

Corticolous Myxomycetes in three different habitats in southern Finland

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Bark from living trees was periodically collected from three localities in southern Finland: from an urban, air-polluted park, a virgin forest and a managed forest, representing similar boreal coniferous forest areas. In moist chambers 19 species of Myxomycetes appeared on the pieces of bark. Eight are new to Finland: *Echinostelium minutum* de Bary, *E. cribrarioides* Alex., *Perichaena chryso sperma* (Currey) A. Lister, *Stemonitis pallida* Wingate, *Comatricha elegans* (Racid.) G. Lister, *Paradiacheopsis fimbriata* (G. Lister & Cran) Hertel, *P. solitaria* (Nann.-Brem.) Nann.-Brem., *Physarum pusillum* (Berk. & Curt.) G. Lister. Six species were abundant: *Echinostelium minutum* de Bary, *Arcyria pomiformis* (Leers) Rost., *A. cinerea* (Bull.) Pers., *Comatricha nigra* (Pers.) Schroet., *Enerthenema papillatum* (Pers.) Rost. and *Paradiacheopsis fimbriata* (G. Lister & Cran) Hertel.

Slime moulds appeared on bark with a wide range of pH, 2—9. Some species, e.g. *Comatricha nigra*, seemed to prefer an acid substrate, others, e.g. *Arcyria cinerea*, a less acid one. Among the common species the incubation time needed for fructifications to develop varied from a couple of days to over 40 days. Bark from the urban locality yielded many fructifications but of only six species. *Paradiacheopsis fimbriata* was very common and formed large colonies in places inhabited by the lichen *Bacidia chlorococca* (Stenh.) Lett., which is highly resistant to atmospheric pollution. Bark from the virgin forest produced fewer fructifications, but of many more species (16). Bark from the managed forest had few fructifications and few species (5). With the moist chamber culture method no phenological variation can be shown.

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I. Materials and methods

1. Collecting

Bark from living trees was collected in three localities in the province of Uusimaa:

Helsinki, The Botanical Garden of the University of Helsinki, in the centre of the city (Grid 27°E: 6675:386)

Espoo, Luukkaa, a virgin forest, about 25 km northwest of Helsinki (Grid 27°E: 6693:373)

Vantaa, Seutula, a managed forest, 20 km north of Helsinki (Grid 27°E: 6689:388)

The Botanical Garden was chosen to represent an air-polluted place. Even in the 1930s the lichens on the trunks were deteriorating or had disappeared (Vaarna 1934), and nowadays almost no corticolous mosses or lichens are to be found there except *Bacidia chlorococca* (Stenh.) Lett. Luukkaa and Seutula are two similar boreal coniferous forest areas including some rocky places with scanty undergrowth of *Juniperus* and moist depressions lined with *Sphagnum*. The main trees are *Picea abies*, *Pinus sylvestris*, *Betula pendula* and *B. pubescens*. Other frequent tree species are *Alnus glutinosa* (more in Luukkaa) and *A. incana* (more in Seutula), *Populus tremula*, *Salix caprea* and *Sorbus aucuparia*. The difference is that

Seutula receives normal silvicultural treatment although not recently treated with fertilizers or other chemicals and Luukkaa is left in a natural condition.

From October 1974 to May 1975 I collected tree bark for about 20 moist chambers every other week from the Botanical Garden and from the virgin forest. During May to November 1975 the project was extended to the managed forest, and bark was collected for 25 moist chambers from each of these three places every other week. In the Botanical Garden material was collected from both native and foreign tree species, about half from deciduous trees and half from conifers. From the forests equal amounts bark from corresponding tree species were collected. Each time bark from *Betula*, *Picea* and *Pinus* were included, and other trees sampled were *Juniperus*, *Alnus*, *Salix caprea* and *Populus tremula*. All bark specimens were taken from a convenient height below about 1.5 m. I was careful not to take living wood within. Every specimen was placed in a separate, clean paper bag. In all, bark was incubated in 1209 moist chambers.

2. Incubation

The bark was put in clean Petri dishes (diam. 9 cm), lined with filter paper. The bark formed a single layer covering the bottom as entirely as possible. The dishes were then filled with distilled water (adjusted with KOH to pH 7) and the covers put on. After 24 h the surplus water was poured off and the covers replaced. After another 24 h the pH of the moisture in the dishes was measured to the nearest 0.5 pH unit with pH sticks (Merck Universalindicator). The Petri dishes were kept in normal room conditions (cf. v. Stosch 1965) in diffuse daylight (cf. Gray 1938). The dishes were examined daily under a dissecting microscope for 4 weeks. When developing sporangia were found, the pH was measured once more and the cover left slightly open so that the moist chamber dried slowly. The following day the sporangia were usually mature, and if so the cover was removed. In some cases the plasmodium did not form sporangia, but turned into a sclerotium or died. From June to November 1975 I dried those chambers which had not produced slime mould fructifications and rewetted them 2 weeks later. The pH was measured once more, and the Petri dishes observed for 3 more weeks.

3. Documentation

Representative specimens are deposited at herbarium H. Because many specimens were scanty, I preserved a permanent slide of every one, and some specimens exist only as a permanent slide. At first the specimens were mounted in lactic acid, but this was laborious, and later Hoyer's medium (see Martin & Alexopoulos 1969) was used. The sizes of the sporangia were measured under a dissecting microscope. The colour code numbers refer to Maerz & Paul (1950). For small sporangia it was difficult to find a corresponding colour square even under a hand lens. For microscopical characters, such as spore colour, comparisons with the colour chart were not made because of the different lighting for the specimen and colour chart. Spore sizes are given here as means of ten measurements accurate to within 0.5 μm .

Species were identified from the following books: Lister (1926), Martin & Alexopoulos (1969), Nannenga-Bremekamp (1974).

II. List of species

Of the 19 species of slime moulds detected, eight were new to Finland. The species are described here in systematical order according to Nannenga-Bremekamp (1974). The number of specimens in the three habitats is given under the following symbols: L = Luukkaa, the virgin forest, S = Seutula, the managed forest, B = the Botanical Garden of the University of Helsinki. Each variable is described with three numbers (e.g. 3—18—49 days), indicating the smallest, mean, and greatest values. Total distribution range is according to Martin & Alexopoulos (1969) and the Finnish range according to Härkönen (1974).

Echinostelium minutum de Bary

85 specimens: L 69 / S 16 / B -. 60 on conifers, 25 on deciduous trees. 56 specimens (66 % of all) on *Pinus sylvestris*. pH of substrate 2.5—5. Incubation time 3—18—49 days. Probably cosmopolitan. New to Finland.

