RUHLÉ 1947) it is said to occur together with *Tulostoma brumale*, *T. granulosum*, *Disciseda candida* and *Stipa capillata*.

Scandinavian Distribution.

Sweden.

Skåne. Löderup, Löderup's beach, on sand-fields and sand-hills, 2.X.1946, OLOF ANDERSSON (L.). — Vitaby, Vitemölla, sand-fields, in the summer 1944, FENNIA FRIES; Aug. 1947, ROB. E. FRIES, 15.XI.1947, OLOF ANDERSSON (L.). — Ravlunda, Knäbäck-Havång, sand-hills,

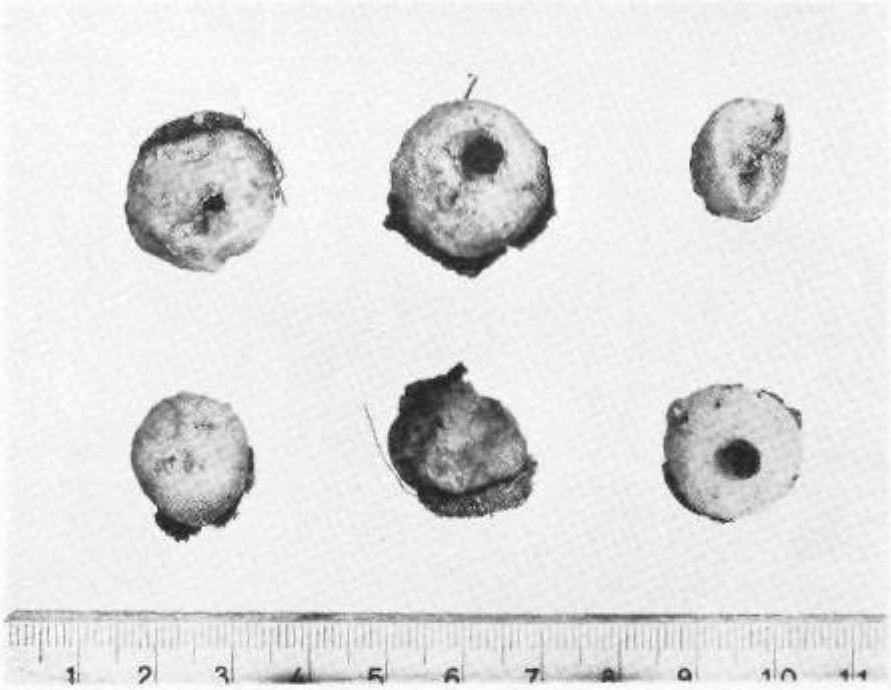

Fig. 23. *Disciseda Bovista* from Ravlunda, Skepparp.

10.XI.1948, OLOF ANDERSSON (L.); Kungsmölla, on sand-hills in *Koeleria glauca* - community, 24.IV.1948, OLOF ANDERSSON and ANN-MARIE BRÜDIGAM (L.). — Brösarp, in the neighbourhood of the railway station, 6.VII.1945, OLOF ANDERSSON (L.). — Maglehem, 1 km W of the church, sand-hills, 20.VII.1948, OLOF ANDERSSON and ANN-MARIE BRÜDIGAM (L.); L. Juleboda, sand-hill, together with *Tulostoma brumale*, 19.III.1948, OLOF ANDERSSON and ANN-MARIE BRÜDIGAM (L.).

Öland. Between Färjestaden and Torslunda, growing on sandy soil, together with i.a. *Pulsatilla pratensis*, 13.IV.1913, S. G:SON BLOMQUIST (U.). — Stora Rör, 1912, G. LAGERHEIM (TH. C. E. FRIES l.c.).

Gotland. Stora Karlsö, on the »Alvaret», 11.V.1913, R. SERNANDER (U.). — Martebo, Snaldarve, the »Ancylusvallen», 1.VI.1914, R. SERNANDER (U.). — Hardhem, Lingvide, pine-wood on sand, 28.VII. 1945, BENGT PETTERSSON (U.). — Grötlingbo, Sandes, on a previously cultivated sand-field amongst *Corynephorus canescens* 28.V.1946, BENGT PETTERSSON (U., S.), LUNDELL & NANNFELDT Fungi Exs. Ups. 1440.

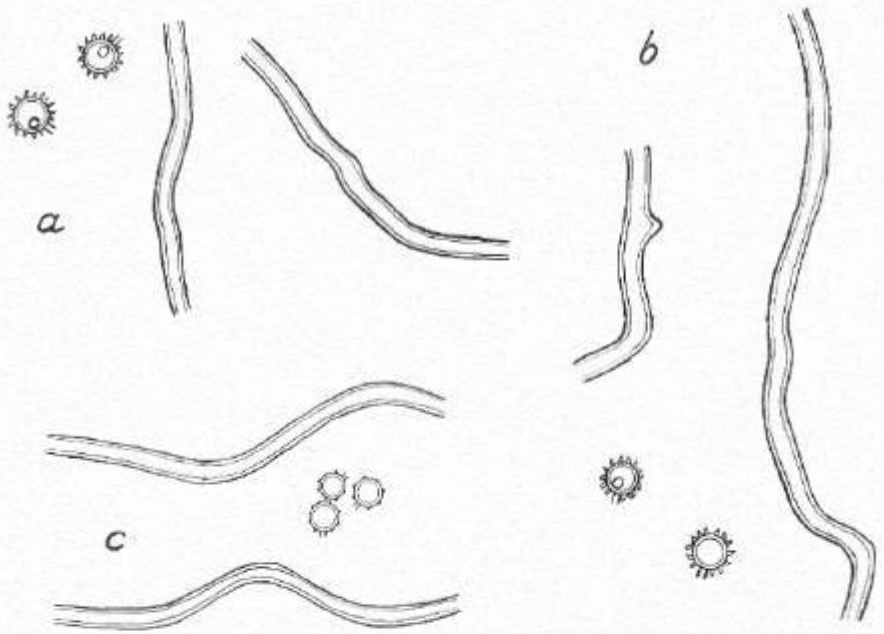

Fig. 24. Capillitium threads and spores of *Disciseda Bovista*, collected by CZERNIAÏEV. (Specimens in the Herb. of Uppsala). (× 600). — b. Capillitium threads and spores of *Disciseda Bovista* from Ravlunda, Skepparp. (× 600). — c. Capillitium threads and spores of *Disciseda candida*. (× 600).

Bohuslän. Kärnö, Syd-Koster, Kilesand, sandy beach, 5.VII.1947, STELLAN ERLANDSSON (S.).

Stockholm. Djurgården, IX.1889, K. KUGELBERG (S.).

Uppland. Uppsala, in the »Långhagen», 1890, K. HEDLUND (TH. C. E. FRIES l.c.).

Denmark.

Sjælland. Svinkløv and Slettestrand (FERDINANDSEN and WINGE 1943).

Extra-Scandinavian Distribution. — Like *G. minimus*, *G. nanus* has an extensive area. In the rest of Europe it is known from Poland (TEODOROWICZ 1936), Holland (EYNDHOVEN l.c.), Germany (GRAMBERG l.c.), France (CORBIÈRE 1924—29), Switzerland (FAVRE et RUHLÉ l.c.), Italy (PETRI 1909), Hungary (HOLLÓS l.c.).

According to LLOYD (1902) and COKER and COUCH (l.c.) *G. nanus*

occurs in the United States (sub. nom. *G. Schmidelii*), but it seems to be much rarer than *G. minimus*. It is known only from North Carolina, Virginia, New Jersey, Nebraska, Texas and Cuba.

CUNNINGHAM (l.c.) reported it from Australia and BOTTOMLEY (l.c.) from South Africa.

Disciseda Bovista (KLOTZSCH) KAMBLY

Description. — *Exoperidium* 1—3 cm., depressed globose brittle, the apical part disappearing, encrusted with sand particles, blackish-brown.

Endoperidium of roughly the same shape, smooth, leathery, opening with a pore, whitish to grey.

Gleba olive—brown.

Capillitium threads thick-walled, broken into lesser pieces, 3—4 μ thick.

Spores spherical, strongly warted, generally provided with a short pedicel, 6—9 μ.

Taxonomical notes and history. — The species occurs under many names in the literature, and as the descriptions, especially the older ones, are not comprehensive, considerable trouble has arisen in deciding the synonymy and the distribution of the species.

A commendable effort was made by EYNDHOVEN (1942), and therefore I shall only review his work briefly and add some supplementary material.

The genus *Disciseda* was defined by CZERNIAÏEV (1845), who gave the following description: »Capillitium filamenta simplicia, aequalia, parcu, sporidiis conspersa; Peridium duplex, exterius volvaceum, in basin disciformem, pededentim descendens, interius membranaceum, ostiolo dehiscens Morphosis subterranea.» To this genus he also added the species *collabescens*, *compacta* and *mollis*. He gave a very scanty description of these, however, and did not complete it with pictures. *D. compacta* is considered, among others, by TH. C. E. FRIES (1918, 1921) as synonymous with *D. Bovista*. It seems very probable that this is the case, because CZERNIAÏEV (l.c.) wrote that *D. compacta* was similar to *Bovista plumbea*, but his description can apply equally well to *D. candida*. ROB. E. FRIES (1909), however, stated that there is a rich material of CZERNIAÏEV's *compacta* in the Botanical Museum at Uppsala (Herb. E. FRIES), collected by CZERNIAÏEV himself in Ukraine. According to FRIES *compacta* is the same species as described by

HOLLÓS (1904 sub nom. *debreceniensis*) and MORGAN (1892 sub nom. *subterranea*). I have studied CZERNIAÏEV's collection of *compacta* and there is no doubt that it is identical with *D. Bovista*.

Three years before CZERNIAÏEV had defined the genus *Disciseda*, *D. Bovista* had been described by KLOTZSCH (1843) sub nom. *Geaster Bovista*, from material collected in Peru. KLOTZSCH's material, which was preserved, has been investigated by HOLLÓS and found to agree with *D. debreceniensis* (= *D. Bovista*) (HENNINGS 1901, EYNDHOVEN l.c.).

