

## The Danish Species of the Discomycet Genus *Pezicula*.

By

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The genus *Pezicula* Tul., which belongs to the discomycetous family *Dermateaceae*, consists of small, fleshy, brightly coloured (yellow, orange, red-brown, cinnamon-brown) fungi, which grow singly or, most often, several together on a thin stroma, which is formed under the bark of different trees, from where they break out later.

The apothecia are most often short-stalked, and in the beginning cup-shaped, but they quickly open and become flat or arched, as the excipulum does not protrude beyond the hymenium. Asci are rather large and porus is coloured blue with iodine. The paraphyses are thread-formed, often forked and somewhat swollen at the tip. Ascospores are hyaline-yellowish, oval, elliptical or spindle-shaped, at first one-celled, later provided with one or more transverse walls and often also with a few longitudinal walls.

The genus *Dermatea* differs from *Pezicula* by much darker and coarser apothecia and especially by the conidial stage. This is, with *Dermatea*, types of *Micropera* which form pycnidia with long, thread-formed conidia which are often crooked, while the conidial stage connected with *Pezicula* are *Cryptosporiopsis* species. According to Groves (8), transition forms between *Pezicula* and *Dermatea* do occur.

The genus *Cryptosporiopsis* was treated by Bubak and Kabat in 1912. In the original diagnosis the conidial layer is described as flat lensshaped. Petrak has however examined the original

specimen, which was previously called *Myxosporium dispodioides*, and has found that it was formed like pycnidia, but still retained the family name *Cryptosporiopsis*; therefore fungi are still classed with this genus when their conidia are formed in acervuli or pycnidia or both. The latter is often the case with the conidial stage of the species of *Pezicula*. Neither was it mentioned in the original diagnosis that conidia can, with age, develop transverse and occasional longitudinal walls. As this is the case with the conidia of most *Pezicula* species this characteristic must also be reckoned with. Hereafter, belong to the genus *Cryptosporiopsis* fungi whose conidia are formed in closed containers, or in or on cushion or pillar-shaped stromata. Owing to the great variation, these fungi have been classed with many different genera. See Wollenweber: »Diskomyzetenstudien« (17).

*Cryptosporiopsis* conidia are hyaline — yellowish, oval, elliptical, spindle-shaped, one-celled or with one or more transverse walls and occasionally longitudinal walls. Pycnidia with staff-shaped spermatia occur.

Table 1. Survey over the species.

	Host plant	Size of		Conidia $\mu$
		Asci $\mu$	Ascospores $\mu$	
<i>Pezicula livida</i> (Berk. et Broome) Rehm ...	different coniferous trees	99.0 × 15.1	28.6 × 6.7	22–28 × 8–12
<i>Pezicula stipitata</i> n. sp. ....	<i>Acer pseudo-platanus</i>	129.3 × 25.8	37.6 × 12.3	
<i>Pezicula Rostrupii</i> n. sp. ....	<i>Fraxinus excelsior</i>	159.0 × 22.5	37.3 × 10.8	36.4 × 12.3
<i>Pezicula cinnamomea</i> (DC.) Sacc. ....	<i>Quercus</i> sp.	120.8 × 17.7	24.6 × 7.7	28.8 × 11.0
<i>Pezicula carpinea</i> (Pers.) Tul. ....	<i>Carpinus betulus</i>	160.0 × 18.5	22.9 × 9.9	
<i>Pezicula frangulae</i> (Pers.) Fuckel ....	<i>Frangula alnus</i>	100.0 × 13.2	19.4 × 7.8	
<i>Pezicula crataegi</i> (Lasch) Fuckel ....	<i>Pyrus Malus</i>	119.1 × 19.0	26.5 × 8.6	22–34 × 9–11
<i>Pezicula pruinosa</i> Farlow var. <i>pruni</i> ...	<i>Prunus cerasifera</i>	122.3 × 18.0	20.6 × 8.5	19.1 × 7.5

Apart from to the *Pezicula* genus, *Cryptosporiopsis* are also attached to the genera *Ocellaria* and *Habrostictis* the apothecia of these genera of fungi, unlike those of *Pezicula*, remain sunken in the bark.

Most of the *Pezicula* species mentioned here appear as parasites in the conidial stage, while in the ascospore stage they live saprophytically. The disease caused by them which generally has the character of a bark cancer (according to C. A. Jørgensen: Bark cancer on apple and pear (9)), can most often be seen on the trunk or the somewhat thicker branches. Occasionally the fungi can do considerable damage, as described by Rostrup on ash 1883 (13); but as a rule the abcessed bark wounds are only shallow, and the attacked tissue is eliminated without much damage being done.

### 1. *Pezicula livida* (Berk. et Broome) Rehm.

In Rostrup's Herbarium in the Botanical Museum of the University of Copenhagen there are specimens of *Dermatea eucrita* (Karsten) Rehm found on the bark of *Abies alba*, *Picea excelsa*, *Picea Menziesii*, *Pinus montana*, *Pinus silvestris*, *Pinus strobus* and *Pseudotsuga taxifolia*. According to Wollenweber (17), *Dermatea eucrita* is identical with *Pezicula livida*, which has the conidial stage *Cryptosporiopsis abietina* (Rostr.) Petr. Rostrup (in Lind (10)) states that *Micropera abietis* Rostr. is the conidial stage of *Dermatea eucrita*, but Lind doubts this and points to *Stilbella Rehmiana* (Rabenh.) Lindau as a possibility. It does not appear from Lind's information whether he relies on his own observations. I have examined Rostrup's material of *Dermatea eucrita* without finding conidia of any type, and the ascospore stage is a typical *Pezicula* and on the whole agrees with *Pezicula livida*, it can doubtless be classed here.

In Rostrup's Herbarium there is also a fungus named *Pezicula laricicola* Fckl, from bark of *Pinus montana*. Macroscopically it is not quite like *Dermatea eucrita*, as it was orange in colour, whereas *Dermatea eucrita* is chestnut-brown; but as it agrees with *Pezicula livida* in all other ways, and as this fungus may vary in colour from orange to chestnut-brown, all according to age, then this specimen must doubtless be classed here.

*Dermatea eucrita* has also been found by O. Rostrup on the bark of *Abies balsamea*.

Ferdinandson and Jørgensen (1) state that they have seen *Pezicula livida* parasitize on young Sitka spruce, which had previously been damaged by *Hylobius*, frost or the like. According to Wollenweber (17) the fungus can appear, apart from on the already mentioned host plants, on *Abies pectinata*, *Juniperus communis* and *Larix europaea*; and according to Gregor (2) on *Abies nobilis*, *Araucaria imbricata*, *Chamaecyparis Lawsoniana* and *Larix leptolepis*.

The conidial stage is described by E. Rostrup under the name *Myxosporium abietis* Rostr., and it was found on the bark of *Pseudotsuga taxifolia*, *Picea sitchensis* and *Larix decidua*.

Both the perfect and the imperfect stages of the fungus have been described under many different names. Wollenweber (17) has made a critical survey of the taxonomy in this case and in the case of most of the species mentioned later.

The apothecia of *Pezicula livida* appear singly or several together on a stroma. They are formed under the bark, but break out quite soon. They are low or short-stemmed, first closed, later spread out, flat or arched, orange-coloured — ochreous when fresh, chestnut-brown in dried up, older specimens. The paraphyses are hyaline-yellowish, thread-formed, forked at the top and somewhat swollen at the tips. They form an epithecium. Asci are club-shaped and contain 4 spores, more seldom 6—8 which lie in 1—2 rows. The ascospores are hyaline, oblong-spindle-shaped, often somewhat crooked, first one-celled, later with 3 or more transverse walls and occasionally with a few longitudinal walls. On their size, see table II.