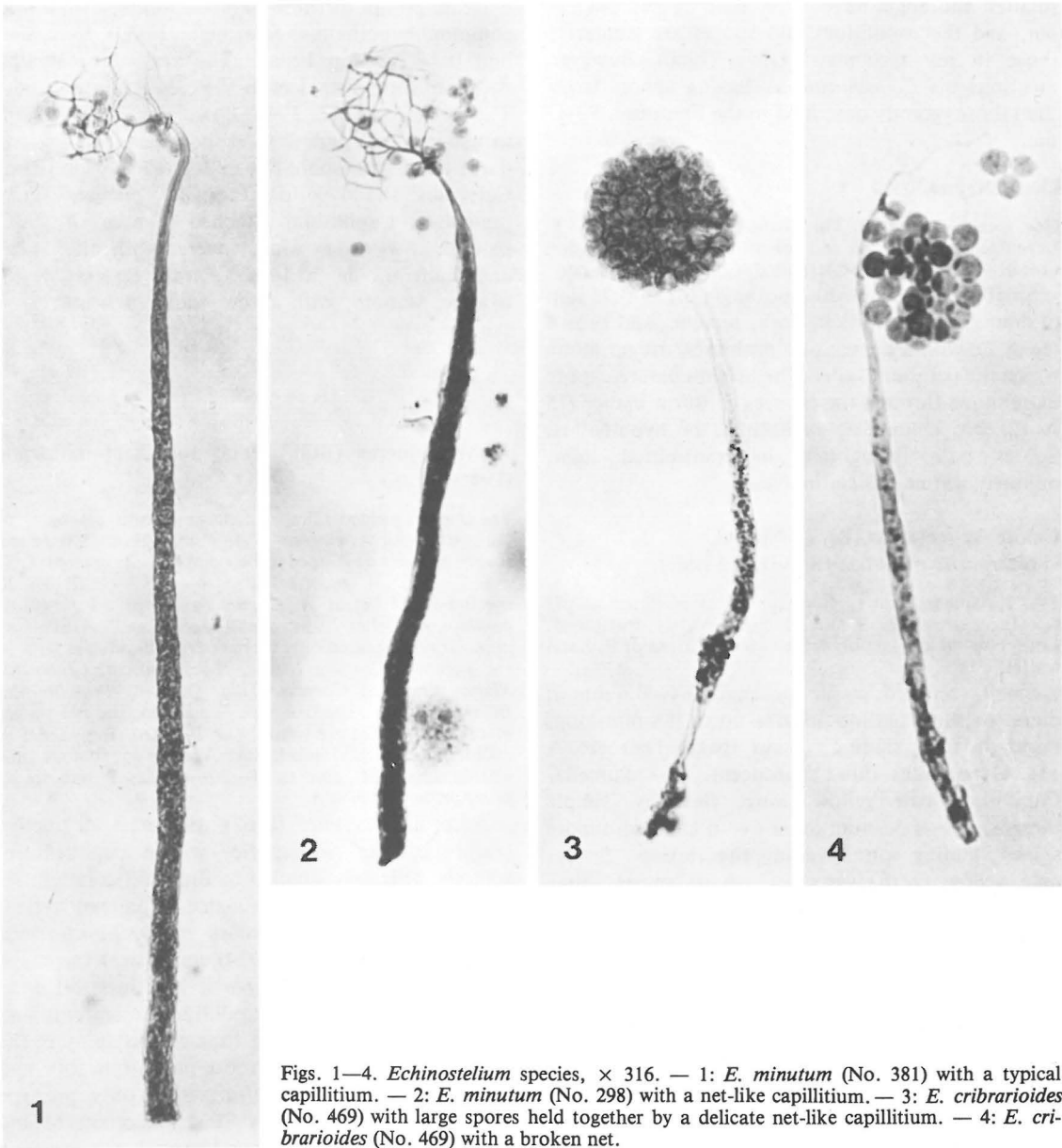
Sporangia stalked, scattered or gregarious, 220—421—600 μm high. Head globose 35—49—60 μm diam. Peridium represented only by a collar round the stem. Stalk hair-like, white or black or upper part white and lower part black, somewhat shining, 4—8 times as long as sporangium, in transmitted light yellow and filled with granular material at least below; thickness below collar 1—2.6—8 μm and at base 8—13.8—24 μm . Columella small, ending in a scanty, dichotomously branched, seldom anastomosing capillitium with pointed tips (see Figs. 1—2). Spores hyaline in transmitted light, smooth, 5.5—6.5—8 μm in diam.

Two colour forms, white and pinkish, are recognized by Alexopoulos (1960). In the present material the developing sporangia of 18 specimens were deep pink, the others being white or pale pinkish. About 1 year later all the specimens looked white or nearly so (2 A 1, 2 B 1) under a dissecting microscope with a mercury lamp which is said to resemble daylight.

Echinostelium cribrarioides Alex.

Three specimens, all from L. All on *Betula* at pH 5. Incubation time 10, 22 and 24 days. Reported from Greece and Dominica (Martin & Alexopoulos 1969), the Netherlands (Nannenga-Bremekamp 1974), and France (Mitchell & Nannenga-Bremekamp 1976). New to Finland.

Sporangia 264—317—350 μm tall, head white, 48—58—72 μm in diam., with no peridium except a basal collar. Stalk about four times height of sporangium, white or with white upper and black lower part, yellow in transmitted light and filled



Figs. 1—4. *Echinostelium* species, $\times 316$. — 1: *E. minutum* (No. 381) with a typical capillitium. — 2: *E. minutum* (No. 298) with a net-like capillitium. — 3: *E. cribrarioides* (No. 469) with large spores held together by a delicate net-like capillitium. — 4: *E. cribrarioides* (No. 469) with a broken net.

with granular material, under collar 2—2.2—5 μm in diam., and at base 11—12—13 μm . Columella short, dividing into capillitium net with large meshes, which tend to break when one tries to wash out the spores. (The spores stay within the sporangium on the slide, whereas in *E. minutum* they escape spontaneously. See Figs. 3—4.) Spores hyaline, with distinctly plate-like areas, 10—10.1—10.5 μm in diam.

My specimens do not exactly correspond to the original description of the species (Alexopoulos 1961). The sporangium has a smaller head, and the capillitium does not show such a complete globose net. But the spores are typical and clearly larger than the largest spores (8 μm) of my specimens of *E. minutum*. The specimens correspond better to the description and drawings of Nannenga-Bremekamp (1974). In a duplicate of her specimen 9487, the

smallest sporangia have a diameter of less than 50 μm , and the capillitium and spores are similar to those in my specimens. Olive (1960), however, mentions his *E. minutum* as having spores larger than those recently described in the literature, 9–13 μm .

***Licea minima* Fr.**

One specimen from B. On *Taxus cuspidata* at pH 4.5. Developed, after drying and rewetting in total incubation time of 47 days. Widely distributed. Common in Finland.

Small, scattered, sessile sporangia 0.15–0.25 mm in diam. Peridium thick, dark, opaque, and brown (16 A 2), with a network of prominent ridges along which the peridium splits. The bright-coloured spore mass shows through the fissures as Burnt umber (15 A 12). No columella, capillitium, or hypothallus. Spores pale ferruginous in transmitted light, minutely warted, 10 μm in diam.

***Calomyxa metallica* (Berk.) Nieuwl.**

(*Margarita metallica* (Berk.) A. Lister)

Two specimens from L. Both on *Alnus glutinosa* at pH 4.5. Incubation time 9 and 17 days. Widely distributed. From Finland known only from two collections of P. Karsten (H).

Small, scattered, sessile sporangia 0.4–0.6 mm in diam. or short plasmodiocarps up to 0.8 mm long. Peridium thin, shining, colour Biskra Date (16 A 12). Hypothallus thin, translucent. No columella. Capillitium pale yellow, long, flexuous, simple threads, 0.8–1.5 μm in diam., with band of minute spines winding spirally along the threads. Spores pale yellow, with warts and sharp spines, 10–10.5–11 μm in diam.