KLOTZSCH's description reads in extenso: »*Geaster* FRIES .1. p. 8 . . . *Geaster Bovista*. Peridio exteriori paucifido, flaccido, brevi; interiori sessili, globoso, tenui, papyraceo, argenteo-caesio, nitido, ore subplano, dentato-lacero, nudo.

Peridium exterius tenue, flaccidum, usque ad medium in lacinias (5—6) extus umbrinum, aut saturate fuscum, intus sordide albidum, peridio interiore duplo brevius, radiis bifidis. Peridium interius sessile, globosum, tenuissimum, glabrum, argenteo-caesium, nitidum, $^1/_2$ unc. vix latum. Ostiolum planum, demum inaequaliter dentato-lacerum, nudum. Capillitium argillaceo-fuscum. Sporidia globosa, sessilia, uninucleata, sordide fusca.

Ad terram circa Pisocomam in altis Peruviae.«

HAZSLINSKY (1877) did not know either CZERNIAÏEV's or KLOTZSCH's works, and for this reason he described *Disciseda Bovista* as new to science under the name of *Globaria debreceniensis*. SOROKIN (1890) placed it under *Bovista plumbea*. A careful examination of SOROKIN's description and pictures makes it obvious that *D. Bovista* was intended.

In America the species was first described by PECK (1879), who also placed it under the genus *Bovista* and calls it *B. subterranea*. MORGAN (1891—92) founded an entirely new genus, *Catastoma*, and called the species *C. subterranea*. HENNINGS (l.c.) adopted this genus name and introduced the combination *Catostoma Bovista*.

HOLLÓS (1903) discovered CZERNIAÏEV's work and brought to light the latter's description of the genus *Disciseda*. HOLLÓS (l.c.) called the species *D. debreceniensis*. Later (1904), however, he maintained that *D. debreceniensis* was synonymous with *Geaster Bovista*. In accordance with the Rules of Botanical Nomenclature the species name *Bovista* should have priority, but HOLLÓS inconsequently keeps to *D. debreceniensis*. CUNNINGHAM (1927) considered *D. cervina*, described by BERKELEY from material collected by DARWIN in Patagonia, to be identical with *D. debreceniensis*. EYNDHOVEN (l.c.), however,

has investigated the type material of *D. cervina* and found that it does not agree with *D. debreceniensis* (= *D. Bovista*). The correct name of the species should be *D. Bovista*. This combination was first used by KAMBLY (KAMBLY and LEE 1936).

The genus *Disciseda* was reported as new in Scandinavia by TH. C. E. FRIES (1918). He reported the discovery of two species, *D. compacta* (= *Bovista*) and *D. circumscissa* (= *candida*) from Slottsbacken in Uppsala. This locality has been destroyed, but both species have been found again later in a neighbouring locality. For nearly thirty years Uppsala has been the only known Scandinavian place where it has been found. In the year 1946, however, *D. Bovista* was found in Scania.

Ecology. — Any accurate description of the milieu in which *D. Bovista* occurs has not previously been made. Sociological analyses of the Scanian habitats and certain investigations of the chemical and physical nature of the substratum have now been made. In Scania *D. Bovista* is a characteristic species in the sand grass heaths, constituted mainly of continental flora-elements (cf. table 3 and p. 72).

HOLLÓS mentioned it as very typical of Hungary's »Sandpuszta» and also speaks of having found it 1200 m. above sea-level. *D. Bovista*, together with *D. candida*, *Secotium agaricoides*, *Mycenastrum Corium*, *Astraeus stellatus*, *Tulostoma brumale* and *T. granulosum*, were included in the myco-sociological analyses, carried out by DE UBRISZY (1943) in the communities of »*Festucetum vaginatae*» and »*Brometum tectorum*», which are distinguished by their xerophytical character. Concerning its Dutch locality EYNDHOVEN (l.c.) wrote: ». . . The locality is very interesting, as there is a fine vegetation of *Geastrum nanum* PERS. and of *Geastrum badium* PERS.» The scanty information about the habitat's characteristics in America resemble European conditions. »Growing in thick sandy soil», according to MORGAN (l.c.). It is interesting to note the occurrence of *D. Bovista* in dry, sandy soil in Puna de Jujuy, 5000 m. above sea-level, in South America (ROB. E. FRIES 1904).

Scandinavian Distribution. — In Scandinavia *D. Bovista* is only known from Sweden. Its area resembles that of *Tulostoma granulosum* as it does not occur on Öland or Gotland.

Sweden.

Skåne. Åhus, S of Horna Railway station, sand-field, 23.IX. 1946, OLOF ANDERSSON and ANN-MARIE BRÜDIGAM; RYDBERG (1949). —

Fig. 25. The total distribution of *Disciseda Bovista*.

Maglehem, 1 km E of the church, sand-hill, 21.VII.1947, OLOF ANDERSSON. — Ravlunda, Kungsmölla, sand-hill, 24.IV.1948, OLOF ANDERSSON and ANN-MARIE BRÜDIGAM; Haväng-Knäbäck, sand-field, 10.XI.1948, ANN-MARIE BRÜDIGAM; Haväng, on sand-field, March 1949 (RYDBERG l.c.). — Löderup, Löderup's beach, on sand-hills, Feb. 1947 (RYDBERG l.c.). — Degeberga, 1 km. SW of the church, 27.II.1950, OLOF ANDERSSON.

Uppland. Uppsala, Slottsbacken, on the football field, IX.1912, IV. 1917, TH. C. E. FRIES (U.); Polacksbacken, 18.X.1938, H. SMITH; about 200 m. E of the end station of the tramway, sandy soil, X.1934, GUSTAF SANDBERG (U.).

Extra-Scandinavian Distribution. — Like many other sand-fungi *D. Bovista* has a bihemispherical distribution.

In Europe it is known from France (LLOYD 1906), Germany (HOLLÓS l.c.). HOLLÓS reported many localities from Hungary. It has also been recorded from Caucasus.

Only a few localities are known from Asia, Ak-Tube (HOLLÓS l.c.) and Siberia, prov. Jeniseisk, distr. Minusinsk (leg. A. JAVORSKI, in Herb. S.).

In the United States it is distributed mainly in the western and

central parts. LLOYD (1902) and COKER and COUCH (1928) recorded it from the following states: Colorado, Kansas, Michigan, Minnesota, Nebraska, Washington, Wyoming and South Carolina. To these can be added Arizona, California, North Carolina, North and South Dakota, Iowa, Idaho, Montana, New Mexico, Oklahoma, Oregon, Texas, Utah (LONG in letter). COKER and COUCH (l.c.) gave also a record from Canada.

In South America there are only a few localities known from Peru (KLOTZSCH l.c.), Argentina (ROB. FRIES l.c.), Chile and Bolivia (LLOYD 1906).

BOTTOMLEY recorded it from South Africa (sub nom. *D. cervina*).

CUNNINGHAM (1926, 1944) and CLELAND (1934) reported it from Australia and New Zealand.

Disciseda candida (SCHWEIN.) LLOYD.

Description. — *Exoperidium* depressed globose, 0.7—2 cm., brittle, the apical part breaking away circumscissilely, the basal part persisting as a small, irregular sand-incrusted cup, blackish-brown.

Endoperidium of the same shape, ash-grey, finally brownish; dehiscing by an apical, fimbriate mammose mouth.

Gleba olivaceous-pale brown. *Capillitium* threads 3.5—5.5(—6) μ, almost hyaline to pale brown.

Spores globose, 4—5.5 μ, almost smooth or finally and sparsely warted, without or with a stump of the pedicel.

Taxonomical notes. — Macroscopically *D. Bovista* and *D. candida* resemble each other so closely that a differentiation is difficult, but the ornamentation and size of the spores distinguish them from each other.

History. — *D. candida*, as already has been pointed out, was known in Sweden for thirty years only from Uppsala. During latter years it has also been recorded from Scania (RYDBERG l.c.). According to RYDBERG the first find of *D. candida* in Sweden was made by ROMELL in Stockholm (sub. nom. *Bovista plumbea*).

Ecology. — It belongs to the same ecological and phytogeographical group as *D. Bovista*. From Sweden there exists no detailed description of its milieu, but the localities in Scania («sand-hills») indicate the ecological relation between the species.

FAVRE and RUHLÉ (l.c.) classified it as a typical steppe-fungus, which in Switzerland appears together with, among others, *Stipa capillata*, *T. brunale*, and *T. granulosum* as well as *Geaster nanus*. HOLLÓS (l.c.) mentioned it as characteristic of the »Sandpuszta» of Hungary.

Scandinavian Distribution.

S w e d e n.

Skåne. Ravlunda, Haväng, on sand-hills, March 1949 (RYDBERG l.c.). — Löderup, Löderup's beach, on sand-hills, Feb. 1947 (RYDBERG l.c.). — Falsterbo, 10.X.1946, OLOF ANDERSSON.

Stockholm. Ladugårdsgärde, 4 April, 1894, LARS ROMELL (sub nom. *Bovista plumbea*) (S.). — Fiskartorpet, side of road, July—Aug. 1948 (RYDBERG l.c.).

Uppland. — Uppsala, Slottsbacken, IX.1912, TH. C. E. FRIES (U.); about 200 m E of the end station of the tramway, sandy soil, X.1934, 5.X.1945, GUSTAF SANDBERG; 18.X.1938 H. SMITH (U.).

Extra-Scandinavian Distribution. — *D. candida* seems to be much rarer in Europe than *D. Bovista*.

It has been reported from many localities in Hungary (HOLLÓS l.c., MOESZ l.c.). ALEXANDRI (1934) recorded it from Rumania. It is also known from Mähren (Herb. Stockholm).

From Asia it was recorded by SOROKIN (l.c.). HOLLÓS (l.c.) also mentioned it from Ural, but without any definite locality.