The conidial stage, *Cryptosporiopsis abietina* (Rostr.) Petr. develops before the ascospore stage on the same stroma or in special places. It is founded under the bark, which gradually arches forward cone-shaped and opens with a crevice. The conidial layers have about the same size as the apothecia. The conidia are at first hyaline, later faintly yellowish, cylindrical, often a little crooked, broadly rounded at the top and with a papilla below, at first one-celled, later with 1 or more transverse walls and occasionally with a few longitudinal walls. They measure  $22-28 \times 8-12 \mu$  (Acc. to Wollenweber (17)  $28 \times 10.6 \mu$ ).

The Danish collections are as follows:

Table II. *Pezizula livida*. Size of apothecia, asci and ascospores.

	Measured by	Size of		Ascospores $\mu$
		Apothecia mm	Asci $\mu$	
<i>Dermatea eucrita</i> Karst.		0.3–1	70–80 × 15–20	21–33 × 6–8
»	Rostrup		100 × 18	24 × 9
»	Johansen	0.4–0.7	99.0 × 15.1 (80–108 × 14.5–16)	28.6 × 6.7 (26.5–30.5 × 5.5–8.5)
<i>Pezizula laricicola</i> Fckl.	Rostrup		90 × 17	26–28 × 6
»	Johansen	0.4–0.9	89.2 × 15.0 (84–99 × 13.5–16)	29.7 × 6.9 (26–37 × 6–8.5)
» <i>livida</i> Rehm		0.5–1.5	90–120 × 15–18	27–30 × 6–7
»	Wollenweber	0.5–1	94 × 16 (70–130 × 14–22)	27 × 6–7 (15–41 × 5–9)

On the bark of *Abies alba*: Grevinge Skov 1893 (E. Rostrup), Frijsenborg 1931 (C. A. Jørgensen), — *Abies balsamea*: Hastrup Plantage 1919 (O. Rostrup). — *Abies grandis*: Brahetrolleborg 1938 (N. F. Buchwald). *Picea excelsa*: Jyderup Plantage 1893 (E. Rostrup). — *Picea Menziesii*: Glorup 1899 (E. Rostrup). — *Picea sitchensis*: Østerild Klitplantage 1931 (C. A. Jørgensen), Vester Thorup 1938 (C. A. Jørgensen), Svinkløv 1938 (C. A. Jørgensen), Blaabjerg 1939 (C. A. Jørgensen). — *Pinus montana*: Birkebæk 1897 (E. Rostrup). — *Pinus silvestris*: Jyderup Plantage 1893 (E. Rostrup). — *Pinus strobus*: Vrangsgaard 1883 (C. F. Lyman), Silkeborg 1883 (E. Rostrup), Geelskov 1891 (O. Rostrup).

As I know the fungus from herbarium specimens only, I have been unable to observe spore germination or make infection experiments.

According to Wollenweber (17), club-formed spermatia measuring  $5.5 \times 1.2$  ( $4-8 \times 1-1.5$ )  $\mu$  appear at the germination of the ascospores. In Rostrup's material they measure  $5-6 \times 1 \mu$ .

Gregor (2) made infection experiments with many isolates of the fungus on different host plants, but came to a negative result in all cases; her observations in nature, however, imply

that certain forms of the fungus with relatively small ascospores (isolated from *Pseudotsuga*, *Abies* and *Chamaecyparis*) could occasionally appear as weak parasites.

Wollenweber (17) made infection experiments on Pomes, with the result that the fungus would rotten the apples completely in 5 weeks, while quinces were only very slightly affected. A culture of *Myxosporium abietinum* Rostr., however, developed in quince.

## 2. *Pezicula stipitata* n. sp.

In the Herbarium of the Botanical Museum of Copenhagen there is a specimen of *Dermatea acericola* (Peck) Rehm collected by O. Rostrup on *Acer pseudoplatanus* in Ermelunden near Copenhagen in 1911. *Dermatea acericola* is now recognized as a *Pezicula* with the name *P. acericola* (Peck) Rehm. Wollenweber classes it to *P. cinnamomea* (DC.) Sacc., which is hardly correct, as both asci and spores are somewhat larger in *P. acericola* than in *P. cinnamomea*. Rostrup's specimen differs from *Pezicula Rostrupii*, mentioned later, by the strong, pillarshaped stem and a far lesser development of the stroma, also by shorter asci.

For *Dermatea acericola* the size of asci is stated to be  $130-175 \times 18-24 \mu$  and size of the ascospores  $27-36 \times 7-8 \mu$ . Groves (4 and 7), who has worked with *Dermatea*- and *Pezicula* species on *Acer*, measured the asci of *P. acericola* to  $(90) - 100-125- (150) \times 15-20- (24) \mu$  and the ascospores to  $22.5-37.0 \times 7.5-11.0 \mu$ . In O. Rostrup's material the asci measured  $129.3 \times 25.8 (110-114 \times 24-28) \mu$  and the ascospores  $37.6 \times 12.3 (34-42 \times 10-14) \mu$ , thus somewhat larger than stated for *Dermatea acericola* and *Pezicula acericola*.

Groves (7) has described a new species of *Pezicula*: *P. subcarnea* Groves, which differs from *P. acericola* in that the apothecia are a little smaller and of not such a bright yellow colour neither do they appear in such quantities and tightly together in clusters or rows (in *P. acericola* they often form rows up to 2 cm); they also have broader asci and ascospores. The asci measured  $(90)-110-130-(150) \times (21)-23-28-(30) \mu$  and the ascospores  $(21)-25-35-(40) \times (10)-12-14-(16) \mu$ .

O. Rostrup's *Dermatea acericola* seem to be closely related to *Pezicula subcarnea*, as the size of the asci and ascospores is

about the same; but it differs with regard to the colour of the apothecia and the way they are placed.

In the summer of 1947 I had in Zürich the opportunity to meet Dr. Groves, who had found a European *Pezicula* on *Acer*. We both thought then that it was identical with Rostrup's and different from the types as yet described. When I returned to Denmark I sent Dr. Groves some of Rostrup's material and later was informed by him that Rostrup's fungus was not identical with the European *Pezicula* which Groves had found on *Acer*. At the same time I received material of the *Pezicula* species treated by Groves and in agreement with him I find that Rostrup's material differs from them all. Thus it must be regarded as a new species. Owing to the relatively strongly developed stalk, I have given it the name *Pezicula stipitata* n. sp.

The diagnosis is as follows:

*Pezicula stipitata* n. sp.

Stroma subcorticale, debite.

Apothecia erumpentia, plerumque singula vel 2—4—(8) congregata, initio clausa, postea expansa, plana, ochracea vel dilute fusca, stipite columnari, 0,5 mm longo, 0,4—0,5 mm crasso suffulta.

Paraphyses parce ramificatae, filiformes, septatae, apicibus incrassatis epithecium validum efficientes.

Asci octospori claviformes 129,3×25,8 (110—144×24—28)  $\mu$ .

Ascospores distichae 37,6×12,3 (34—42×10—14)  $\mu$ , oblongae vel ellipsoideae, rectae vel curvulae, apicibus rotundatis vel saepius acutis, initio hyalinae, continuae, postea fulvae, parietibus transversalibus 1—3 divisae.