***Perichaena chrysosperma* (Currey) A. Lister**

Two specimens from L. Both on *Populus tremula* covered with mosses at pH 5.5 in 13 and 36 days. Cosmopolitan. New to Finland.

Sporangia 0.3–0.6 mm in diam., sessile or having extremely short, thick, black stalks or short plasmodiocarps up to 1.5 mm long. Outer peridium thick, shining; colour Chestnut (7 E 10); inner layer thin, translucent. Dehiscence irregular. No hypothallus. Capillitium threads yellow, 2–5 μm thick, some with short papillae, some with spines up to 2 μm long, and most with both. Spores yellow, minutely warted, 10–10.5 μm in diam.

***Arcyria incarnata* (Pers.) Pers.**

Two specimens from L. Both on *Alnus glutinosa* at pH 4.5. One developed in 17 days, the other, after drying and rewetting, in 35 days. Cosmopolitan. Common in Finland.

Dense groups of short-stalked sporangia on a thin common hypothallus. Sporangia 1–1.8 mm high and 0.3–1.2 mm broad. The very thin, shining peridium soon evanesces as the capillitium expands. The red-brown (7 J 9) coalescing plasmodium turned into pale pink (2 C 9) sporangia. Stalk short, dark, filled with spore-like cells 8–16 μm in diam. Calyculus shallow, longitudinally plicate, finely punctuate. Capillitium attached to apex of stalk, pale pink, 3–4 μm wide, covered with blunt pegs and halfrings in a loose spiral. Spores nearly hyaline, smooth, with a few scattered warts, 7–8 μm .

***Arcyria cinerea* (Bull.) Pers. and *A. pomiformis* (Leers) Rost.**

The samples yielded 128 specimens apparently belonging to the species pair *A. cinerea* — *A. pomiformis*; 15 were too scanty or badly developed to be examined. *A. cinerea*: L 37 / S 7 / B 5; *A. pomiformis*: L — / S — / B 59. 36 specimens (74 %) of *A. cinerea* developed on *Juniperus communis*. Other substrates: *Malus* and *Alnus*. *A. pomiformis* appeared only on bark from deciduous trees in the Botanical Garden: *Ulmus*, *Acer*, *Syringa*, *Crataegus*, *Malus*, *Fraxinus*, *Corylus*, *Tilia*, *Quercus*, *Populus* and *Betula*. Although the tree species differed, the pH ranges of the two species are similar (see Fig. 16). Both seem to avoid the most acid substrates. Average incubation time was longer in *A. cinerea* (3–20–41 days) than in *A. pomiformis* (3–9–40).

According to Farr (1962), the main distinctive feature of the two species is the cup texture: smooth, delicately stippled or finely reticulate in *A. cinerea*, and marked with coarse, prominent reticulations, papillae, or blotches in *A. pomiformis*. Nannenga-Bremekamp (1974) emphasizes the shape of capillitium. In *A. cinerea* it has three different parts. At its base the capillitium is smooth and thick, becoming somewhat thinner and spiny in the middle, and in the uppermost parts it is thin and bears long spines. *A. pomiformis* has only one type of capillitium. A study by SEM (Schonknecht and Small 1972) revealed that: »Although the capillitia of *A. pomiformis* are much larger than those of *A. cinerea*, they are morphologically similar. The capillitia of both species are ornamented with blunt spines.» Using SEM Robrecht (1973) found two capillitial types in *A. cinerea*, one finely built with an av. diam. of 2.2 μm and the other massively built with an av. diam. of 3.7 μm .

In the present study 49 specimens with a smooth or almost smooth cup and at least two types of capillitium were referred to *A. cinerea*, another 59

with a cup with prominent reticulations and only one type of capillitium being referred to *A. pomiformis* (see following list). Five specimens were exceptional in one way or another.

	<i>A. cinerea</i> 49 specimens	<i>A. pomiformis</i> 59 specimens
Total height	0.4—1.6—2.8 mm	0.3—0.9—1.5 mm
Diameter	0.2—0.4—0.7 mm	0.1—0.3—0.6 mm
Ratio stalk/total height	0.2—0.4—0.6	0.1—0.5—0.7
Shape of sporangium	ovate to cylindrical, sometimes with fused stalks	ovate to globose, scattered
Colour	grey, sometimes with a yellowish tint (ivory 10 B 2, oyster white 10 B 1, beige 11 C 2)	greenish yellow to bright yellow (light stone 12 J 5, popcorn 9 J 3)
Peridium	thin, shining; though fugacious, mostly some fragments left	not persistent
Cup markings	smooth or delicately punctuate	fragmented reticulations
Hypothallus	mostly present	mostly absent
Stalk	same colour or lighter or darker than sporangium filled with spore-like cells 8—44 μm in diam	same colour or lighter or darker than sporangium filled with spore-like cells 8—40 μm
Capillitium	dense, not expanding the base smooth or nearly smooth 2—8 μm , the apical part 1.5—3.5 μm with long sharp spines	more robust, less dense, expanding, only one type with cogs, short spines or half rings, 2.5—8 μm
Habitat:		
Specimens on conifers	36	—
Specimens on deciduous trees	13	59
Specimens in:		
Botanical Garden	5	59
Virgin forest	37	—
Managed forest	7	—

Robrecht (1974) does not agree with Farr's opinion that the stalk in the two species is similar and not useful for distinguishing the species. He draws attention to the spore-like cells in the stalk: In *A. pomiformis* the stalk is filled with spore-like cells, that are large (av. diam. 25 μm up to 38 μm) and somewhat polygonal while those of *A. cinerea* are smaller (15—21 μm) and more rounded. In some specimens of the present material the spore-like cells were difficult to distinguish and could not be measured. In general, the spore-like cells also varied greatly in size and so only the largest and the smallest were measured. In both species the size of the spore-like cells gradually diminishes towards the apex. The smallest cells are often about the size of true spores and can be distinguished from them only by the absence of scattered warts. From Fig. 5 it is evident that although on average the cells in *A. pomiformis* are larger, the overlap is great.

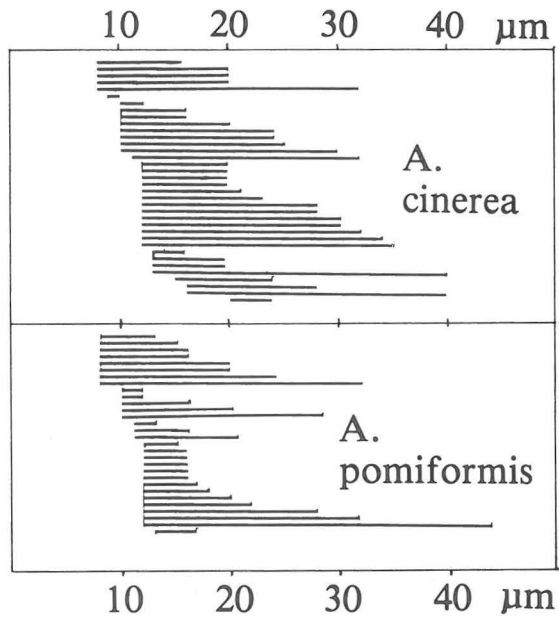


Fig. 5. The size ranges of the spore-like cells in the stalks of *Arcyria cinerea* and *A. pomiformis*.