Like *D. Bovista* it occurs in many states of America (LLOYD l.c., COKER and COUCH l.c.), and has also been reported from Mexico.

According to a note (671) by LLOYD (1916—1919) it has been found in South America: in Argentina, Uruguay, Chile and Brazil.

BOTTOMLEY (l.c.) reported it from South Africa and CUNNINGHAM (l.c.) from Australia and New Zealand.

Disciseda pedicellata (MORGAN) HOLLÓS

Description. — (See COKER and COUCH l.c.)

Taxonomical notes. — I have not seen the Swedish material, collected by RYDBERG, for which reason I cannot with certainty decide if *D. pedicellata* is a good species. It seems to be nearly related to *D. Bovista*, of which it is possibly only a variety. RYDBERG (l.c.) writes that the spores have »a short pedicel rarely up to 7 μ.» As RYDBERG does not

Fig. 25. *Tulostoma brumale* from Ravlunda, Knäbäck. (× 4). — Photo OSCAR GEHLIN.

refer to other papers than MORGAN's (1892), I will here call attention to the descriptions of GUNNINGHAM (1944) and BOTTOMLEY (l.c.) which state that the length of the pedicels is 10 μ or more. As maximum length they state 25 and 37.4 μ respectively.

Ecology and distribution. — RYDBERG (l.c.) reports it from only one locality, Löderup in Scania, where it occurs on sand-hills. Like other *Disciseda* species it seems to be an obligate sand fungus. It is distributed in Europe, South Africa, Australia and North America.

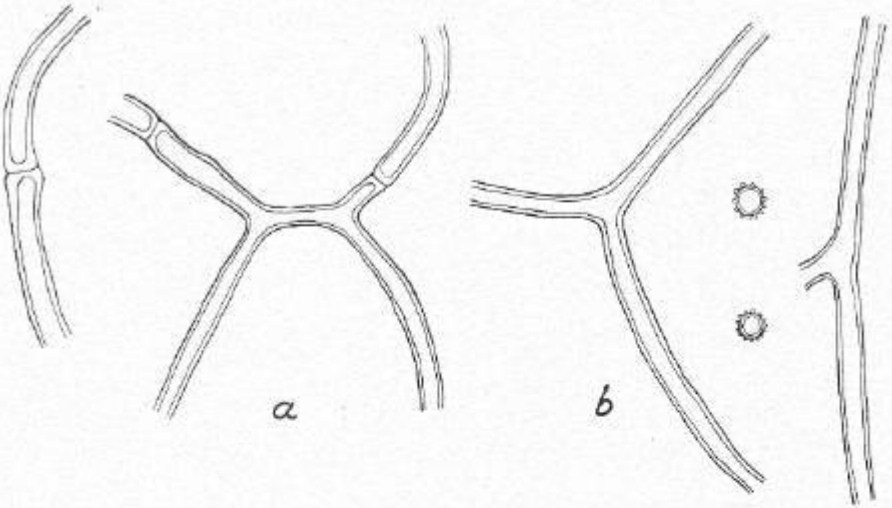

Fig. 27. a. Capillitium threads of *Tulostoma brumale*. (× 650). — b. Capillitium threads and spores of *Tulostoma granulosum*. (× 600).

Tulostoma brumale Pers.

Description. — *Exoperidium* globose to depressed globose, 6—10 mm. diam., brittle, finally disappearing from most of the upper part and only persisting at the base, dark brown.

Endoperidium of the same shape, 0.5—10 mm., membranaceous, greyish white or pale brown. Stoma 1—1.5 mm., short tubular, round, margin entire, typically darker than the rest of the peridium.

Stem 2—4 cm., smooth or slightly scaly, not or somewhat striate, fistulose, chestnut brown or bay brown, with a basal mycelial bulb.

Gleba rust-coloured. *Capillitium* threads septate, septa somewhat swollen, branched, 5.5—6.5 μ.

Spores globose, 4.5—6 μ, ochraceous brown, strongly but generally sparsely echinulate.

Taxonomical notes. — Whether *T. brumale* consists of a number of »micro species», is difficult to say. I have found the Scandinavian population quite uniform. In my opinion the variation of the microscopical and macroscopical characteristics lies within the normal variation range. Rydberg (l.c.) mentioned i.a., *T. floridanum* as new to Sweden. I have not seen Rydberg's material, but *T. floridanum* according to Lloyd is only a synonym of *T. brumale*. *T. mammosum*, *Tulas-*

nodea leprosa, *Tylostoma leprosum*, *T. pedunculatum*, *T. pygmaeum*, *T. rufum*, *T. simulans* and *T. melanocyclum* are other synonyms of *T. brumale*.

History. — LINNAEUS' knowledge of fungi was comparatively scanty for reasons that are easily explained. Among the small number of species, however, which he treated in his Flora Suecica (1745), *Tulostoma brumale* was described as follows: »Lycoperdon longissimum capitulo globoso, ore cylindraceo integerrimo.» In Species Plantarum (1753) LINNAEUS gave the species in question a binary description: *Lycoperdon pedunculatum*. Concerning the place of growth he reported: »Habitat in Scania campestris locis arenosis». Did LINNAEUS observe *Tulostoma brumale* during his student years or did some other alert observer inform him of its discovery? We shall probably never receive an answer to this question. LINNAEUS' report appeared in the works on flora which were published during the latter part of the eighteenth century and at the beginning of the nineteenth. According to LILJEBLAD (1798) it grew on sand-hills and was described as rare. In the third edition of the latter's flora (1816), in which the fungi were reexamined by ELIAS FRIES, it was said to grow on seaweed banks in Scania. WAHLENBERG (1826) also reported it from Scania, and from the Uppsala district. According to MÖRNER (1939) WAHLENBERG's report concerning the occurrence of *T. brumale* at Uppsala was incorrect. He maintained that it must have been confused with *T. fimbriatum* (= *granulosum*). Probably MÖRNER was not right. I have seen the material collected in Luthagen at Uppsala from LILJEBLAD's herbarium which represents *T. brumale*.

For nearly a century Scania was the only Swedish province in which *T. brumale* had been observed with any certainty. First ELIAS FRIES published a definitive locality, namely Åhus, where it was later observed by MALME, with many others, most recently last summer. During the nineteenth century it was collected in Östergötland (TH. C. E. FRIES 1921). Thus the above-mentioned localities were the only ones known with any certainty during the nineteenth century. During the twentieth century it has been encountered in several new localities, in Gotland (TH. C. E. FRIES l.c., MÖRNER l.c.), Öland (MÖRNER l.c.), and Uppland (MÖRNER l.c., SANDBERG 1940). Up to 1942 most of the localities were distributed in Gotland (MÖRNER l.c.). From Scania, also, two localities were mentioned besides the Åhus locality, the sandy stretches at Vitemölla (STERNER 1922) and Haväng, Ravlunda parish

(ANDERSSON 1942, UDDLING 1945). In the west of Sweden it was not previously known, but ERLANDSSON (1948) has now reported it from Bohuslän. During 1944, '45, '46, '47, '49 it was observed in many Scanian localities, a fact which has given rise to this resumé of the Swedish history of the discovery of the species.

Ecology. — MÖRNER gave in the above-mentioned works certain clues to the vegetation in which *Tulostoma brumale* grows. Thus he published two vegetation analyses from the *Tulostoma brumale* habitats in Gotland. Among the phanerogams and cryptogams included in these analyses worthy of mention are *Artemisia campestris, Carex arenaria, Anemone pratensis, Cerastium semidecandrum, Thuidium abietinum, Tortula ruralis* **ruraliformis, Cladonia rangiformis* and *Cornicularia aculeata*. In both localities the vegetation was reported as entirely closed.

In SANDBERG's analyses from Billudden it occurred together with *Fragaria vesca, Hippophae rhamnoides, Plantago lanceolata, Silene nutans, Vicia Cracca, Thuidium abietinum*, and one *Cladonia*-species. Concerning the milieu it was added, moreover, that the species together with *Geaster minimus, Bovistella echinella*, and *Bovista plumbea* belong to the dry sandy soils of the lower epilitoral or to the sparsely grown thickets on sandy soil. Further, the opinion was put forward that *Tulostoma* and *Geaster minimus* and *Bovistella echinella* are lime-constant, which is presumably correct. This information with SERNANDER's analyses from the stretches of sand at Vitemölla are the only reports giving any indication of the vegetation in which it appears in Sweden.

In Scania *Tulostoma brumale* is bound to the sand-grass heaths, the so-called *Koeleria glauca*-vegetation (ANDERSSON and WALDHEIM 1946). For comparison see table 2 and the detailed description of this vegetation on p. 72.

T. brumale is always associated with the occurrence of *Tortula ruralis* **ruraliformis* in Scania and Gotland. Whether *Tulostoma brumale* lives in symbiosis with *Tortula ruralis** *ruraliformis* is difficult to say. This matter must first be experimentally tested before one can form an opinion. The reason for its intimate occurrence must first be traced to their similar ecological requirements.

In his description of *Tortuletum ruralis** *ruraliformis* GAMS (1927) referred to MASSART (1910 fig. 242) and wrote: »Die letztgenannte Figur

zeigt die Vergesellschaftung mit *Erodium* und *Tulostoma brumale*. Dieser *Gasteromycet* scheint in Wallis derart an die *Tortula* gebunden, dass ich ein Symbioverhältnis annehmen möchte wie ja von zahlreichen Laub- und Lebermoosen bekannt ist.»

In the moss and lichen communities, described by REIMERS (1940) from Kyffhäuser and Harz, *T. brumale* occurs with a thermophile and xerophytical flora, recalling from many points of view the Scanian sand flora. In the analyses were included among others the following mosses: *Barbula convoluta, B. Hornschuchiana, Brym caespiticium, Ceratodon purpureus, Encalypta vulgaris, Funaria mediterranea, Pottia lanceolata* and *Tortula ruralis*. Of lichens may be mentioned *Peltigera rufescens* and *Toninia caeruleonigricans*. The therophytes, also, are astonishingly numerous, e.g., *Cerastium pumilum, Hornungia petraea, Holosteum umbellatum, Myosotis arenaria, Saxifraga tridactylites* and *Sedum acre*.