Hab. in ramis *Aceris pseudoplatani* silvae Ermelunden Selandiae.

Typus anno 1911 ab O. Rostrup lectus in Museo Botanico Hauniensi depositus.

**3. *Pezicula Rostrupii* n. sp.**

On the Botanical Society's excursion to Hareskoven in North Zealand (October 6th 1940) a discomycet was found on the stem of *Fraxinus excelsior*. It was given to me by Professor C. A. Jørgensen, who thought that it might be the ascospore stage of a *Myxosporium* species, which was found on ash by Rostrup in 1882, and that the fungus was probably a *Pezicula* species, which later also proved to be correct. It had very large asci and ascospores and large cylindrical conidia. It was certainly not identical with *Pezicula cinnamomea* (DC.) Sacc., as the measurements ex-



ceeded by far the characteristic size for this type. *Pezicula subcarnea* Groves has somewhat broader ascospores and the asci are a good deal shorter (129.3 against 159.0  $\mu$ ) than those of the fungus found on ash. According to the original diagnosis for *Dermatea acericola*, (which is identical with *P. acericola*), the asci of this fungus can, in extreme cases, reach the same length as those of the ash fungus, but the ascospores are somewhat shorter and, according to the original diagnosis, also a good deal narrower. Groves (4) states the ascospore measurements for *Pezicula acericola* as being 22.5—37.0 $\times$ 7.5—11.0  $\mu$  and Rehm (12) for *Dermatea acericola* 27—36 $\times$ 7—8  $\mu$ . The ascospores of the fungus found on ash measured 37.3 $\times$ 10.8 (30—45 $\times$ 8—14)  $\mu$ . Both *Pezicula subcarnea* and *Pezicula acericola* seem also to be especially attached to *Acer*. The differences between *Pezicula stipitata* and the fungus found on ash are mentioned on page 6.

Dr. J. Walton Groves drew my attention to *Dermatella Fraxini* Ell. & Ev., which Groves (8) classes with the genus *Pezicula*, and whose ascospore measurements (25—35 $\times$ 10—12)  $\mu$  are close to the measurements I made of the *Pezicula* species from Hareskoven in Denmark. Still, asci are somewhat shorter and much narrower (125—150 $\times$ 12—15)  $\mu$ . Dr. F. J. Seaver, New York Botanical Garden, was so kind as to send me material of *Dermatella Fraxini* and Dr. Seaver informed me that he had previously had his attention drawn to the possibility that the fungus was a *Pezicula*. It appeared clearly from the material that the American fungus was quite different from the one found in Denmark.

The clusters of apothecia of the latter fungus were much larger and much closer together than in *Dermatella Fraxini*. Further, there was a great difference in the colour of the apothecia, which are far more reddish in *Dermatella Fraxini*. Finally, the stroma is much more developed in the Danish specimens than in *Dermatella Fraxini*. The *Pezicula* found on ash in Hareskoven must therefore be regarded as a new species.

In 1882 E. Rostrup (13) described a bark cancer on young ash-trees in the Frederiksborg forests in North Zealand and ascribed the disease to a species of *Myxosporium*, which forms black pycnidia under the bark, causing it to swell in the form of warts and later to burst. In the pycnidia, cylindrical, colourless conidia, measuring 32—38 $\times$ 11  $\mu$  were found. In the same patches where



the pycnidia were found, apothecia of *Hysterographium Fraxini* (Pers.) Duvot. appeared later, and Rostrup therefore presumed that the *Myxosporium* species was the imperfect stage of *Hysterographium*. Ferdinandsen and Jørgensen (1) disputed this and named the *Myxosporium* species found by Rostrup *Myxosporium Rostrupii* Ferd. & Jørg.

I have made single ascospore cultures from the *Pezicula* fungus from ash. From a suspension of ascospores in a hanging drop of sterile water, with the help of a glass needle with at very fine eye, placed in a micromanipulator, ascospores were taken out one by one and transferred to hanging drops of potato-dextrose-agar. Sterile ash twigs in glass tubes with a little potato-dextrose-agar were later grafted with single ascospore cultures of the fungus and after a time pycnidia and conidia of the same shape and size as those described by Rostrup were formed. The fungus was a typical *Cryptosporiopsis* and, according to examinations I have made on Rostrup's material in the Botanical Museum, this is true also of the *Myxosporium* described by Rostrup.

Further, single spore cultures were produced from the fungus which had developed on the ash twigs in the glass tubes, and these cultures proved to be identical with single ascospore cultures, and developed conidia of the same shape and size as these.

The *Pezicula* found in ash must therefore be considered as the ascospore stage of *Myxosporium Rostrupii* Ferd. & Jørg. and ought therefore to be given the name *Pezicula Rostrupii*. The characteristics of this species are embodied in the following diagnosis:

### ***Pezicula Rostrupii* n. sp.**

Stroma subcorticale, validum, fulvum, plectenchymaticum, sub ipsis apotheciis contextum fuscum, sclerotigenum saepe continens. Apothecia erumpentia, singula vel usque ad 12 congregata, sessilia vel stipite conico 0,1—0,3 mm longo, 0,3—0,5 mm crasso suffulta, cum stipite 0,4—0,7 mm alta, diametro 0,5—1 mm, initio clausa, postea expansa, plana vel convexa, recentia ochracea, postea cinereo-fuscescentia. Excipulum discopaulo pallidius. Hypothecium fulvum, pseudoparenchymaticoplectenchymaticum, extus fuscum, sclerotigenum.

Paraphyses fulvae, parce ramificatae, filiformes, septatae, 2—2,5  $\mu$  latae, apicibus claviformibus, 5  $\mu$  latis epithecium validius efficientes.

Asci octospori cylindrici vel claviformes 159×22,5 (132—195×19—26)  $\mu$ .

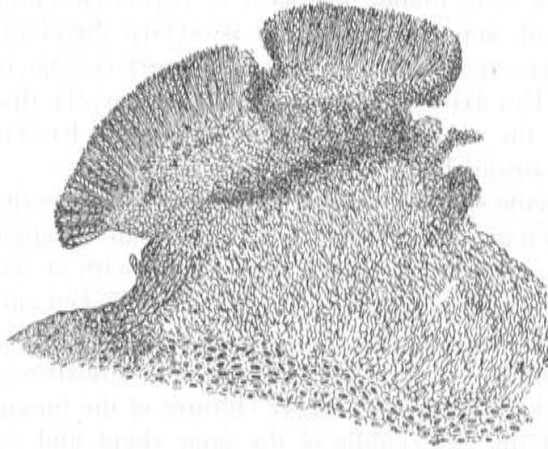


Fig. 1. *Pezicula Rostrupii*. Cross section through bark of *Fraxinus excelsior* with two apothecia on a common stroma. 50 X. (N. Bolvig del.)