In this material *A. cinerea* was always grey, and *A. pomiformis* always showed some tints of yellow, never grey. In mature specimens *A. pomiformis* always had a somewhat expanded capillitium and there was never any peridium left. *A. cinerea* mostly had a thin peridium or at least fragments of it left

and the spores were so firmly attached within the sporangium that it was difficult to blow them away. The spores of the two species are similar; even the slight size difference that Farr (1962) reports, *A. cinerea* 6–7 μm , *A. pomiformis* (6–) 7–8 (–9) μm , is hardly a reality (see Fig. 6).

Three specimens have an almost smooth cup, but only one type of capillitium. All of them are greyish, and the capillitium is not expanded. So they are nearest to *A. cinerea* and, as Farr (1962) writes, the cup markings seem to be the most constant character for distinguishing the two species.

Two specimens with very small sporangia have no cup. Otherwise they are typical *A. pomiformis*.

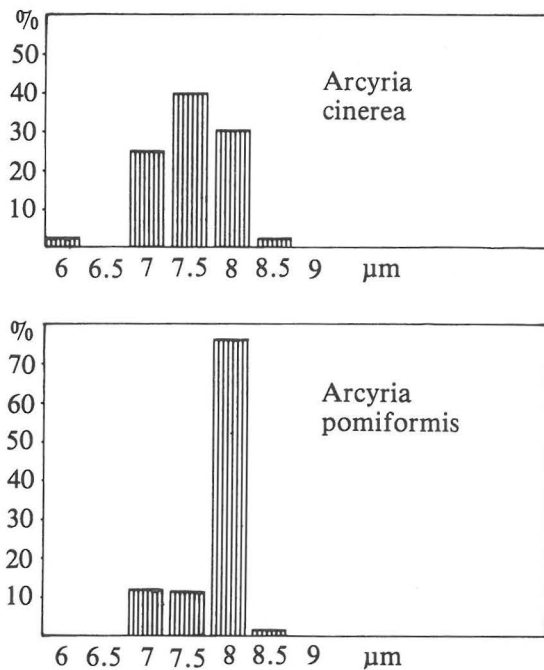


Fig. 6. The spore dimensions of *Arcyria cinerea* and *A. pomiformis*.

Trichia botrytis (J. F. Gmel.) Pers.

One specimen from L. On *Betula* at pH 5 after rewetting, appearing after 40 days' incubation. Widely distributed, collected in different parts of Finland, too.

Sporangia stalked, solitary or in twos on one stalk, pyriform, 0.4–0.5 mm in diam., total height 0.8–1 mm. Outer peridium thick, mottled: sepia (8 A 10) plates on a buff (11 K 7) background. Inner peridium membranous. Stalk opaque, furrowed, nearly black, filled with amorphous material. Hypothallus thin, dark brown. Elaters consist of smooth spirals, yellow, 4 μm in middle and

gradually tapering to long tips. Spores not swelling properly, pale yellow and minutely warted, about 11 μm in diam.

Stemonitis pallida Wingate

One specimen from L. On *Junipers communis* on mosses at pH 4.5 in 32 days. According to Martin & Alexopoulos (1969), distributed in Europe, the Malay Peninsula, Japan, and the Eastern United States to Iowa. Found also in Africa, Angola (Almeida 1974) and the Galapagos Islands (Eliasson 1971). New to Finland.

The dark hypothallus bore 13 sporangia in a dense cluster. Total height about 3 mm, stalk 1 mm; thickness of single sporangium about 0.3 mm. Stalk black. Sporangia sepia (8 A 10). The dark columella becomes thinner and lighter towards the apex. Surface net pale brown; meshes angular, spinulose, about 4–30 μm in diam, absent from top of sporangium. Spores pale brown in transmitted light, minutely warted, 7–8 μm in diam.

Comatricha elegans (Racib.) G. Lister

One specimen with a single sporangium from L. On *Alnus glutinosa*, pH 5, after 37 days. Widespread. New to Finland, but known from Sweden (Santesson 1964).

Sporangium globose, stipitate, 0.2 mm in diam. Total height 1 mm. Stalk black, 68 μm thick at base, 8 μm at tip. No hypothallus. Columella short, dividing into four stout main branches, which then divide again into a slender, flexuous, anastomosing capillitium. Spores pale brown, evenly and minutely warted, 8 μm in diam.

Comatricha nigra (Pers.) Schroet.

79 specimens: L 25 / S 3 / B 51. Seems to prefer coniferous trees (79 % of specimens). 26 specimens on *Larix* spp., 23 on *Picea abies*. Other substrates: *Pinus* sp., *Pinus sylvestris*, *Pseudotsuga*, *Thuja*, *Picea*, *Alnus*, *Populus*, *Sorbus*, *Crataegus*, *Ulmus*, *Betula*, *Quercus*. On rather acid media, pH 2–5. Development took 7–30–46 days. Mostly (in 68 % of cases) the medium had to be dried and rewetted before *C. nigra* appeared. Cosmopolitan and also common in Finland.

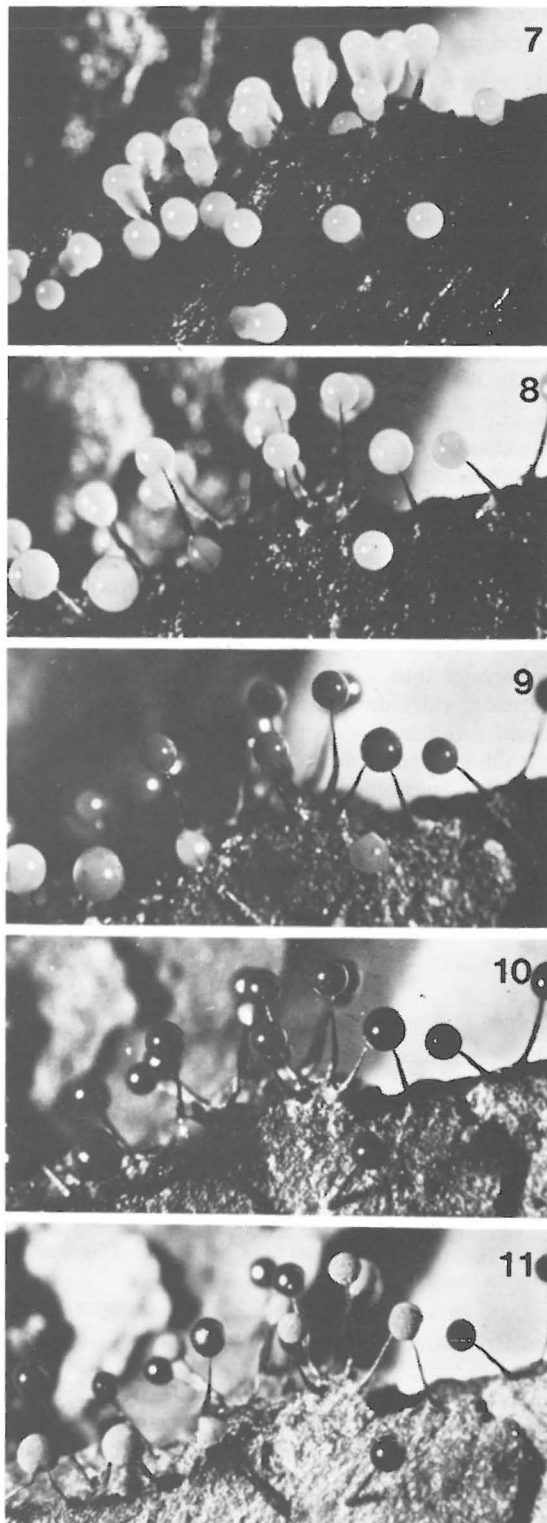
Sporangia scattered or in small groups. Total height 0.7–2–3.5 mm. (Possibly fructifications develop smaller in moist chambers than in nature; Martin & Alexopoulos (1969) give the size limits as 2–8 mm.) Head of sporangium dark brown (8 E 10), 0.25–0.4–0.8 mm in diam., mostly globose, sometimes ovate. Peridium evanescent. Stalk black, thin; width 40–85–150 μm at base, at apex 8–15.5–16 μm . Ratio of head to total height 0.1–0.2–0.4. Hypothallus small, thin, transparent, brownish or lacking, sometimes continuing round the stalk as a hyaline sheath. Columella reaches from 1/4 to top within sporangium, mostly 2/3.