In the *Koeleria glauca - Jurinea cyanoides* - association from the Rhineland, described by VOLK (1931), were also included among others *Tulostoma brumale* together with the characteristic bottom-layer species *Tortula ruralis* and *Rhacomitrium canescens*. The therophytes make up roughly 38 per cent of the total number of species. Among the xerophytic chamaephytes and hemicryptophytes mention may be made of *Koeleria glauca, Helichrysum arenarium, Jurinea cyanoides, Artemisia campestris, Silene Otites, Satureja Acinos* and *Sedum acre*.

T. brumale usually occurs on clean sandy soils but is also found here and there in the thin covering of earth on the lime rocks. It seems to be able to colonize localities where the possibilities for germination and existence for other plants are scanty. GREIS (1943) gave the following example: ». . . So fanden sich auf einem Felsen an der Donau zahlreiche Fruchtkörper von *Tulostoma mammosum* (einige Tausende), während von höheren Pflanzen nur *Sedum spurium, Hieracium Pilosella* und einige Gräser und von Flechten auch nur wenige Exemplare vorhanden waren.»

T. brumale is bound to a calcareous substratum within the whole of its distribution area. From the diagram it is seen that *T. brumale* in Scania is correlated with a substratum with alkaline reaction and a relatively high electric conductivity. SANDBERG's analyses from Billudden also point to this. The same is true of Gotland, from whence I analysed a few soil samples, generously placed at my disposal by Mr. BENGT PETTERSSON. In the Rhine area it occurs on sandy soils with a pH between 7.8 and 7.3.

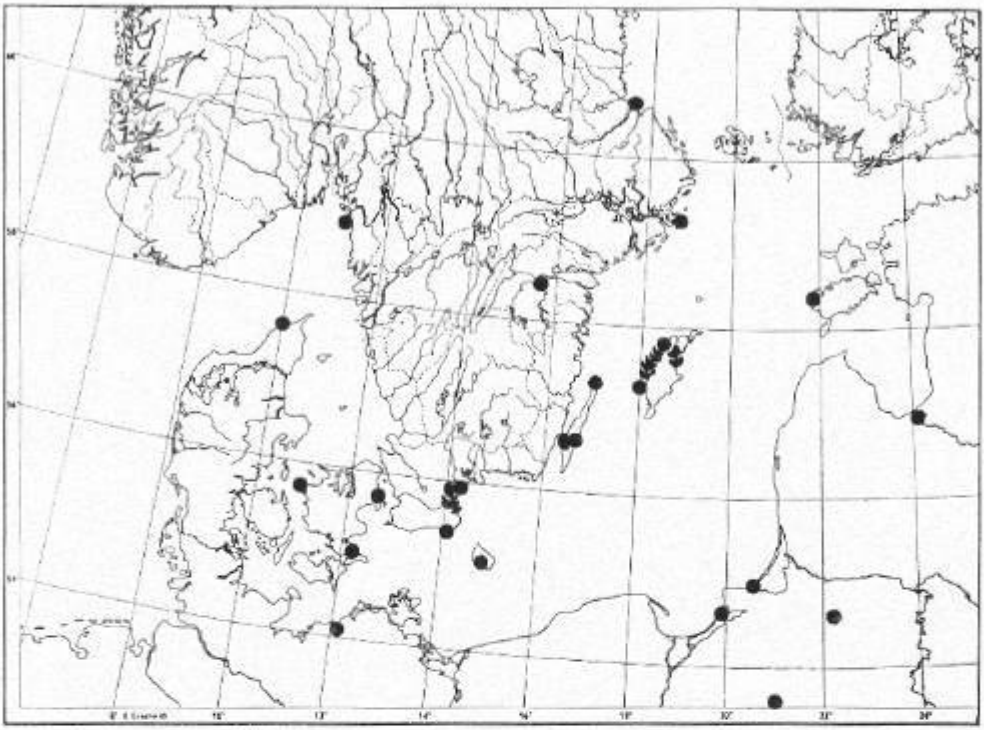

Fig. 28. *Tulostoma brumale* in Scandinavia. (The Uppsala-locality not mapped).

Scandinavian Distribution. — In Scandinavia *T. brumale* has a very divided area, which is due to its strict ecological specialization. It is obviously bound to districts with calcareous rocky soil or calcareous, loose layers, such as Uppland, Öland, Gotland and Denmark.

(In addition to the localities given by MÖRNER (l.c.) the following new ones may be mentioned.)

S w e d e n.

Skåne. Löderup, Löderup's beach, sand-hills, 3.VII.1946. — Brösarp, S of the Brösarp railway station, sand-hill with i.a. *Tortella inclinata*, 6.VII.1945; 1 km. SW of the station, sand-hill at Verkeån, 13.VII.1945. — Ravlunda, Kungsmölla, *Koeleria glauca*-community with i.a., *Toninia caeruleonigricans*, *Geaster nanus*, and *Disciseda Bovista*, 24.IV.1948; between Haväng and Knäbäck, sand-hill, 20.VII. 1946. — Maglehem, Juleboda, sand-hill, with *Anthericum Liliago*,

Fig. 29. The total area of distribution of *Tulostoma brumale*.

16.VII.1945. — Everöd, Lyngby, on sand-field, 17.VII.1945; Öradal, *Thymus Serpyllum - Tortula ruralis** *ruraliformis* - community, sand-field, 17.VII.1945. — Vittskövle, »Drivan», *Tortula ruralis** *ruraliformis* - community, 17.VII.1945; 1 km. W of Eskilstorp, *Tortula ruralis** *ruraliformis* - community with *Anthericum ramosum*, 18.VII. 1945. — Degeberga, 1 km. SW of the church, sand-hill with i.a., *Medicago minima* and *Alsine viscosa*. — Maglehem, 1 km. SW of the church, sand-hill, 17.VII.1947; 2 km. W of the church, sand-hill, 18.VII.1947.

Öland. Vickleby, 1 km S of the church, *Tortula ruralis** *ruraliformis* - community, 16.VI.1950, OLOF ANDERSSON.

Bohuslän. Syd-Koster, Kilesand, sandy beach, 5.VII.1947. STELLAN ERLANDSSON (S.).

Uppland. Uppsala (LILJEBLAD's herb. U.).

Denmark.

Sjælland. Refsnæs, Kongstrup Klint, sparsely covered with grasses and lichens, 7.IX.1940 (MORTEN LANGE 1950).

Bornholm. Limensgade, 31.V.1946 (MORTEN LANGE l.c.).

Møen. Ulfshale, on a heath near the sea, sparsely covered with *Carex arenaria* and *Elymus arenarius*, etc. 6.VI.1943 (M. LANGE in letter).

Fig. 30. *Tulostoma granulosum* from Vitaby, Vitemölla. (× 4). Photo OSCAR GEHLIN.

Extra-Scandinavian Distribution. — *T. brumale* is a cosmopolitan species. Its European area includes Russia, Hungary, Rumania, Czechoslovakia, Austria, Italy, Spain, France, Switzerland, Germany, Belgium, Holland, England, Estonia and Latvia.

In America it is known from the Atlantic coast in the east to the

Pacific in the west, from south Canada in the north to Mexico in the south.

BOTTOMLEY (l.c.) mentioned it from South Africa. MAIRE and WERNER (1937) reported it from North Africa, Morocco.

In addition it has a small area in Australia and New Zealand (CLELAND 1934, CUNNINGHAM 1944).

It has also been said, from reports in the literature, to occur in Japan, and India (AHMAD 1939).

Tulostoma granulosum LÉV.

Description. — *Exoperidium* globose or depressed globose, brittle, finally falling away, except for the basal part, persisting as a cup.

Endoperidium of the same shape, 10—12 mm., papyraceous, pale tan.

Stoma not tubular, shallow, indistinct protruding edge.

Stem 2—5 cm. long, hollow, striate to furrowed, scaly, reddish-brown, with a mycelial basal bulb.

Gleba orange-brown, somewhat darker than in *T. brumale*.

Capillitium threads not or seldom septate, 6.5—8 μ, hyaline.

Spores globose, verrucose, 6—7(8) μ.

Taxonomical notes. — HOLLÓS (l.c.) regarded *T. fimbriatum* and *T. granulosum* as distinct species, but, in my opinion, the differentiating characteristics are very diffuse. According to him the capillitium threads are not septate in *T. fimbriatum* and not or seldom septate in *T. granulosum*. Like TH. C. E. FRIES I consider them to be identical.

From the description and figures in the work of COKER and COUCH (1928) *T. campestre* seems to be nearly related to *T. granulosum*. Possibly it is only a North American subspecies of this.

History. — This species was described by E. FRIES in Systema mycologicum (»meum tantum legi in aggeribus e fucis exstructis juxta litora freti Öresund, Scania occidentalis.»). Then it was found at Åhus by MALME. In latter years it has been found in Scania in new places. In the Herb. Lund I have found a collection, made by TH. C. E. FRIES, from Vitemölla.

Ecology. — *T. granulosum* occurs in the sand-grass heaths of Scania (cf. table 3), but it prefers habitats where a leaching has begun. The pH lies often between 6 and 7.

From abroad there is little information about its ecology. I refer to the papers of HOLLÓS (l.c.), MOESZ (l.c.) and FAVRE and RUHLÉ (l.c.).

Scandinavian Distribution. — In Scandinavia *T. granulosum* is only known from Sweden and Norway. An investigation of the material serving as a basis for MÖRNER's (l.c.) and SANDBERG's (l.c.) reports on the occurrence of *T. brumale* in Norway, shows that it is a question of *T. granulosum*.