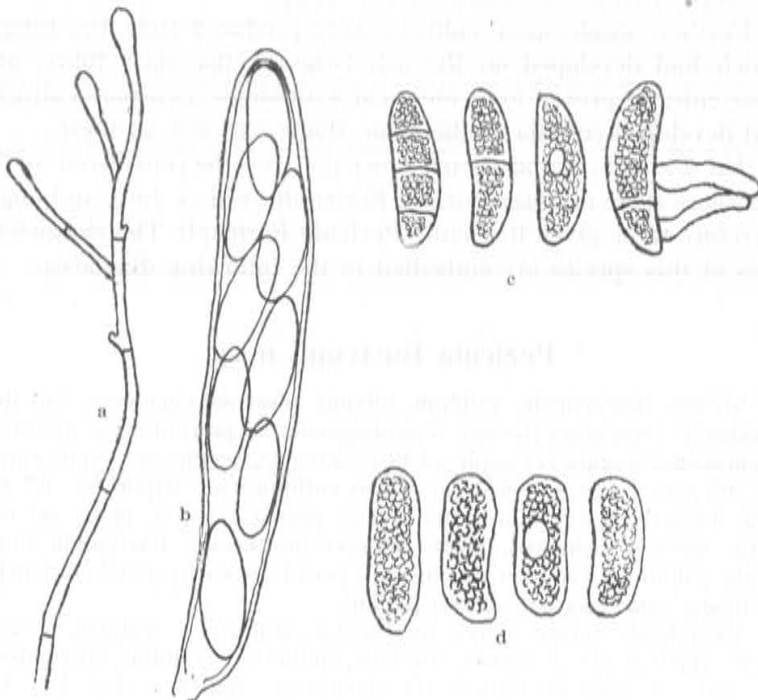


Fig. 2. *Pezicula Rostrupii*. a: Paraphyse. b: Ascus. c: Ascospores. d: Conidia. 500 X.

Ascosporae oblique, mono-vel distiche sitae  $37,3 \times 10,8$  ( $30-45 \times 8-14$ )  $\mu$  oblongae vel fusiformes, leniter saepe curvatae, apicibus rotundatis vel acutis, recentes hyalinae, continuae, postea flavae, parietibus transversalibus 1-6 (plerumque 3), raro pariete oblique longitudinali divisae.

Hab. in trunco Fraxini excelsioris silvae Hareskoven Selandiae.

Typus anno 1940 lectus, in Museo Botanico Hauniensi depositus.

On potato-dextrose-agar ascospores germinate with one or more hyphae from the top or the side and are often narrower at the dividing walls.

The conidial stage *Cryptosporiopsis Rostrupii* (Ferd. & Jørg.) n. comb. is formed before the apothecial stage. The conidia (see fig. 2 d) are formed in thin-walled, dark brown pycnidia, which are about 230  $\mu$  deep and about 270  $\mu$  broad. The conidiophores are short, single or slightly forked. The conidia are first hyaline and granulated, later yellow-brown and with a lateral oil drop. I have only observed crosswalls in a very few cases and at most three. Longitudinal walls have not been observed. The conidia are oblong-cylindrical, often uneven in shape and measure  $36,4 \times 12,3$  ( $23,3-43,2 \times 10,3-13,8$ )  $\mu$ , according to Rostrup  $32-38 \times 11$   $\mu$ .

On the ash twigs in the glass tubes, pycnidia 170  $\mu$  deep and 250  $\mu$  broad appeared singly or two side by side and containing  $6-7 \times 1-1,5$   $\mu$  large spermatia.

Danish collections are as follows:

On the bark of *Fraxinus excelsior*: Slagslunde 1882 (E. Rostrup), Sophiedal 1884 (E. Rostrup), Hareskoven 1940 (C. A. Jørgensen and G. Johansen).

Single ascospore cultures of *Pezicula Rostrupii* grow quite slowly on potato-dextrose-agar. After 10 days at about 20° C. they measured about 8 mm in diameter. The cultures were cushion-shaped in the middle, more flat at the edges: the mycelium is grey-white with a faint yellowish tone. The agar was not coloured.

Late in October 1940 an infection experiment was made with single ascospore cultures of *Pezicula Rostrupii* on one year old and two years old branches of *Fraxinus excelsior* and of *Pyrus malus*. A triangular cut was made in the bark, the bark flap was lifted and a piece of agar with mycelium was placed under it. Around the branch a glass cylinder was placed, closed in both

ends with a holed-out cork, which fitted around the branch. The air in the glass was kept damp with the help of a piece of damp filter-paper. In the end of May the following year the fungus had still not taken, and both on ash and apple only a hollow rim about 2 mm broad was found around the wound. This rim was not found on uninfected branches, which had been wounded and covered in the same way as the infected branches. Although the result of the infection experiment was negative, there is hardly any doubt that Rostrup's valuation of the fungus as causing bark wounds on young ash-trees is correct. But other conditions are necessary to start the growth than those of the infection experiment. Possibly the infection should have been carried out on younger or older branches or on stems and in the spring, as the natural infection, as pointed out by Jørgensen (9), often takes place at this time of the year.

On apple fruits the fungus proved to be only slightly parasitical as after two months there only appeared a rotted patch of 1.6 cm in diameter, (see fig. 8). The patch was red-brown and wrinkled in concentric rings and carried a few pycnidia around the infection wound.

#### 4. *Pezicula cinnamomea* (DC.) Sacc.

Material and drawings of *Pezicula cinnamomea* have been kindly handed over to me by Professor C. A. Jørgensen, who found both apothecia and the conidial stages in cancer wounds on *Quercus* in Tved Plantage in Jutland in 1930 and in Rude Skov in North Zealand in 1932.

A fungus classed as *Dermatea quercina* (Fckl.) Rehm which is a typical *Pezicula cinnamomea*, was found by E. Rostrup on *Quercus* in Vejstrup in Funen in 1861 and by Lind in Nørre Skov near Furesø in Zealand in 1910.

In October 1940 I found the fungus on older branches of *Corylus avellana* in Grønnegade, North Zealand. The ascospore stage has not previously been observed on *Corylus* here, but in the Herbarium of the Botanical Museum of Copenhagen there is a *Myxosporium* species which has been classed by Lind as *Myxosporium coryli* Oudemans, and which was found in Krabbesholm Skov in Jutland in 1904. *Myxosporium coryli* Oudemans is reckoned by Wollenweber to be synonymous with *Cryptosporiopsis grisea*

(Pers.) Petr. which is the conidial stage of *Pezicula cinnamomea*. The material of *Myxosporium coryli* from Krabbesholm had conidia which are a good deal shorter than normal for *Cryptosporiopsis grisea* (see Table III), but as I only found one-celled conidia in the material, and as these are generally shorter than the septated, the fungus no doubt is *Cryptosporiopsis grisea*, although the spores of these fungi are normally more constant in size. Also in the case of *Myxosporium griseum* (Fries) Sacc., which has been found on *Corylus avellana* near Trelde Skov in Jutland and near Hjortshøj in Zealand, the spores are under the normal for *Cryptosporiopsis grisea*.

In 1900, Rostrup found on *Alnus incana* in Trelde Skov in Jutland a fungus which he called *Myxosporium alneum* Rostrup. It appeared as a parasite on 5 cm thick branches. The attacked parts of the bark became grey-brown, slightly sunken and sharply defined from the normal tissue.

Groves (6) mentions 3 *Pezicula* species on *Alnus*, viz. *Pezicula aurantiaca* Rehm, *Pezicula alni* Rehm and *Pezicula alnicola* Groves. *Pezicula aurantiaca* Rehm is classed by Wollenweber to *P. cinnamomea*. *Pezicula alni* has conidia which measure 14—18—20×5—7.5  $\mu$ , which is somewhat less than *Myxosporium alneum*'s. *Pezicula alnicola* has conidia of *Micropera* type, 35—53×4—5  $\mu$ . Groves therefore referred it to a new genus. As the *Myxosporium alneum* conidia agree with *Cryptosporiopsis grisea* and not with any of the other fungi in this group, which are found on *Alnus*, it can doubtless be classed to *Cryptosporiopsis grisea*.