Capillitium dark, flexuose, branching and anastomosing, forming dense net and especially at top of sporangium having many, sometimes swollen, free ends. Spores dark brown in mass and light violaceous brown by transmitted light, never dark as stated by Martin & Alexopoulos (1969), faintly warty to nearly smooth. Some, at least, of the spores in every specimen have a paler and smoother area on one side. Diameter 7.5–8.3–10 μm , somewhat less than the (8–) 9–10 (–11) μm given by Martin & Alexopoulos (1969), but fitting well with the data on Dutch material, 7.5–9 μm (Nannenga-Bremekamp 1974). Plasmodium colourless, but turning white when beginning to coalesce. Then the stalks inside the white mass turn black. As the black stalks grow, the plasmodium moves up and forms white heads of the young sporangia. These then turn pink, red, dark red, and finally black (cf. Goodwin 1961). While maturing, the head dries and turns brown (see Figs. 7–11).

Enerthenema papillatum (Pers.) Rost.

29 specimens: L 27 / S 1 / B 1. Seems to prefer coniferous bark. 25 specimens (85 % of all) on conifers, 16 being on *Picea abies*. pH rather low, 3–5. Incubation time 3–26–41 days. Widely distributed; common in Finland.

Sporangia scattered or in small groups. Total height 0.6–0.8–1 mm. Head 0.3–0.6–1 mm in diam., dark brown (like 16 A 6–12 but darker). Peridium evanescent except for some silvery-grey flakes on some sporangia and basal ring around the stalk in most of them. Stalk stout, shining black, opaque, averaging somewhat under 1/3 of total height or absent; length never as great as diameter of sporangium (Martin & Alexopoulos 1969; about equal to the sporangium). Stalk then narrows to a columella, which reaches top of sporangium. Columella terminating in a shining black plate 28–128–320 μm in diam. Capillitial threads black, flexuous, spreading downwards from apical disk. Near the tips they divide dichotomously once or twice and have some uneven warts. Hypothallus inconspicuous. Spores greyish brown in transmitted light, minutely warty, 9.5–11–12 μm in diam. Plasmodium in coalescence white. Developing sporangia turn successively pink, dark red and black.



Figs. 7–11. The development of *Comatrixha nigra* (No. 248), $\times 11$. — 7: white, 8: pink, 9: red, 10: black, 11: partially mature, brown sporangia. Between the last two photos there are 12 hours, between the others two hours.

Paradiacheopsis fimbriata (G. Lister & Cran) Hertel
(*Comatricha fimbriata* G. Lister & Cran)

217 specimens: L — / S 33 / B 184. On 27 tree species, 65 specimens on coniferous bark, 152 on deciduous bark. Commonest on *Acer* and *Ulmus*. Most abundant on bark that was green with *Bacidia chlorococca* (cf. Ing 1976: »Usually associated with the alga *Pleurococcus*.) The pH range of the substrates was very wide, from pH 2 to 9. *P. fimbriata* is the most abundant Myxomycete species in the Botanical Garden. In the virgin forest none developed. All the *Paradiacheopsis* there proved to be *P. solitaria*. The time needed for development was mostly short, 3—10—43 days. Distribution: Great Britain, the Netherlands (common: Nannenga-Bremekamp 1974), Belgium, Greece and several states in the U.S.A. (Martin & Alexopoulos 1969), France (Mitchell & Nannenga-Bremekamp 1976); also found in Sweden (Santesson 1964) and Czechoslovakia (Svrček 1972). Possibly common in Finland, although not found before, because of its small size.

Sporangia stalked, dark brown, nearly black, scattered, globose. Total height 0.3—0.7—1.1 mm. No peridium, and spores flow away easily, leaving naked capillitium. Stalk black, fibrillose, especially below, where the colour also turns brown, much thicker, 20—73—280 μm at base than on top, 2—8—24 μm . Hypothallus small. Columella short, branching into very delicate, colourless capillitial threads, which darken and thicken towards the tips. Some branches with prominently expanded tips. Capillitial threads dichotomously forked, but mostly without anastomoses (see Fig. 12—13). Spores purplish grey-brown, minutely spinulose, paler and smoother on one side, some of them slightly oval, 10—12—14 μm in diam. Plasmodium colourless, turning white when beginning to coalesce. Stalk then turns black and head pink, coral red, dark red and finally black.

Paradiacheopsis solitaria (Nann.-Brem.) Nann.-Brem.

(*Comatricha solitaria* Nann.-Brem.)

10 specimen, all from L. 6 specimens on *Alnus glutinosa*, 3 on *Juniperus communis*, one on *Picea abies*. Substrate pH 3.5—5. Incubation time 4—9—17 days. So far reported only from the Netherlands (Nannenga-Bremekamp 1962), Great Britain (Ing 1967) and France (Mitchell & Nannenga-Bremekamp 1976). New to Finland.

Dark brown, almost black, stalked sporangia, mostly standing solitarily, but some of them in colonies, the largest having nearly a hundred sporangia. Total height 0.7—0.9—1.2 mm. Sporangia globose, 0.25—0.4—0.6 mm in diam. No peridium. No hypothallus. Stalk black, fibrous at base, at apex 12—39—72 μm , at base 80—142—240 μm in diam. Columella ends about halfway in sporangium.

Capillitium black and stout throughout, branching dicotomously, but usually without anastomoses. Tips not expanded. Spores in transmitted light greyish brown, minutely and evenly warted, 12—13.5—16 μm in diam. Nannenga-Bremekamp (1962), in the description of the species, gives the spore size as (13—) 14—16 (—20) μm . Maybe the range should be widened a little, because even on the slide I received from her (No. 9287) there are spores 12 μm in diameter.

According to Martin & Alexopoulos (1969), *P. solitaria* may well be no more than an extreme variant of *P. fimbriata*. However, the capillitium of *P. solitaria*, which is rigid throughout, makes the two species clearly distinguishable (See Figs. 12—14).

Physarum viride (Bull.) Pers.

Three specimens from L. All on *Betula* at pH 5 and only after drying and rewetting. Incubation time 31—33—35 days. Cosmopolitan. Widely distributed in Finland.