Sweden

Skåne, Löderup, Löderup's beach, sand-hills, together with *T. brumale* and *Geaster nanus*, 2.X.1946. — Vitaby, Vitemölla, TH. C. E. FRIES (L.). — Ravlunda, Kungsmölla, sand-hill, 20.IX.1948, OLOF ANDERSSON and HANS RUNEMARK. — Maglehem, 1 km. SW of the church, sand-hill, 10.XI.1949, OLOF ANDERSSON and ANN-MARIE BRÜDIGAM-ANDERSSON. —Åhus, Horna Railway Station, 23.IX.1946, OLOF ANDERSSON and ANN-MARIE BRÜDIGAM; Åhus, G. MALME (U.). — Lomma (ELIAS FRIES 1829). — Ystad, Sandskogen, X.1946, OLOF ANDERSSON.

Stockholm, Skanstull, 4.V.1928, E. INGELSTRÖM (1940).

Norway.

Oslo, between Ruselokkveien and Munkedamsveien, IV.1848, (M. N. BLYTT) (O.)

Extra-Scandinavian Distribution. — *T. granulosum* does not seem to have as a great an area as *T. brumale*.

According to HOLLÓS (l.c.) and ALEXANDRI (l.c.) it is distributed in Hungary, Rumania, Czechoslovakia, Italy, France, Switzerland and Germany. EYNDHOVEN (1937) reported it from Holland.

Outside Europe it is known in North America.

Lycoperdon pusillum PERS.

Description. — (See TH. C. E. FRIES 1921).

Ecology and distribution. — *Lycoperdon pusillum* prefers genuine sandy soils, but can also occur on moraine soils. It is very common on grass heaths in southernmost Sweden. Its northern limit in Scandinavia it not known with certainty. The northernmost Swedish locality is Ragunda in Jämtland.

It is reported from different parts of the world.

Scleroderma Bovista Fr.

Description. — (See Th. C. E. Fries 1921). Fries mentions no spore measure. The material examined has a spore measure of 10—14 μ.

Ecology and distribution. — This species is a facultative sand fungus. In Scandinavia it seems to prefer sandy, foliiferous woods and parks. Degelius (l.c.) reports it from other habitats, e.g. heaps of slag. I have found it in open sand-dunes among *Ammophila arenaria* and *Elymus arenarius*. Its Swedish northern limit may coincide with that of the oak.

New Swedish localities:

Skåne. Ystad, Ystad's beach, in sand-dunes, X.1946, Olof Andersson. — Löderup, Sandhammaren, in sand-dunes, X.1946, Olof Andersson, Torsten Håkansson. — Ravlunda, Brostorp, sandy beech wood, 4.IX.1949, Olof Andersson.

Småland. Växjö, sandy beech wood, 20.IX.1948, Olof Andersson.

Västergötland. Österplana, 800 m SSW of the church, in a copse, 26.IX.1948, Olof Andersson.

Ecological summary.

Due to their practical significance the ecology of some fungi, e.g., soil fungi, plant pathogenic fungi, mycorrhiza-forming and lignin-destroying fungi, has been studied in greater detail. On the other hand, the ecology of the larger saprophytic fungi in woods, fields, etc., is almost unknown, although the interest in them has greatly increased during the last few years (cf. WILKINS and others 1937, 1938, 1939, 1940, 1946, FRIEDRICH 1940, M. LANGE 1948 a). The authors mentioned have carried out instrument measurements of air and soil temperature, humidity, or analyses of the chemical and physical conditions of the substratum.

Investigations on fungus flora and vegetation should be combined to the greatest possible extent with such measurements and analyses, which should be carried out on a very large scale. Even although, by field ecological studies, one cannot determine the factor or factors, which decide the occurrence of the different species in different habitats and the constitution of the fungus vegetation, an indication can, however, be obtained of the conditions in their natural milieu. In this manner one can also contribute to a solution of the causal connection.

Such investigations should always precede experimental studies or at least be carried out simultaneously. If one carries out field ecology and experimental ecology separately without taking into consideration the results of each, a solution is never reached. I should like to agree with J. E. LANGE (1923), when he wrote: »As long as cultivation of the larger fungi and other experimental work within this domain is mainly a thing of the future, most of the problems raised cannot be fully solved, one can only contribute suggestions towards their solution. Nevertheless I do think it worth while, as done here, briefly to state some of my observations within this province of plant-life, the result of thirty years of experience in the field.»

As appears from the above, some stress has been laid upon the ecology of the different sand-fungi. Any detailed description has, how-

ever, not been given for each species. In my opinion the best method would be to give a comprehensive description of the character of the habitats, so that the treated species can be brought together in definite ecological groups.

Sociology. — With regard to their presence in Scandinavia the sand-fungi can be divided into two main groups from a sociological viewpoint. One group — hereafter called A-group — consists of species only growing on marine sand-dunes along the coasts, e.g., *Peziza ammophila, Laccaria trullisata* var. *maritima, Inocybe lacera* var. *halophila, I. serotina, Psilocybe ammophila* and *Phallus Hadriani*.

The vegetation of marine sand-dunes, often called the *Ammophila arenaria* - community (*Ammophiletum*), is very poor in species and is mainly constituted of the sand grasses:

Agropyron junceum
Ammophila arenaria
Elymus arenarius
Festuca rubra var. *arenaria*
— ×*Calamagrostis epigeios*

These can be classified as characteristic species of this vegetation, but to them can also be added *Eryngium maritimum* and *Petasites spurius*, although very rare in Scandinavia. The following strange species occur: *Artemisia campestris, Cakile maritima, Carex arenaria, Minuartia peploides, Lathyrus maritimus*, and *Salsola Kali*. The vegetation covers 25 to 50 per cent of the ground. In its characteristic constitution this community is free from mosses and lichens. The only cryptogams are the fungi mentioned, which may be referred to the character species of this community.

The other group — B-group — comprising *Disciseda Bovista, D. candida, Geaster minimus, nanus, Tulostoma brumale* and *granulosum* are included in quite another community, the dry, continental sand-grass heaths, the *Koeleria glauca* - community (*Koelerietum*, cf. ANDERSSON and WALDHEIM 1946). The local characteristic species are:

Anthericum Liliago
Astragalus arenarius
Cerastium glutinosum
Festuca polesica
Hornungia petraea
Koeleria glauca
Kohlrauschia prolifera
Medicago minima

Prominent species in the field layer are *Anemone pratensis, Carex arenaria, Dianthus arenarius* and *Thymus Serpyllum*, of which the latter often are dominating or subdominating. The number of thero-

Table 1. Analyses of *Ammophila arenaria* vegetation with *Peziza ammophila*.

1 m²	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Agropyron junceum	—	—	—	—	—	—	—	—	—	—	—	—	—	1	—	1
Ammophila arenaria	3	2	3	2	2	1	4	3	3	3	4	3	1	1	1	1
Ammophila arenaria × Calamagrostis epigeios	1	1	—	—	—	—	—	—	—	1	1	—	2	2	3	3
Elymus arenarius	1	1	1	2	3	4	1	1	1	—	—	1	1	2	1	1
Festuca rubra var. arenaria	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1	—
Peziza ammophila	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Psilocybe ammophila	—	—	—	1	1	1	—	—	1	—	—	—	—	—	—	—

1—13: Löderup, near Sandhammaren's lighthouse, 28.VII.1947. — 14—16: Löderup, Löderup's beach, 29.VII.1947.

phytes is considerable, of which may be mentioned *Erophila verna*, *Cerastium semicandrum*, *Phleum arenarium* and *Veronica verna*. The bottom layer is mainly composed of *Tortula ruralis* **ruraliformis* and *Rhacomitrium canescens*, with a great number of lichens, e.g., *Cladonia foliacea* var. *alcicornis*, *furcata*, *pyxidata*, *rangiformis*, *Cetraria crispa*, *nivalis* (only one locality), *Cornicularia aculeata*, *Peltigera lepidophora*, *rufescens* and *Toninia caeruleonigricans* (only one locality).

Concerning *Corynetes arenarius*, *Geoglossum Cookeianum* and *Inocybe maritima* no general sociological conclusions can be drawn.

Soil Conditions. — Thus the two groups of obligate sand-fungi are sociologically clearly separated. This sociological differentiation must have its cause in the physical and chemical nature of the substratum.

As regards the mechanical composition of the substratum there exist essential differences. The A-group is exclusively bound to moving sand. Only the fractions »medium sand» and »coarse mo» occur.

The species of the B-group grow on a sandy moraine or glacial river material, extremely seldom in moving sand. The sand fractions are dominant. Other fractions, however, have made their appearance here, owing to which the proportions between the different fractions are otherwise. This inequality in the mechanical composition must be of differentiating importance, so much so that the first named group does not seem capable of growing in a sandy moraine or glacial river material, whereas the species of B-group would appear to be able to tolerate moving sand. »Vittskövle Driva» in Scania, on which *Tulostoma brumale* and *Geaster minimus* grow, is entirely built up with calcareous moving sand.

Table 2. Sociological analyses from biocoenoses with *Tufostoma brumale*.