According to Wollenweber (17) *Pezicula cinnamomea* has further been found on *Castanea vesca* and the conidial stage on *Juglans regia*.

The apothecia of *Pezicula cinnamomea* are usually formed many together on a yellowish stroma. They are short-stemmed, first closed, later spread out flat or convex, orange-red — fine red-brown, the disc often being little darker than the excipulum.

The paraphyses (see fig. 3 b and f), which form an epithecium, are forked, septated and thickened at the tip. Asci (see fig. 3 a and g) are cone-shaped and contain (6) — 8 ascospores in 1—2 slanting rows. The ascospores (see fig. 3 c and h) are first hyaline, later yellowish, oblong, spindle-shaped, often somewhat crooked, first one-celled, later with 1—6 (often 3) dividing walls and occasionally with longitudinal walls. On the size see table III.

Table III. *Pezizula cinnamomea*. Size of apothecia, asci and ascospores.

		Size of			
		Apothecia mm	Asci $\mu$	Ascospores $\mu$	Conidia $\mu$
<i>Dermatea quercina</i> . . . . .	on <i>Quercus</i>	0.4-0.7	114.3×16.3 (102-131.5×15-17)	25.1×8.1 (21-28×6.5-9.5)	
<i>Pezizula cinnamomea</i> ..	»	0.4-0.7	120.8×17.7 (115-126×15-20)	24.6×7.7 (20-30.5×6-10)	
» ..	on <i>Corylus</i>	0.4-0.8	120×18 (109-135×17-19)	25.4×8.6 (18-31×6.5-10.5)	
» ..	according to Wollenweber	0.5-0.6 (0.3-1.5)	118×17 (80-150×12-24)	25×8 (18-34×6-10)	
<i>Dermatea cinnamomea</i> .	according to Rehm	0.5-2	90-120×12-14	20-27×5-7	
<i>Cryptosporiopsis grisea</i> .	on <i>Quercus</i>				28.8×11 (26-33×9-12.8)
» ..	on <i>Corylus</i>				32.5×12.1 (28.1-35.5× 10.8-14.4)
» ..	on Agar. Isol. from <i>Corylus</i>				33.8×10.4 (30-38×8.5-12)
<i>Myxosporium coryli</i> . . . . .	on <i>Corylus</i>				21.3×9.9 (19.5-25×8.5-11)
<i>Myxosporium griseum</i> ..	»				23.5×9.0
<i>Myxosporium alneum</i> ..	on <i>Alnus</i>				24-28×9-10
<i>Cryptosporiopsis grisea</i> .	according to Wollenweber				34×10.2 (20-42×8-13)

According to Wollenweber (17) the conidia are formed in pycnidia, which are oval-cylindrical, black-brown and outside grey with delicate, pale hyphae. On the specimens of the fungus

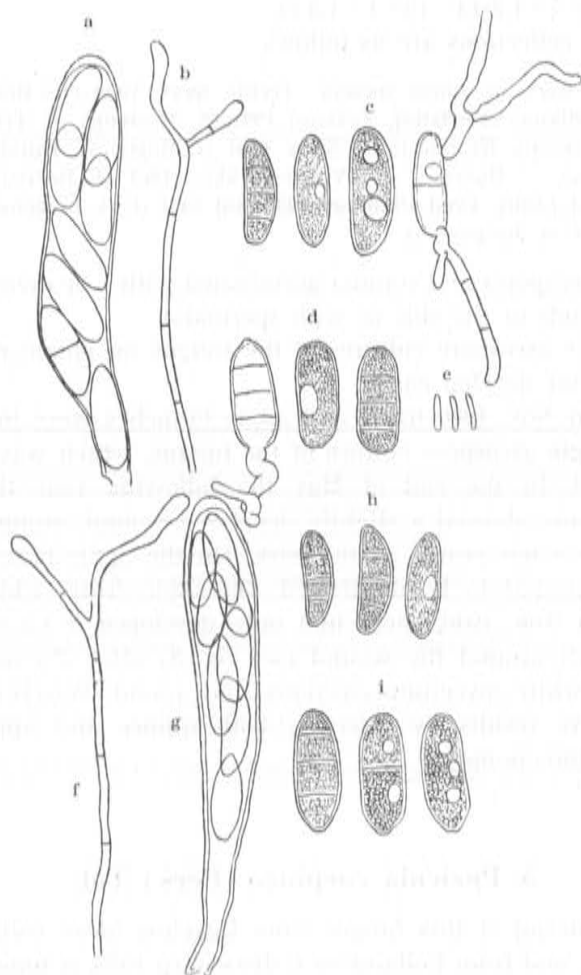


Fig. 3. *Pezicula cinnamomea*. a—e: from *Quercus* (drawing C. A. Jørgensen). f—i: from *Corylus*. a and g: Asci. b and f: Paraphyses. c and h: Ascospores. d and i: Conidia. e: Spermata. 500  $\times$ .

from hazel the conidia formed on broad acervuli under the bark, which burst as the conidia break out, first as cream-coloured, later yellowish drops. The conidiophores consisted of long, thread-formed hyphae. The conidia are cylindrical, rounded at the top and cone-shaped below with a papilla.



In the material collected by C. A. Jørgensen from Rude Skov, Spermata (see fig. 3 e) appeared. They are staff-shaped, often slightly crooked, measuring  $9-10 \times 1.5 \mu$ , according to Wollenweber  $7 \times 1.2$  ( $4-10 \times 1-1.5 \mu$ ).

Danish collections are as follows:

On the bark of *Alnus incana*: Trelde Skov 1900 (E. Rostrup). — *Corylus avellana*: Hjortshøj, Zealand 1901 (E. Rostrup). — Trelde Skov 1901 (E. Rostrup), Krabbesholm Skov 1904 (E. Rostrup), Hørsholm 1940 (G. Johansen). — *Quercus* sp.: Vejstrup Skov 1861 (E. Rostrup), Nørre Skov 1910 (J. Lind), Tved Plantage 1930 and 1931 (C. A. Jørgensen), Rude Skov 1932 (C. A. Jørgensen).

Both ascospores and conidia germinated with 1 or more hyphae from the ends or the side or with spermata.

In single ascospore cultures of the fungus on potato-dextrose-agar *acervuli* develop easily.

Early in Nov. 1940 hazel and apple branches were inoculated with a single ascospore culture of the fungus, which was isolated from hazel. In the end of May the following year the hazel branches only showed a slightly depressed wound, around which there were a few cracks in the bark. On the apple branches the wound appeared to be uninfected. On apple fruits which were infected in Nov. 1940, there had only developed a 1.2 cm wide rotten patch around the wound (see fig. 8) after  $2\frac{1}{2}$  month. In the patch white mycelium cushions were found. Wollenweber had positive results by infecting both quince and apple with *Pezicula cinnamomea*.

### 5. *Pezicula carpinea* (Pers.) Tul.

The material of this fungus from Uggeløse Skov, collected by Lind 1891, and from Lolland by E. Rostrup 1879, is found in the Herbarium of the Botanical Museum of Copenhagen. Ferdinandsen and Jørgensen (1) have seen the fungus partly saprophytic and partly parasiting on hedges of hornbeam at Sorgenfri 1931. In this country the species has only been found on *Carpinus betulus*, while according to Wollenweber (17) in Germany it has also been found on *Fagus sylvatica*. In Germany it is stated that the *Cryptosporiopsis* stage may appear as a dangerous parasite not only on the above-mentioned trees, but also on *Rhododendron* sp.