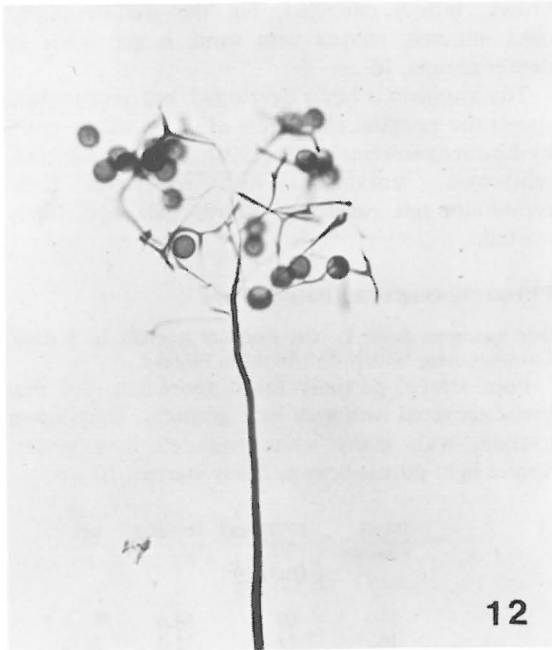
Scattered, stalked sporangia 0.9—1.1 mm tall. Sporangia globose to lenticular, some of them nodding, 0.25—0.4 mm broad, 0.2—0.3 mm high. Peridium fragile, covered with yellow (9 K 2) lime granules. Stalk furrowed, bright orange at apex and dark brown below, containing no lime; upper half transparent in transmitted light, lower half thicker and filled with refuse matter. No columella. Hypothallus a small dark plate. Capillitium hyaline, with fusiform orange or greenish yellow lime nodes. Spores pale lilac brown in transmitted light, finely warted, with some bigger warts in denser groups, 8—8.5—9 μm in diam.

Physarum oblatum Macbr.

(*Physarum maydis* (Morgan) Torrend)

One specimen from L. On *Juniperus communis* at pH 5 in 21 days. According to Martin & Alexopoulos (1969) cosmopolitan. Found in Finland only once before (Satakunta: Kankaanpää, 6. II. 1935 Matti Laurila, H) and not reported from the other N European countries or even from Netherlands.

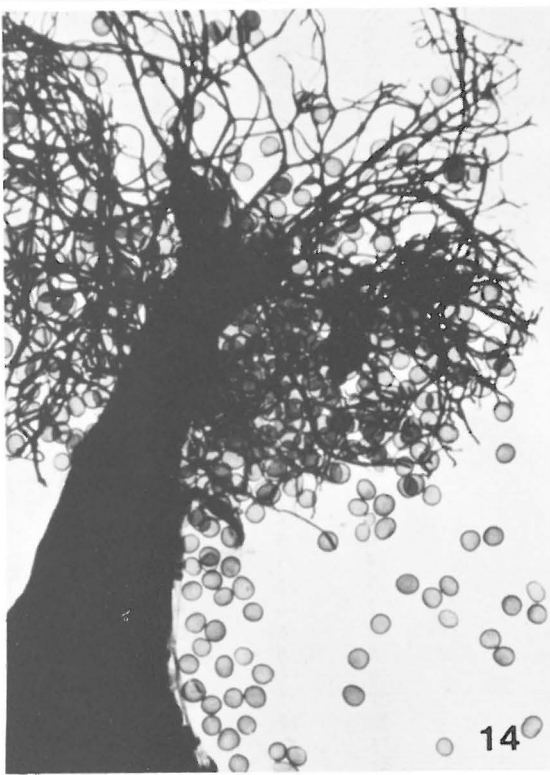
11 stalked sporangia in two small groups. Total height 0.9—1.1 mm. Sporangia globose 0.3—0.4 mm in diameter. Peridium membranous, roughened with golden yellow (9 L 6) lime granules; base darker, having same tint as stalk. Stalk red-brown, transparent, furrowed, having no lime or refuse matter. No columella. Hypothallus inconspicuous. Capillitium hyaline having many large, irregular lime nodules of same colour as lime on peridium. Spores purple brown in transmitted light, finely and evenly warted, 11 μm .



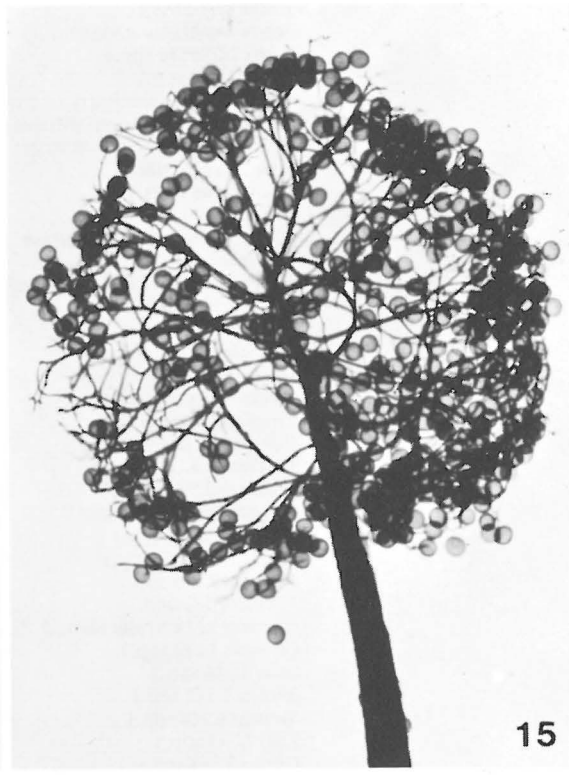
12



13



14



15

Figs. 12—15. *Paradiacheopsis* species, $\times 162$. — 12: *P. fimbriata* (No. 649), a typical sporangium. — 13: *P. fimbriata* (No. 577) with an abundant capillitium. — 14: *P. solitaria* (No. 534) — 15: *P. solitaria* (No. 665).

Physarum pusillum (Berk. & Curt.) G. Lister

One specimen from L. On bark of *Sorbus aucuparia* at pH 5.5 only after drying and rewetting, in 41 days. Cosmopolitan. New to Finland. Bjørnekaer & Klinge (1963) report it from Denmark.

Six scattered, stalked sporangia 0.5—1 mm high. Sporangia slightly flattened and umbilicate below, 0.25—0.6 mm in diam. Peridium thin, brownish grey (8 C 9, 8 E 9), base thicker and more reddish brown. Some sporangia totally without, some with sparse white lime granules. Stalk cylindrical, furrowed, dark brown, dark yellowish red in transmitted light, having no lime or refuse matter. Stalk merges into dark basal part of sporangium. Hypothallus disk-shaped, brown, translucent. No columella. Capillitium a network of hyaline threads with sparse white lime nodes. Spores light lilaceous

brown, mostly damaged, but the well-developed ones minutely warted with some larger warts in denser groups, 10 µm.

The specimen is badly developed, but nevertheless, shows the essential characters of *P. pusillum* given by Nannenga-Bremekamp (1974): stalk translucent, red-brown, sporangium with red-brown base, capillitium not radiating, spores pale and finely warted.

Physarum cinereum (Batsch) Pers.

One specimen from L. On *Populus tremula* in 5 days. Cosmopolitan. Widely distributed in Finland.

Four sessile, partially fused sporangia, 0.4 mm broad, covered with grey lime granules. Capillitium hyaline, with many white rounded lime nodes. Spores light purple-brown, finely warted, 10 µm.