1 m²	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34
Alyssum Alyssoides	—	—	—	—	—	—	—	—	—	—	1	—	—	—	—	—	—	—	—	—	1	1	—	—	—	—	—	—	—	—	—	—	—	—
Androsace septentrionalis	—	—	—	1	—	1	1	1	1	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1	—	—	—
Anemone pratensis	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1	—	—	—	—	—	1	—	—	—	—	—	—	—	—
Anthericum Liliago	—	—	—	—	—	—	—	—	1	1	2	—	—	—	—	—	—	—	—	1	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Anthyllis Vulneraria	—	—	—	—	1	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Arenaria serpyllifolia	1	—	—	—	—	1	1	1	1	1	1	1	1	1	1	1	1	1	1	—	1	—	—	—	—	—	—	1	—	1	—	1	1	1
Artemisia campestris	—	—	—	—	—	1	—	—	—	—	1	1	1	1	1	1	1	—	—	1	—	—	1	1	1	1	1	1	1	—	1	—	—	—
Astragalus arenarius	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Cerastium glutinosum	1	1	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1	1	—	1	1	—	—	—	—	—
— semidecandrum	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	—	1	1	1	1	1	—	—	—	—	—	1	—	1	—	—
Dianthus arenarius	1	1	1	1	1	—	—	—	—	—	—	—	—	—	—	—	1	—	—	2	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Erodium cicutarium	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1	1	—	—	—	—	—	—	—	—	—	—	—	1
Erophila verna	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1	—	—	—	—	—	—	—	—	—	—	—	—
Galium verum	1	1	1	1	1	—	—	—	—	—	—	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	—	—	—	1	—
Geranium molle	—	—	—	—	—	—	—	—	—	—	—	1	1	1	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1	—
Helichrysum arenarium	—	—	—	1	—	—	—	—	—	—	—	1	—	1	1	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1	1	1	—	—
Hieracium Pilosella	—	—	—	—	1	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
— umbellatum	1	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Hornungia petraea	—	1	1	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Medicago falcata	1	1	1	1	—	—	—	—	—	—	1	2	2	1	2	1	—	—	1	—	1	—	1	—	—	—	—	—	1	1	1	—	1	—
— lupulina	1	—	—	1	—	—	—	—	—	1	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1	—	1	—	—
Pimpinella Saxifraga	1	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1	—	—	—	—	—	1	—	—	—	—	—	—	—	—
Satureja Acinos	—	—	—	—	—	—	—	—	—	—	1	1	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1	1	—	—	—
Saxifraga tridactylites	—	1	—	1	1	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Sedum acre	1	1	1	1	1	1	1	1	1	1	1	1	2	1	1	1	1	2	1	1	1	—	1	1	1	1	—	1	1	1	1	1	1	1
Senecio vernalis	—	—	—	—	—	—	1	1	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1	—
Silene conica	—	—	—	—	—	1	—	1	1	1	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
— nutans	—	—	—	—	—	—	—	—	—	—	1	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Thymus Serpyllum	1	1	1	1	1	2	1	—	1	4	1	4	5	4	5	3	1	2	1	2	—	2	1	2	1	1	1	1	1	1	2	1	2	1
Trifolium arvense	—	—	—	—	—	1	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1	—	—
Viola rupestris	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1	—	—	—	—	—	—	—	—	—	—	—	—	—	—
— tricolor	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1	1
Bromus mollis	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1	—	1	1	—	—	—	—	—	—	—	—	—	—
— tectorum	—	—	—	—	—	—	—	—	—	—	1	—	—	—	—	—	1	—	—	—	—	—	—	—	—	—	1	—	1	—	—	—	—	—
Carex arenaria	1	1	1	1	1	—	—	—	—	—	—	2	1	1	1	1	1	1	1	—	1	1	1	1	2	1	1	1	—	—	—	—	—	—
Corynephorus canescens	—	—	—	—	—	1	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1	—	1	—	—	1	1	1	2

1 m²	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34
Festuca polesica	1	1	1	1	1	—	—	—	—	—	—	—	—	—	—	—	1	—	1	1	3	2	—	—	—	—	—	—	—	—	—	—	—	—
— rubra	—	—	—	—	—	—	—	—	—	—	—	—	1	—	1	1	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Koeleria glauca	1	1	1	3	1	3	4	5	4	4	4	—	—	—	—	—	4	4	3	1	1	1	—	1	1	1	1	1	1	3	3	3	1	2
Luzula campestris	—	—	—	1	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Phleum arenarium	1	1	1	1	1	1	—	—	—	—	1	—	—	—	—	—	1	—	1	1	1	1	—	1	—	1	1	1	1	1	1	—	1	1
Poa compressa	—	—	—	—	—	—	—	—	—	1	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
— pratensis	—	—	—	—	—	1	1	1	1	—	—	1	1	—	1	1	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Barbula Horaschuchiana	—	—	—	—	1	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Brachythecium albicans	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Bryum argenteum	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1	1
— sp.	1	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1	—
Camptothecium lutescens	—	—	—	1	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Ceratodon purpureus	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1	1	—	—	—	—	—
Encalypta vulgaris	—	—	—	—	—	—	1	1	1	1	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Rhacomitrium canescens	1	1	1	1	5	—	1	—	2	—	1	—	—	—	—	—	1	2	—	1	—	—	—	—	—	1	—	—	—	5	5	5	—	—
Thuidium abietinum	—	1	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1	—	1	1	—	—	—	—	—
Tortella inclinata	1	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1	1	—	1	1	—	—	—	—	—
Tortula ruralis (forma)	1	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
— — *ruraliformis	4	5	4	4	1	4	5	5	3	4	2	5	5	5	5	5	5	3	5	5	5	5	5	5	5	5	5	5	5	1	1	1	5	5
Bacidia muscorum	—	—	—	—	—	—	—	—	1	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Cladonia fimbriata	—	—	—	1	—	1	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
— foliacea var. alcicornis	—	—	—	—	—	—	—	—	—	—	1	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
— furcata	1	1	1	1	1	—	—	—	—	—	1	—	—	—	—	—	—	1	—	1	—	—	—	—	—	—	—	—	—	1	1	1	1	1
— pyxidata	—	—	—	1	—	1	1	1	1	1	1	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1	—
— rangiformis	—	—	—	—	—	—	—	—	—	—	1	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Cornicularia aculeata	1	—	1	1	1	1	—	—	—	—	—	—	—	—	—	—	—	1	—	2	—	—	2	1	1	1	1	1	—	1	1	1	1	1
Leptogium lichenoides	1	—	—	1	1	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Peltigera lepidophora	—	—	—	—	—	—	—	—	1	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
— rufescens	1	—	—	1	1	1	1	1	1	1	1	—	—	—	—	—	—	1	—	1	—	—	—	—	—	—	—	—	—	—	1	1	1	1
Tulostoma brumale	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1

1—5: Brösarp parish, Bockamöllan, sand-hill, 5.VII.1945. — 6—10: Degeberga parish, sand-hill, near the Railway station, 2.VII.1945. — 11: Maglehem parish, Blåherremöllan, sand-hill, 7.VII.1945. — 12—16: Everöd parish, Öradal, sand-field, 15.VII.1945. — 17—19: Ravlunda parish, Skeppsarp, sand-hill, 22.VI.1946. — 20: Vitaby parish, Vitemölla, sand-field, 20.VI.1946. — 21—22: Löderup parish, Löderup's beach, sand-hill, 29.VI.1946. — 23—24: Vitaby parish, Torup, sand-hill, 21.VI.1947. — 25—29: Ravlunda parish, sand-hill between Knäbäck and Havång, 13.VII.1946. — 30—32: Maglehem parish, between Maglehem and Lillehem, sand-hill, 15.VII.1946. — 33—34: Maglehem parish, 800 km WSW of the church, 16.VII.1946.

Table 3. Sociological analyses from biocoenoses with *Tulostoma granulosum* and *Disciseda Bovista*.

1 m²	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
Androsace septentrionalis	1	1	1	1	1	—	1	—	—	1	—	1	1	—	1	—	—
Anemone pratensis	—	1	1	—	—	1	1	1	—	—	1	1	—	—	—	—	—
Anthyllis Vulneraria	—	—	—	—	—	1	—	—	—	—	—	—	—	—	—	—	—
Artemisia campestris	1	1	1	1	1	1	1	1	1	1	1	1	—	—	1	—	—
Cerastium semidecandrum	—	1	1	—	—	1	—	—	—	—	—	—	—	1	1	1	—
Galium verum	1	1	—	1	1	1	1	1	1	1	1	1	—	—	—	—	—
Helichrysum arenarium	—	1	1	1	1	1	—	—	—	—	—	—	1	1	—	—	1
Jasione montana	—	—	—	—	—	—	—	—	—	—	—	—	1	1	—	—	—
Medicato falcata	1	1	1	1	—	—	1	—	—	1	1	1	—	—	—	—	—
Pimpinella Saxifraga	—	—	—	—	—	—	—	—	1	—	—	—	—	—	—	—	—
Satureja Acinos	—	—	—	—	—	1	—	—	—	—	—	—	—	—	—	—	—
Sedum acre	1	1	2	2	1	1	1	1	1	1	1	1	1	1	—	1	1
Thymus Serpyllum	1	1	2	2	3	1	1	2	2	1	1	2	1	1	1	1	1
Carex arenaria	1	1	1	1	1	1	1	1	1	1	1	1	—	—	—	—	—
Corynephorus canescens	—	—	—	—	—	—	—	—	—	—	—	—	1	1	1	1	1
Festuca polesica	4	5	3	4	3	5	5	5	2	3	5	5	—	—	—	—	—
Koeleria glauca	3	1	2	2	2	1	1	1	3	3	2	2	2	1	1	1	1
Luzula campestris	—	—	—	—	—	—	—	—	—	1	—	—	—	—	—	—	—
Brachythecium albicans	1	—	1	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Bryum caespiticium	—	—	—	—	1	1	1	—	—	1	1	1	—	—	—	—	—
Ceratodon purpureus	1	1	1	1	1	1	1	1	—	—	1	1	—	—	1	1	1
Rhacomitrium canescens	—	—	1	—	1	2	1	1	2	1	1	1	5	4	4	5	5
Tortula ruralis *ruraliformis	1	1	1	1	2	1	2	1	3	3	3	1	—	—	—	1	1
Cetraria crispa	—	—	—	—	—	—	—	—	—	—	—	—	1	1	1	1	1
— nivalis	—	—	—	—	—	—	—	—	1	1	1	1	—	—	—	—	—
Cladonia coccinea	—	—	—	—	—	—	—	—	—	—	—	—	1	—	—	—	—
— coniocraea	—	—	—	—	—	—	—	—	—	—	—	—	—	1	—	—	—
— cornuto-radiata	—	—	—	—	1	—	—	—	—	—	—	—	—	—	—	—	—
— crispata	—	1	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
— foliacea var. alcicornis	—	—	—	—	—	—	—	—	—	—	—	—	1	1	1	—	—
— furcata	2	3	3	2	2	1	1	4	2	2	2	3	—	1	1	1	1
— pyxidata	1	1	—	1	1	1	—	—	—	—	—	—	1	—	—	—	—
— silvatica	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1	1
Cornicularia aculeata	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Peltigera rufescens	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Disciseda Bovista	—	—	—	—	—	—	—	—	1	1	1	1	1	1	1	1	1
Tulostoma granulosum	1	1	1	1	1	1	1	1	—	—	—	—	—	—	—	—	—

1—12: Åhus parish, Horna railway station, sand-field, 15.VII.1947. — 13—17: Maglehem parish, sand-hill, 25.VII.1947.