The apothecia are most often formed in clusters on a stroma under the bark, which later bursts, whereafter they break out. They are light golden-brown — dark ochre, but in a dry state mealy white. The hymenium is a little more reddish. The apothecia are at first closed, later spread out flat and provided with a short, thick stem. In Rostrup's material they measure 0.5—0.7 mm, (according to Wollenweber 0.5—1 mm and Groves 0.5—1 mm). The paraphyses, which form an epithecium are hyaline — slightly yellowish, forked, septated and  $2.5\ \mu$  broad, above thickening to  $5\ \mu$ . The asci are club-formed. There were only a few well-developed asci in Rostrup's material. They measured  $160 \times 18.5\ \mu$ , according to Wollenweber  $170 \times 20$  ( $100-200 \times 15-36$ )  $\mu$ , and according to Groves (120)—130—160—(190)  $\times$  (14)—17—20—(22)  $\mu$ . The spores are stated to be oval-cylindrical, spindle-shaped, rounded at both ends or cone-shaped pointed, straight or somewhat crooked, first one-celled, later with 1—3 transverse walls and sometimes longitudinal walls. They lie in 1 or 2 rows often irregularly. According to Wollenweber the one-celled measure  $21 \times 10.5\ \mu$ , while the more developed measure  $24 \times 10.6\ \mu$  on an average. Groves (5) states the measurements to be (17)—20—30—(33)  $\times$  (8)—10—12—(14)  $\mu$ . In Rostrup's material the spores had the characteristic form, but were mainly one-celled, only occasionally 2-celled. They measured  $22.9 \times 9.9$  ( $20.5-29.0 \times 9.0-11.0$ )  $\mu$ .

The *Cryptosporiopsis* stage, *Cr. fasciculata* (Tode) Petr., which was not seen in Rostrup's material, is either formed alone or as more or less closed pycnidia in the same stroma as the apothecia; but gradually the conidial layer can appear cushion-shaped. The conidiophores are single or branched, in the latter case, septated. The conidia are oval, pearshaped or cylindrical, rounded at the top, below cone-shaped with a papilla. They are first hyaline and one-celled, later yellowish and with 1—5 (most often 3) dividing walls, occasionally also with longitudinal walls. They measure according to Wollenweber,  $29 \times 11$  ( $10-43 \times 6-14$ )  $\mu$ , and according to Groves, 20—30—(34)  $\times$  (10)—12—15  $\mu$ . Staff-shaped spermatia, which are straight or a little crooked and  $8 \times 1.5\ \mu$ , form in pycnidia on forked hyphae and emerge as yellowish drops. According to Wollenweber they also form at the germination of the *Cryptosporiopsis* conidia. Groves (5) got a positive result in infection experiments with single spore cultures of the fungus on branches of *Carpinus caroliniana*. The fun-

gus is said to have penetrated right into the trunk in the course of 1½ year.

The Danish collections are as follows:

On the bark of *Carpinus betulus*: Stenskov, Lolland 1879 (E. Rostrup), Uggeløse Skov 1891 (E. Rostrup), Lyngby 1931 (C. Ferdinandsen and C. A. Jørgensen).

### 6. *Pezicula frangulae* (Pers.) Fckl.

The above-mentioned fungus is found in Rostrup's Herbarium under the name *Dermatea frangulae* (Fries) Tul. It has been found on *Frangula alnus* at Viborg and Silkeborg in Jutland, and in Klosteris Hegn in Zealand.

The apothecia are at first closed and covered, later they break out through the bark and spread out plate-shaped or convex with a corrugated edge. They appear singly or many together in groups or rows, are petiolate, of a fleshy consistency, with yellow disc and olive-green excipulum. In Rostrup's material they measure 0.9–1.15 mm, according to Wollenweber (17) 1–1.25 mm. Asci are cylindrical cone-shaped, stemlike narrowed below. They measure  $100 \times 13.2 \mu$  in Rostrup's material, according to Wollenweber  $110 \times 13.5$  ( $70-160 \times 11-18$ )  $\mu$  and contain 4 ascospores in one row. The ascospores are first hyaline, later yellowish. They are oblong — elliptical, most often straight, first one-celled, later with 1–5 (mostly 3) transverse walls, occasionally also with a single longitudinal wall. They measure  $19.4 \times 7.8$  ( $16.8-22 \times 7.2-8.4$ )  $\mu$ , according to Wollenweber  $19 \times 7.1$  ( $12-26 \times 4.8-10$ )  $\mu$ . The paraphyses are yellowish, thread-formed, slightly forked, septated, a little thicker at the top and protrude beyond the asci and form a thin epithecium.

I could not find the conidial stage, *Cryptosporiopsis versiformis* (Alb. et Schw.) Wr. in Rostrup's material. According to Wollenweber the conidia form in pycnidia, which are found in the same stroma as the apothecia and which develop before these or in special places. The stroma is first loose, grey or olivecoloured ochre, later it becomes plektenchymatous and darker in colour and sometimes develops more or less numerous, cartilaginous, most often sterile, pillar-shaped growths. The pycnidia are at first covered by the bark and later break out. They are most often

leathery, though occasionally also soft, of very different shapes: ballshaped, lensshaped, bottle-shaped, cylindrical-cone-shaped, or Sphaeronema-like lengthened and narrowed at the tip. Sometimes the conidial layer arch out in a cushion-shaped way on opening.

As a rule, the pycnidia only contain 1 cavity, but can be divided into several. They open with a pore or irregular cleft in the tip. The conidia come out as milk-white, later yellowish drops or vines. The conidiophores are hyaline, thread-formed, and slightly forked, or gathered together bushily and abundantly forked. The conidia are cylindrical, more rarely slightly kidney-shaped, rounded at the top below cone-shaped with a papilla, first one-celled, later with 1—5 (mostly 3) transverse walls and in exceptional cases with a longitudinal wall. They measure  $26 \times 7.9$  ( $12-34 \times 5-12$ )  $\mu$ .

The Danish collections are as follows:

On the bark of *Frangula alnus*: Klosterris Hegn, Zealand 1901 (E. Rostrup), Silkeborg 1907 (J. Lind), Skovsgaard, Viborg 1906 (E. Rostrup).

### 7. *Pezicula crataegi* (Lasch) Fckl.

This fungus was first found in Denmark on the bark of apple trees from Guldborghave in Lolland in 1930: its morphology and parasitism have been treated in detail by C. A. Jørgensen (9), who classed the fungus to the genus *Neofabraea*. This genus is characterized by the apothecia developing in the same stroma as the acervuli, which is the case with the fungus in question, C. A. Jørgensen, though, drew attention to the fact that the short stems of the apothecia were not in agreement with the diagnosis of the genus *Neofabraea*. The fungus has later been transferred to the genus *Pezicula* by Nannfeldt (11), where it rightly belongs, and under the name *P. corticola* (Jørg.) Nannfeldt, Wollenweber has proved its identity with *P. Crataegi* (Lasch) Fckl. It has later been found in various parts of Denmark on the bark of apple and pear.

The apothecia are formed, as mentioned, on the same stroma as the conidial stage. They appear singly or up till 16 together in groups, are at first closed, later, when they have broken out of the bark, flat or somewhat convex, provided with a short, thick stem. The disc measures  $1/2-1\frac{1}{2}$  mm in diameter. The apothecia

are at first yellow-brown, later olivebrown. The paraphyses (see fig. 4a) are thread-formed, septated, slightly forked, club-formed thickened at the tip and form a slight epithecium.