Tree species	moist chambers	chambers with fruitings	fruiting %	pH
<i>Juniperus communis</i> L.	110	60	54.6	4—5.5
<i>Picea abies</i> (L.) Karsten	163	51	31.3	2—4
<i>Pinus sylvestris</i> L.	155	93	60	2.5—5
<i>Abies nephrolepis</i> Maxim.	2	—	0	
<i>Larix</i> Miller (6 spp.)	65	29	44.6	2—4.5
<i>Pinus</i> L. (4 spp.)	31	13	41.9	2—4
<i>Picea engelmannii</i> Parry ex Engelm.	13	4	30.8	3—4.5
<i>Pseudotsuga menziesii</i> (Mirbel) Franco	7	5	71.4	2.5—4.5
<i>Taxus cuspidata</i> Sieb. & Zucc.	15	13	86.7	3—5
<i>Thuja occidentalis</i> L.	20	10	50	2.5—5
Coniferous trees	581	278	47.9	2—5.5
<i>Alnus glutinosa</i> (L.) Gaertner	71	44	62	3—5
<i>Alnus incana</i> (L.) Moench	39	4	10.3	5—5.5
<i>Betula pendula</i> Roth. + <i>B. pubescens</i> Ehrh.	166	37	22.3	2.5—5.5
<i>Populus tremula</i> L.	33	6	18.2	4.5—5.5
<i>Salix caprea</i> L.	27	—	0	4—5.5
<i>Aesculus neglecta</i> Lindl.	1	1	100	
<i>Acer</i> L. (5 spp.)	49	39	79.6	3.5—7.5
<i>Alnus rubra</i> Bongard	1	—	0	
<i>Carpinus betulus</i> L.	4	3	75	4.5—5
<i>Corylus</i> L. (2 spp.)	4	3	75	
<i>Crataegus</i> L. (4 spp.)	20	11	55	3—5
<i>Fraxinus</i> L. (3 spp.)	15	13	86.7	3.5—5
<i>Hippophae rhamnoides</i> L.	2	2	100	
<i>Junglans</i> L. (2 spp.)	6	5	83.3	4—5
<i>Malus</i> Miller (2 spp.)	19	15	79	3—5
<i>Populus</i> L. (6 spp.)	29	22	75.9	3.5—5.5
<i>Prunus</i> L. (2 spp.)	2	—	0	
<i>Pterocarya rhoifolia</i> Sieb. & Zucc.	5	5	100	3—4
<i>Quercus</i> L. (2 spp.)	6	6	100	2.5—3.5
<i>Salix</i> L. (4 spp.)	9	5	55.6	4.5—5
<i>Sorbus</i> L. (2 spp.)	22	3	13.6	4—5.5
<i>Syringa</i> L. (4 spp.)	22	12	54.5	4—5
<i>Tilia</i> L. (3 spp.)	13	12	92.3	3.5—5
<i>Ulmus</i> L. (3 spp.)	61	51	83.6	3—9
<i>Vitis labrusca</i> L.	2	—	0	
Deciduous trees	628	299	47.6	2.5—9
Total	1209	577	47.7	2—9

Table 1. The tree species used for the moist chambers.

III. Ecology

1. Different tree species as habitats for Myxomycetes

Table 1 lists the sources of the material for the moist chamber cultures according to tree species with the respective amplitudes of pH measured. The pH values are mostly somewhat below the averages given by Barkman (1958), but the order of the different tree species is about the same.

47.7 % of the moist chambers yielded Myxomycete fructifications. Alexopoulos (1953) reported a yield of $66/271 = 24.4\%$, whereas Peterson obtained up to ca. 60 % (Alexopoulos 1963).

There seemed to be no major differences between deciduous and coniferous tree bark as habitats for Myxomycetes. Of those trees for which over 20 bark cultures were set up, the most favourable (productivity over 50 %) were: *Ulmus*, *Acer*, *Populus*, *Alnus glutinosa*, *Pinus sylvestris*, *Syringa*, *Crataegus*, *Juniperus communis* and *Thuja*. Least productive (slime moulds appearing in less than 25 %) were *Salix caprea*, *Alnus incana*, *Sorbus* and *Populus tremula*. The low productivity of *Salix caprea*, *Betula* and *Alnus incana* may be caused by the smoothness of their bark. *Salix caprea* and *Alnus incana* also seemed to have very few epiphytic lichens or mosses to make the surface rough enough for trapping Myxomycete spores. As far as pH is concerned, these unproductive tree barks are not extreme.

Fissured barks with loose texture (e.g. those of elms and junipers) are mentioned as favourable for a number of Myxomycetes, while barks of *Junglans* and *Salix* have proved unfavourable (Brooks 1976, Keller & Brooks 1973). In Finland as elsewhere *Ulmus* bark was the most productive, even though collected only from cultivated trees. *Salix caprea* was unproductive. Of native Finnish trees *Pinus sylvestris*, *Alnus glutinosa* and *Juniperus communis*, all with fissured bark, were the most favourable.

Some of the more abundant Myxomycete species developed more often on a certain group of tree species, *Comatricha nigra* and *Enerthenema papillatum* on conifers, *Arcyria pomiformis* on deciduous trees, others, like *Echinostelium minutum* (on *Pinus sylvestris*) and *Arcyria cinerea* (on *Juniperus communis*), preferring a single tree species. Pirola & Credaro (1975), in making a synecological arrangement of Myxomycetes found in Italy, claim that *Enerthenema papillatum* is limited to coniferous forests whilst *Comatricha nigra* is present in both coniferous and deciduous forests.

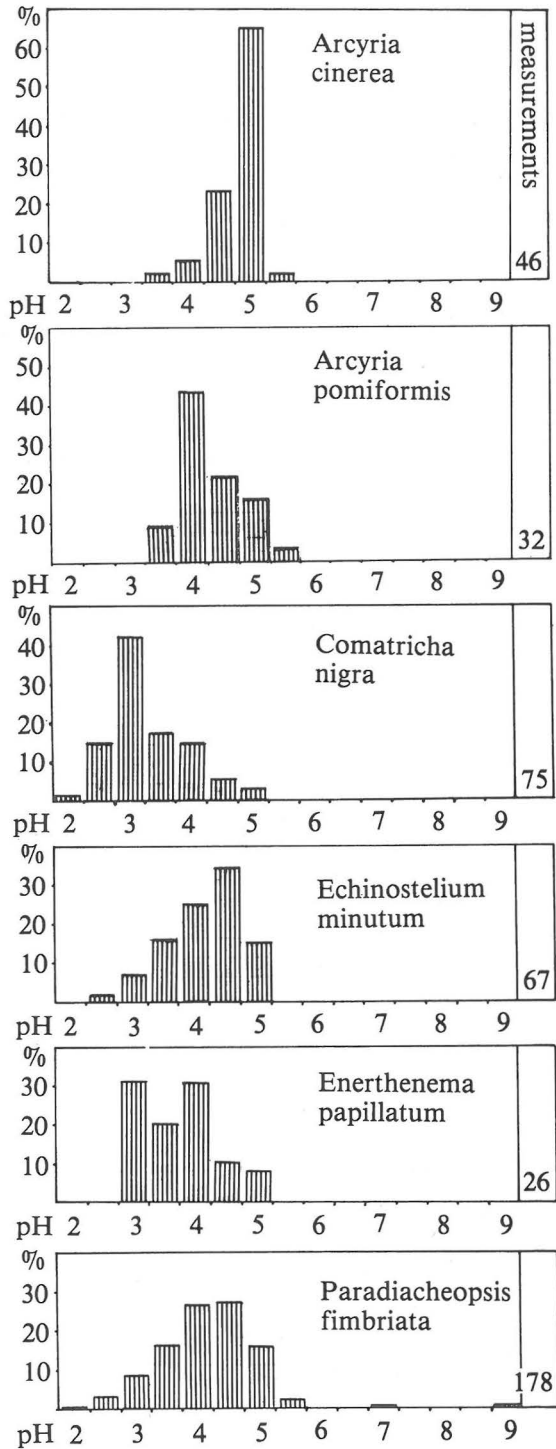


Fig. 16. pH of the substrates of the six most abundant species of Myxomycetes.