Concerning the soil reaction GREIS (1943) wrote: »An die Bodenreaktion stellen die Pilze keine besonderen Ansprüche. Wohl bevorzugen die meisten leicht sauren Böden, doch gedeihen viele auf alkalischen Böden (*Tricholoma*-species).» WOLF and WOLF (1947) maintained: »Among the chemical environmental influences to which fungi are generally known is the reaction of substrata.» As a basis for these

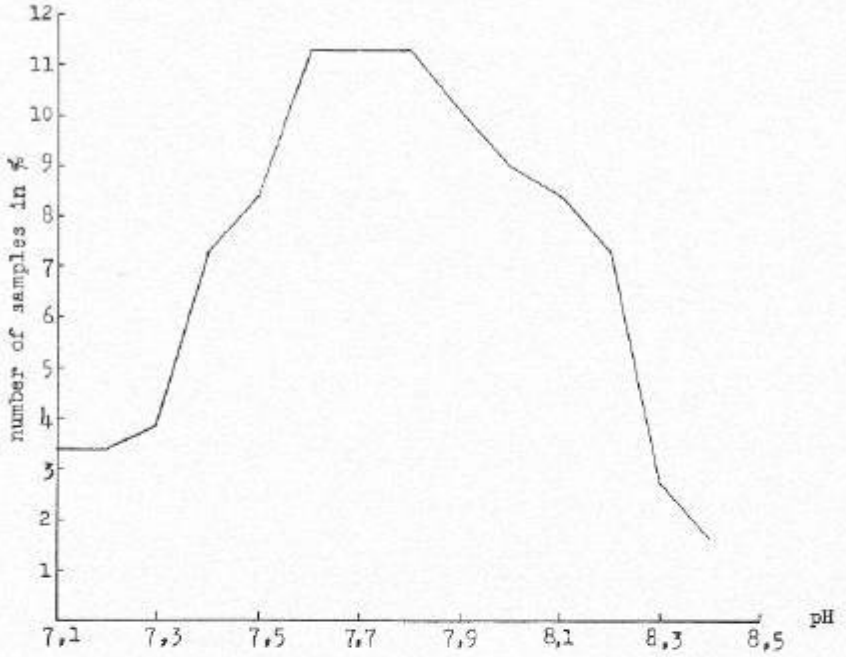

Fig. 31. Dispersion of pH values of samples from habitats with *Tulostoma brumale*.

assertions are mainly the experimental investigations of the capacity of different parasite fungi to grow within certain pH-limits.

The A-group is correlated with a substratum, whose pH-amplitude lies between 6.6 and 7.4. The majority of values lies at 7.0. The B group is correlated with a substratum, whose pH lies between 7.1 and 8.4. Thus pH seems to be of a differentiating importance for both these groups, but it should not be overestimated.

The lime contents also seem to be of great importance for both these groups. The A-group is correlated with an entirely lime-free substratum, whereas the B-group is strictly bound to a calcareous substratum, varying between 2.5 and 15 per cent in the Scanian localities. The importance of the lime content is best seen in the detailed maps of *Tulostoma brumale*, *Geaster minimus* and *nanus*. These species are entirely confined to districts with either calcareous rocks or calcareous, loose deposits.

Certain reports from abroad (KALLENBACH 1931) show that the A-group can live on a calcareous substratum. On the other hand,

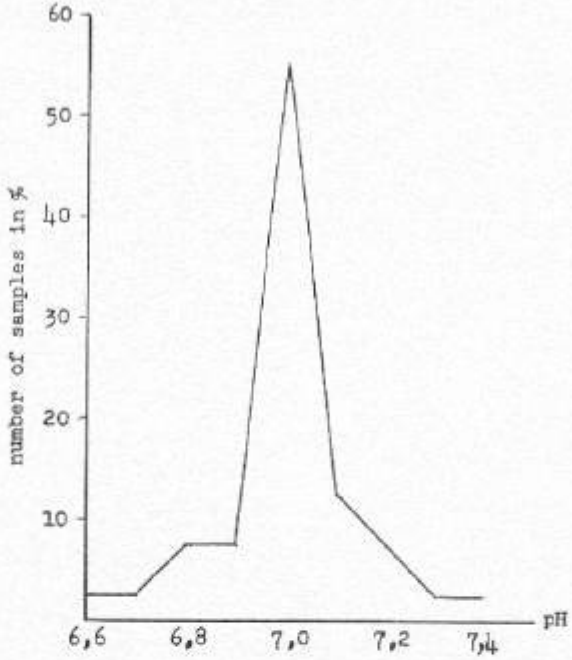

Fig. 32. Dispersion of pH values of samples from habitats with *Peziza ammophila*, *Phallus Hadriani* and *Psilocybe ammophila*.

the B-group does not seem to be able to tolerate an entirely lime-free substratum. Its species require a high lime content for their existence. BOUDIER (1901) assigned *Tulostoma brumale* and *granulosum* to the species occurring in »calcareous soils».

The electric conductive ($\varkappa_{20} \cdot 10^6$) is also dissimilar in the substratum of the two groups, for which reason this also must be considered of differentiating importance. For the A-group it lies between 21 and 39. In the B-group it is considerably higher and varies between 40 and 130. For the B-group no special curve has been drawn. Instead, reference should be made to ANDERSSON and WALDHEIM (l.c.).

Thus it can be briefly said that *Peziza ammophila, Laccaria trullisata var. maritima, Inocybe lacera var. halophila, I. serotina, Psilocybe ammophila and Phallus Hadriani appear in Scandinavia on a substratum, consisting of moving sand, which is non-calcareous, very poor in humus or free from humus, with a pH about neutral point (6.6—7.4) and with a relatively low electric conductivity.*

Disciseda Bovista, candida, Geaster minimus, nanus, Tulostoma

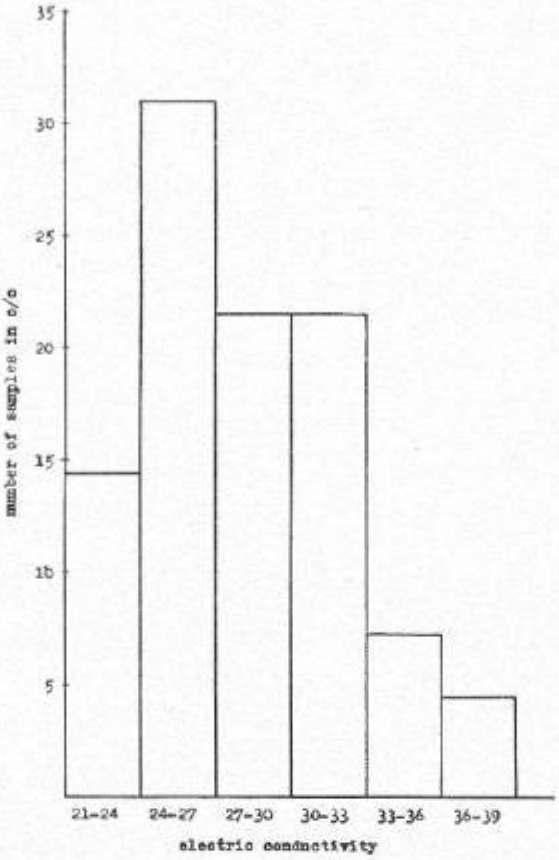

Fig. 33. Dispersion of electric conductivity values of samples from habitats with *Peziza ammophila, Phallus Hadriani* and *Psilocybe ammophila.*

brumale and granulosum are correlated with a substratum, preferably consisting of sandy moraine or glacial river material with an alkaline reaction (7.1—8.4), a high lime content, a relatively high electric conductivity and a fairly low humus content. Disciseda Bovista and *Tulostoma granulosum* often occur in habitats, where a leaching out of the lime has begun.

Whether the same correlation with the substratum exists within the total area of these species, would be difficult to say, at least as far as the A-group is concerned. On the other hand, one may assume with the greatest certainty that it is the case with the species of the B-group, as is indicated by their distribution.

Distribution. — According to BISBY (1933) the distribution of fungi is first determined by the host plants or the substratum. The climate would appear to have a more indirect influence. GREIS (l.c.) maintained that one can scarcely differentiate between a boreal, temperate, subtropical or tropical fungus flora. Principally they are both right, but the direct effect of climate on the distribution of many fungi cannot be neglected. Some genera and many species are restricted to definite climatic zones. In a later work BISBY (1943) emphasized the controlling effect of climate on many fungi. He wrote i.a.: »Dry regions are characterized by xerophilous Gasteromycetes, Agaricaceae and other fungi, many of which are restricted further to warmer dry localities.»

Most sand-fungi dealt with in this paper are xerophilous species. *Disciseda Bovista, D. candida, Geaster minimus, G. nanus*, and *Tulostoma brumale* occur principally in regions with an arid or a semi-arid climate, both in the southern and northern hemisphere (see the maps, figs. 25, 29). They can also grow in humid and semi-humid regions, where the effect of macroclimate is counteracted by an arid or a semi-arid microclimate, originating from edaphic conditions, exposure and slope.