Asci (see fig. 4b) are cylindrical-clubshaped. I measured the size to  $119.1 \times 19.0$  ( $102-129 \times 16.5-22$ )  $\mu$ , according to Jørgensen  $110 \times 12-18 \mu$  and according to Wollenweber  $112 \times 17$  ( $91-150 \times 12-23$ )  $\mu$ . They contain 8 ascospores in 1-2 irregular rows.

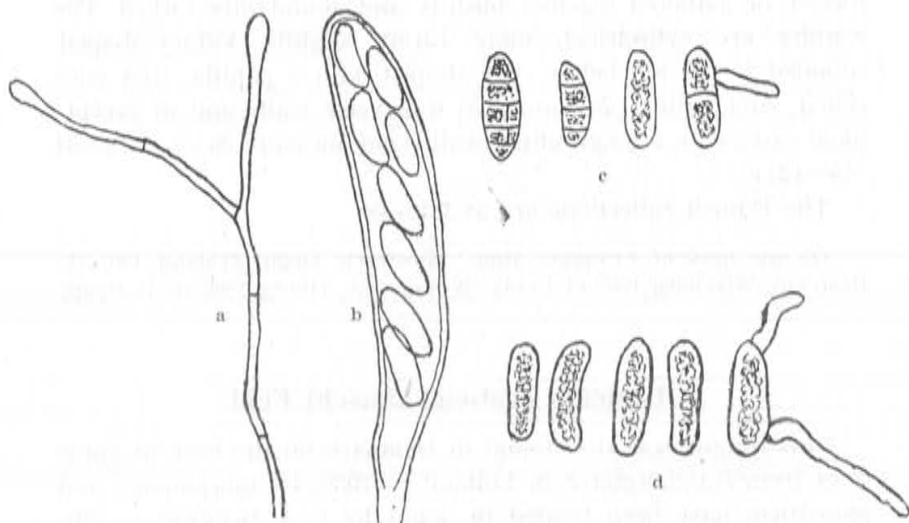


Fig. 4. *Pezizula crataegi*. a: Paraphyse. b: Ascus. c: Ascospores. d: Conidia. 500  $\times$ .

The ascospores (see fig. 4c) are oblong-elliptical, blunt or cone-shaped at the ends, straight or slightly crooked, first one-celled and hyaline, later with 1-5 dividing walls and faintly yellowish. Longitudinal walls are also known to appear. They measure  $26.5 \times 8.6$  ( $22.3-31 \times 6.5-10$ )  $\mu$ , according to Jørgensen  $17-26 \times 7-9 \mu$  and according to Wollenweber  $23 \times 9$  ( $16-30 \times 6-12$ )  $\mu$ .

The conidial stage of the fungus is *Cryptosporiopsis pyri* (Fckl.) Petr. The conidia (see fig. 4d) develop in pycnidia or on acervuli under the bark, which later bursts. The conidiophores are short and threadformed. The conidia are cylindrical, often with a papilla below, straight or slightly crooked and granulated. In Danish material only hyaline and one-celled conidia have been found, but according to Wollenweber they can be 1-4 septated with a tendency to form longitudinal walls. In Jørgensen's material

they measured  $22-34 \times 9-11 \mu$ . Edgerton, who in 1908 has described the conidial stage as *Myxosporium corticolum*, states the measurements to be  $18-32 \times 6-9 \mu$  and Wollenweber gives  $26 \times 8$  ( $17-35 \times 5-12$ )  $\mu$ .

Apothecia formed on sterile apple branches in glass tubes infected with a single ascospore culture of the fungus, which indicates that the fungus is homothallic.

An infection experiment carried out in Nov. 1940 with single ascospore cultures on apple fruits gave a positive result. In the middle of January 1941 the apple was quite rotten (see fig. 8). Wollenweber got a negative result with *Pezicula crataegi* on quince and apple.

According to Jørgensen, who has given a detailed description of the disease, it is chiefly older branches and trunks which are attacked, but on the whole the fungus does not seem to be a malignant parasite.

Infection of 1-year and 2-year old apple branches was carried out in Nov. 1940. In the end of May 1941 a sunken, red-brown wound with a brown-violet outer ring had formed both on the 1-year and 2-year old branches. The wounds were longish and measured about  $20 \times 12$  mm and were separated from the healthy bark by a crack (see fig. 5 b).

According to Wollenweber, the ascospore stage has been observed on *Crataegus oxyacantha*, as well as on *Pyrus malus* and *Pyrus communis*. The conidial stage has also been seen on *Mespilus germanica* and *Sorbus aria*, and according to Grove (3) on *Prunus domestica*.

The Danish collections are as follows:

On bark of *Pyrus malus*: Guldborghave, Lolland 1930 (C. A. Jørgensen), Lyngby 1940 (C. A. Jørgensen and G. Johansen).

### 8. *Pezicula pruinosa* Farlow var. *pruni* nov. var.

On the bark of *Prunus cerasifera* in Lyngby Mose, Professor C. A. Jørgensen and I found late in Nov. 1940 a *Pezicula* species, which I thought at first to be identical with *Pezicula crataegi*; but on closer examination it appeared to have many differences. Especially the conidia (only one-celled were found) were considerably shorter than those of *Pezicula crataegi*. Single ascospore

cultures on branches in glass tubes did not develop apothecia, but pillar-shaped stromata containing pycnidia, and flat pycnidia 250—350  $\mu$  broad and 150—250  $\mu$  deep. These were covered by the bark and later burst out through it. Further, the cultures in the glass

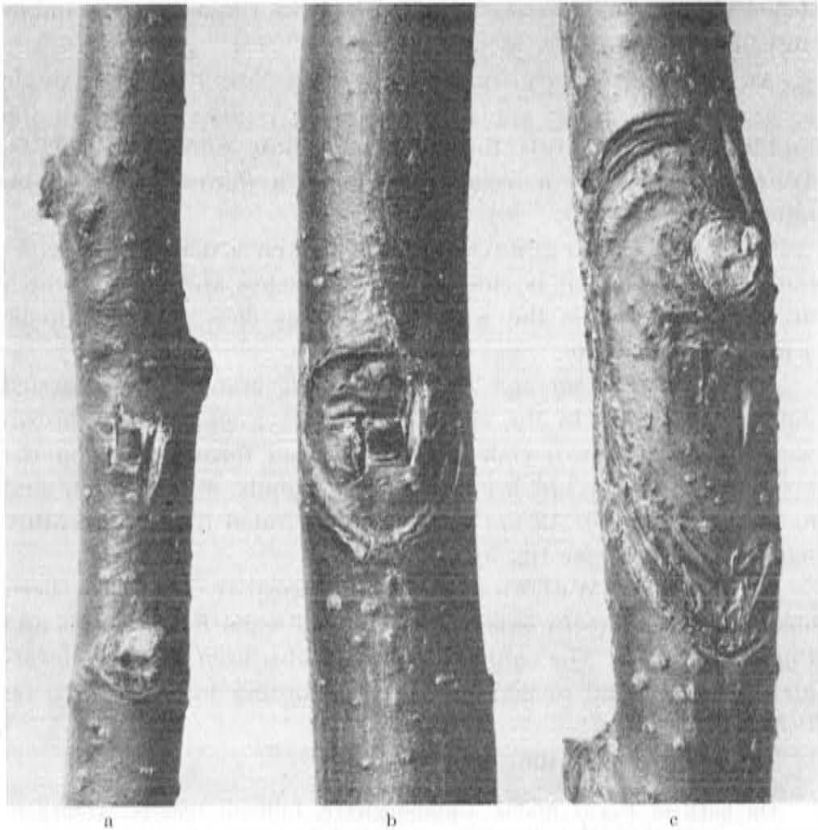


Fig. 5. Apple branches. a: Uninfected. b: Infected by *Pezicula crataegi*. c: Infected by *Pezicula pruinosa* var. *pruni*.

tubes and the two species are a good deal different, as *Pezicula crataegi* forms a brown, felty mycelium on potato-dextrose-agar, while the *Pezicula* on *Prunus* forms a knobby mycelium, white at first, later beige-coloured with a touch of grey.