Table 2. The collecting sites from June to November 1975.

Month	Botanical garden			Virgin forest			Managed forest		
	no. of moist chambers	no. of slime moulds	productivity %	no. of moist chambers	no. of slime moulds	productivity %	no. of moist chambers	no. of slime moulds	productivity %
June	50	32	64	50	33	66	50	14	28
July	50	42	84	50	29	58	50	19	38
August	50	51	102	50	21	42	50	16	32
September	50	46	92	50	28	56	50	11	22
October	50	43	86	50	32	64	50	11	22
November	50	39	78	50	28	56	50	7	14
Total	300	253	84	300	171	57	300	78	26

2. pH of the substrate

The pH of the substrate was measured in the 3-day-old cultures and again when fructifications began to appear. In cultures that were dried and rewetted, the measurement was repeated again on the third day after the procedure. No noteworthy changes of pH were recorded during incubation or drying. This seems essential, since a certain stability of pH is considered important for success of the culture (Mock & Kowalski 1976).

The pH of the bark was lower in conifers (2–5.5) than in deciduous trees (2.5–9). Even on *Ulmus* with the exceptionally high value of pH 9 (presumably caused by some external influence), Myxomycete fructifications were produced. The lowest pH at which slime moulds were recorded was 2. Thus in regard to pH the ecological amplitude seems in general to be wide, but the different slime mould species have different optima and amplitudes (see Fig. 16). E.g. *Comatricha nigra* seems to prefer an acid substrate, differing clearly in this respect from *Arcyria cinerea*. Emoto (1939) found the reaction of rotting wood inhabited by Myxomycetes to be 4.2–7.8. In laboratory cultures also, slightly acid media have been found favourable for growth of Myxomycetes (Howard 1931, Smart 1937, Collins & Tang 1973).

3. The three habitats as producers of Myxomycetes

From October 1974 to May 1975, 309 moist chamber cultures were set up for bark samples from the Botanical Garden and from the virgin forest. Unexpectedly, Myxomycete fruiting bodies were produced more frequently by samples from the Botanical Garden (46 %) than by those from the virgin forest (19.2 %). Inclusion of material from the managed forest and drying and rewetting treat-

ment of the cultures with no Myxomycetes growth did not alter the main picture. The productivity of samples from the Botanical Garden gave the best results during every month except June, and the samples from the managed forest were least productive (Table 2). According to the t test, the difference in yield as Myxomycete fruiting bodies between the virgin forest and the managed forest was highly significant. The reason may have been that the virgin forest is rich in decaying wood on the ground, whereas the managed forest is not. But another possible influence is *Alnus glutinosa* which, in the virgin forest, is more common than *A. incana*, the opposite being the case in the managed forest.

The Myxomycete flora of the samples from the Botanical Garden consists of six species, that from the managed forest of five species and that from the virgin forest of 16 species. In the Botanical Garden there were many specimens but few species. Of the six species present in the Botanical Garden three were abundant: *Paradiachopsis fimbriata* (184 specimens), *Arcyria pomiformis* (59) and *Comatricha nigra* (51). The thick old trees with fissured barks planted in the last century evidently afford favourable habitats for slime moulds. The differences in the composition of the slime mould flora are evidently partially due to differences in tolerance to air pollution. For instance, the commonest species in the virgin forest, *Echinostelium minutum*, seems to be absent from the Botanical Garden. *Paradiachopsis fimbriata*, again, is common there, the colonies being especially rich in sites where *Bacidia chlorococca* turns the bark green. Like this lichen species, which is characteristic of the 'lichen desert' in the centre of cities (Ahti & Vitikainen 1974), *Paradiachopsis fimbriata* may be exceptionally toxitolerant species.

4. Corticolous species

Brooks (1967) writes: »Corticolous slime molds belong predominantly to a few genera, in particular *Licea*, *Macbrideola*, *Echinostelium* and *Badhamia*. If one restricts consideration to only those species collected in situ this is especially true. Fruitings of species of *Arcyria*, *Hemitrichia*, and *Stemonitis*, though common in ground detritus, appear to be infrequent on tree bark.» This fits my results only partially since, in the present material, the abundant species belong to the genera *Arcyria*, *Comatricha*, *Echinostelium*, *Enerthenema* and *Paradiacheopsis*. In the virgin forest *Lycogala epidendrum* (L.) Fries, *Fuligo septica* (L.) Wiggers, *Physarum nutans* Pers., *Trichia decipiens* (Pers.) Macbr., *T. favoginea* (Batsch) Pers., and *T. varia* (Pers.) Pers. were common on decaying wood, although they never appeared in the moist chamber cultures.

5. Seasonal appearance

Myxomycetous spores are long-lived (Erbisch 1964). In the moist chamber cultures there were no great differences in the numbers of developing Myxomycete fructifications in different months. As a further test, some bark samples were kept in storage, and some unproductive moist chamber cultures were dried out after 4 weeks' incubation. Six months to one year later new moist chamber cultures were set up with these bark samples. Several of them produced Myxomycete fructifications. Myxomycetous spores evidently retain their ability to germinate long enough to suppress any seasonal variation in the cultures and have no internal rhythm to cause germination to occur in any particular season of the year.

6. Incubation time

According to Gilbert & Martin (1933), some species may appear on the second or third day, but most will require 5 or 6 days, and a few will require 2 weeks or more. According to Svrček (1972), some Myxomycetes appear only a few days, others later, after 1 to 2 months. *Licea* specimens commonly take 2 or more months to mature (Nannenga-Bremekamp in litt.), and fructifications of an undescribed *Colloderma* continued to appear over a period of about 3 months (Brown & Celler 1976). In the present cultures 3 days was the shortest time for sporangia to appear, the longest time extending to 28 days before and another 19 days after drying and rewetting. The times needed for development in the six commonest species were as follows:

<i>Echinostelium minutum</i>	3 — 18 — 47
<i>Arcyria pomiformis</i>	3 — 9 — 40
<i>A. cinerea</i>	3 — 20 — 41
<i>Comatricha nigra</i>	7 — 30 — 46
<i>Enerthenema papillatum</i>	3 — 26 — 41
<i>Paradiacheopsis fimbriata</i>	3 — 10 — 43

In the cultures, and no doubt also in nature, the spores germinate unevenly, and some may have needed an interval of drying before germination. The very short incubation times may have been due to the presence of sclerotia, which may need less time to form fructifications. *Comatricha nigra* and *Enerthenema papillatum* were the species that most often needed drying and rewetting to develop.

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