Peziza ammophila, Phallus Hadriani, Laccaria trullisata, Inocybe maritima, I. lacera var. *halophila, I. serotina, Psilocybe ammophila* and *Corynetes arenarius* are confined to the northern hemisphere. Concerning *Peziza ammophila* and *Psilocybe ammophila*, see pages 22, 34. None of the species occur in Asia. *Peziza ammophila, Phallus Hadriani, Laccaria trullisata, Inocybe serotina* and *Corynetes arenarius* are definitely known from Europe and North America. Perhaps *Inocybe maritima* has a vicarious species or a subspecies *I. maritimoides* in North America. *Peziza ammophila, Phallus Hadriani* and *Psilocybe ammophila* have a very small area in North Africa.

As seen from the above, the sand-fungi have different areas, although most of them have the same possibilities of being dispersed over long distances because of the little weight of the spores. The climate in this case must have a controlling effect. The recent area of *Phallus Hadriani* the spores of which are spread by animals, especially insects, must be a result of historical causes. It is possible that it in part has been spread by man. There are many examples of species of the families *Phallaceae* and *Clathraceae* having been introduced to Europe by man (ANDERSSON 1950). The most plausible explanation is that *Phallus Hadriani* like many vascular plants in a previous geological period has had a more continuous area, which has subsequently been divided.

In the discussion about the distribution of fungi the effect of both climate and substratum must be taken into consideration. The sand-fungi are in this respect excellent objects of investigation. To draw any conclusions concerning the effect of the historical factors on the recent areas of distribution is generally impossible owing to the great capacity of the spores of the sand fungi to spread long distances during a short period of time.

In writing this paper the following persons have given me valuable information about localities: Professor N. F. BUCHWALD, Copenhagen, Dr. R. W. G. DENNIS, London, Cand. Mag. F.-E. ECKBLAD, Oslo, Dr. STELLAN ERLANDSSON, Stockholm, Lic. Phil. TORSTEN HÅKANSSON, Lund, Cand. Mag. MORTEN LANGE, Copenhagen, Dr. W. H. LONG, Albuquerque, N.M., Dr. SETH LUNDELL, Uppsala, Cand. ARNE NILSSON, Lund, Lic. Phil. BENGT PETTERSSON, Uppsala, Mag. Phil. K. G. RIDELIUS, Molkom, Lic. Phil. GUSTAF RUDEBECK, Lund, Lic. Phil. GUSTAF SANDBERG, Uppsala, Dr. ROLF SINGER, Tucumán, Professor H. SKUJA, Uppsala and Dr. G. A. DE VRIES, Baarn (Holland). To all I tender my sincere thanks.

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To the editor of Botaniska Notiser, Docent HÅKON HJELMQVIST I am much obliged for valuable help in editing this paper.

Addenda.

p. 23. Note to the map, fig. 7. *Peziza ammophila* is also found in Italy (CAVARA 1903, MUSCATELLO 1905).

Following localities shall be added to the lists of localities

on p. 48. (N o r w a y): *Akershus*. Nesodden, Langøya in Bunnefjorden, 13.IX. 1937, TH. ARWIDSSON and I. JØRSTAD (O.). — Fornebu, Langodden, H. RUI (5793) 31.VII.1946; H. RUI and F. E. ECKBLAD, 2.IX.1950. *Oslo*. Ulvøen in Bunnefjorden, IX.1932, ASBJØRN HAGEN (O.). *Vestfold*. Holmestrand, Kammersø, 22.VI.1879, HELLIESEN (O.).

on p. 53. N o r w a y: *Rogaland*. Jaeren, Borseim, at Orrevattnet, 16.VI.1923, J. LID (O.).

on p. 59. *Gotland*. Färö, Ava, on sand, 14., 28.VIII.1948, E. TH. FRIES (U.).

on p. 66. F i n l a n d: *Alandia*. Kökar, Storrevet, 20.VI.1948, G. STENLID (U.). *Regio Aboensis*. Korpo, Jurmo Estrevlan, 13.VI.1949, G. STENLID (U.).

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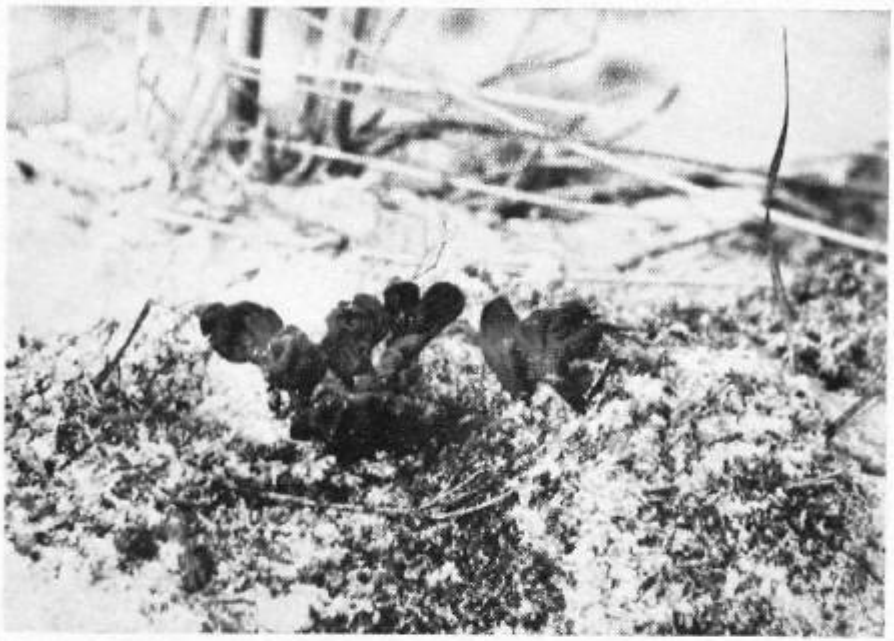


A. *Corynetes arenarius* among *Ammophila arenaria* and *Cladonia* -species. — Sandhammaren, 15.X.1945.

B. *Geoglossum Cookeianum* in a *Thymus Serpyllum*-community. — O. Karup, Malen's beach, 8.X.1945.

Peziza ammophila, different stages in low dunes. Sandhammaren, 26.VII.1947.

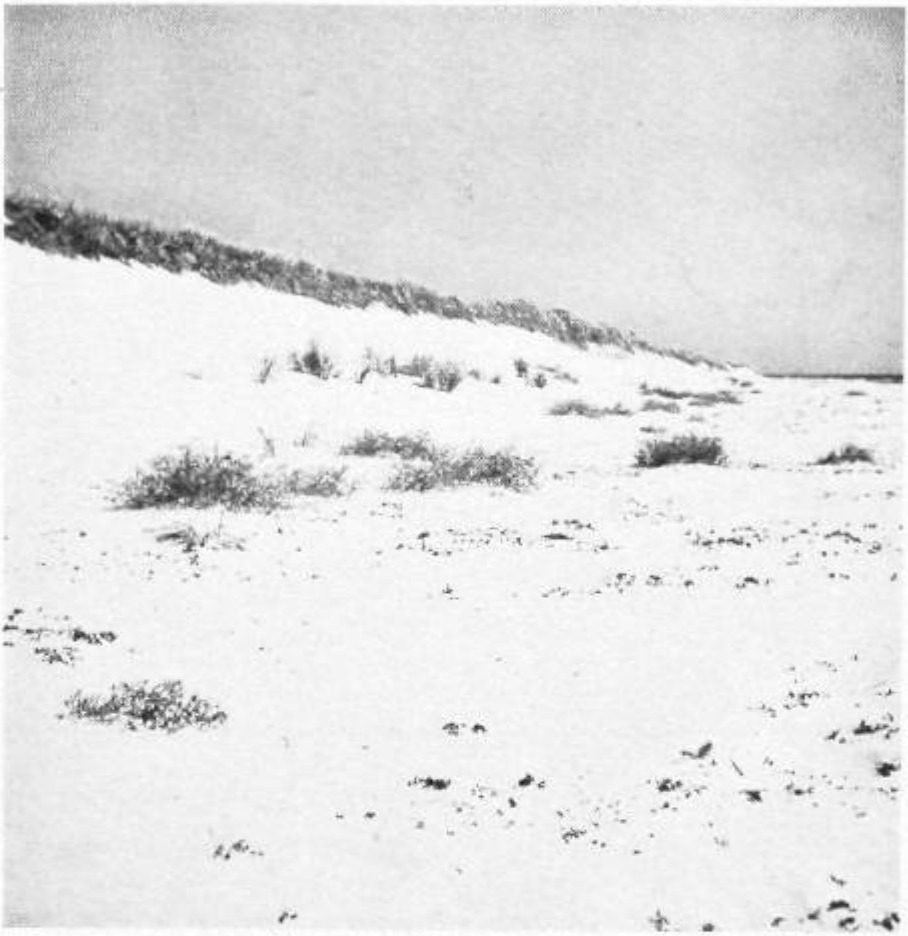
Psilocybe ammophila among *Ammophila arenaria* and *Elymus arenarius*. — Sandhammaren, 15.X.1945.

Phallus Hadriani (the specimens are somewhat dried) among *Elymus arenarius*, *Ammophila arenaria* and *Artemisia campestris*. — Ö. Knuip, Malen's beach, 8.X.1945.

A. *Phallus Hadriani* with a rest of the volva at the cap. — O. Karup, Malen's beach, 8.X.1945.

B. *Disciseda Bovista* among *Thymus Serpyllum*, *Anthyllis Vulneraria* and *Festuca polesica*. — Ahus, Hornu railway station, IX.1946.

From the Sandhammaren locality with *Peziza ammophila* and *Psilocybe ammophila*.



From the Sandhammaren locality with *Psilocybe ammophila*, *Inocybe lacera* var. *halophila* and *I. maritima*.

The sand fields at Vitemölla with flowering *Dianthus arenarius*. Locality for *Genista minimus*, *G. romus*, *Tulostoma brumale* and *T. granulosum*.

The sand-fields at Maglehem with *Koeleria glauca* and *Helichrysum arenarium*. Locality for *Disciseda Bovista*, *Géaster nanus*, *Tulostoma brumale* and *T. granulosum*.