In all essential characteristics the fungus agrees with *Pezicula pruinosa* Farlow, which has been found on *Amelanchier* in different places in U. S. A. and Canada. Different collections have been kindly sent to me by Assistant Curator Miss Katherine E.



Kindleberger, New York State College of Agriculture, Cornell University, by Prof. Dr. H. S. Jackson and Dr. J. Walton Groves, University of Toronto, who both express the view that it is unlikely that the same *Pezizula*-species should occur both on

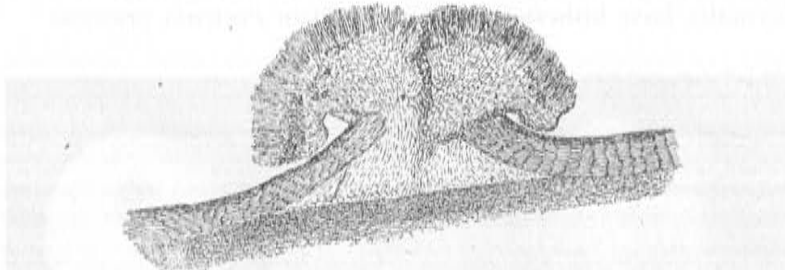


Fig. 6. *Pezizula pruinosa* var. *pruni*. Cross section through bark of *Prunus cerasifera* with two apothecia. 50 X. (N. Bolwig.)

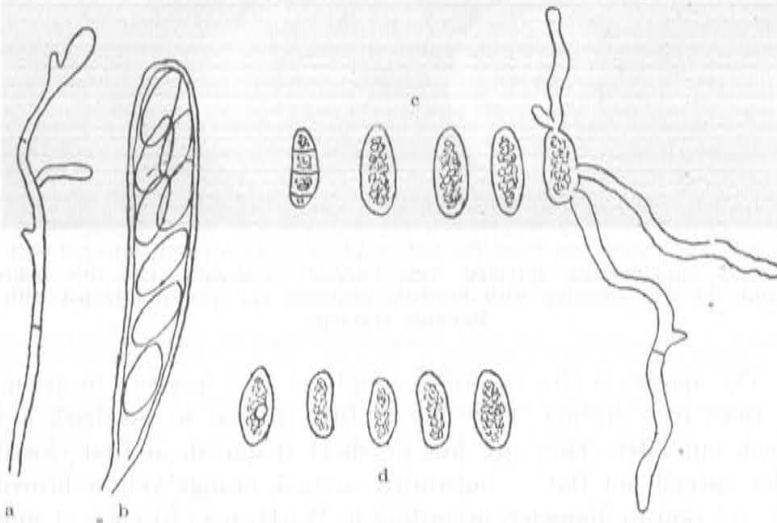


Fig. 7. *Pezizula pruinosa* var. *pruni*. a: Paraphyse. b: Ascus. c: Ascospores. d: Conidia. 500 X.

*Prunus* and *Amelanchier*, as the species of *Pezizula* and *Dermea* are usually very host specific. The similarity between *Pezizula pruinosa* Farlow and the fungus found on *Prunus cerasifera* is nevertheless so great, that I find it correct to place it as a variety, *var. pruni*, of *Pezizula pruinosa*. In the Danish material, most of the apothecia are a little darker in colour than the American, but light ones occur in the Danish and dark ones in the American. The ascospores were

generally slightly more chubby in the American material, but more pointed ones were found in the American and chubby ones in the Danish. Finally spermatia were formed in single ascospore cultures of the Danish material on sterile *Prunus* branches in glass tubes, while both Groves (5) and Wollenweber (17) state that spermatia have hitherto not been found in *Pezizula pruinosa*.



Fig. 8. The upper row from the left: apple fruit uninfected; infected with *Pezizula cinnamomea*; infected with *Pezizula Rostrupii*. The row below from the left: Infected with *Pezizula pruinosa* var. *pruni*; infected with *Pezizula crataegi*.

The apothecia (see fig. 6) are singly or 2–5 together in groups or rows in a stroma. They are at first sunken in the bark and break out later. They are low or short-stemmed, at first closed, later spread out flat — outwardly arched, orange-yellow-brown, 0.5–0.7 mm in diameter, according to Wollenweber 0.5–1 mm, and Groves 0.5–1.5 mm. Asci (see fig. 7 b) are cone-shaped,  $122.3 \times 18.0$  ( $84-164 \times 14-21$ )  $\mu$ , according to Wollenweber  $100 \times 18$  ( $81-130 \times 14-22$ )  $\mu$  and according to Groves (75)–90–100–(130)  $\times$  (12)–14–17–(20)  $\mu$ . They contain 8 spores in 1–2 rows. The ascospores (see fig. 7 c) are elliptical — spindle-shaped, sometimes somewhat crooked, first hyaline and one-celled, later yellowish and with 1–3 dividing walls. They measure  $20.6 \times 8.5$  ( $15.5-28 \times 6.5-11.5$ )  $\mu$ , according to Wollenweber  $24 \times 7.6$  ( $18-28 \times 6-9$ )  $\mu$  and according to Groves (14)–17–25–(30)  $\times$  (6)–7–9–(10)  $\mu$ .

The pycnidia form in the same stroma as the apothecia and before these. The conidiophores are thread-formed and slightly forked. The conidia (see fig. 7 d) are cylindrical, first hyaline, later yellowish, one-celled, according to Wollenweber later with 1—3 dividing walls. They measure  $19.1 \times 7.5$  ( $15.2-22.3 \times 5.0-9.4$ )  $\mu$ , according to Wollenweber  $20 \times 8.6$  ( $15-25 \times 7-11$ )  $\mu$ , according to Groves, who also only found one-celled conidia,  $15-25 \times 7-10$   $\mu$ , and according to Petrak  $15-20-50 \times 7-9$   $\mu$ .

Spermatia measuring  $7-8 \times 1$   $\mu$  are formed in ball-shaped — bottle-shaped pycnidia.

Infection experiments on applefruits were made in Nov. 1940. In Jan. 1941 a 5.5 cm large, red-brown, rotten patch had formed on the apple. In a diameter of 1.3 cm around the actual place of infection a grey fungus-layer was found (see fig. 8).

At the end of Nov. 1940 an infection experiment was made on 1 and 2 year old *Prunus* and apple branches. On *Prunus* the experiment gave strangely enough a negative result, while on both the 1 and 2 year old apple branches a yellow-brown — red-brown wound with a brown-violet outer ring appeared (see fig. 5 c). Below the wound there was a crack between the normal and diseased bark. The wounds measured from  $16 \times 10$  mm —  $39 \times 19$  mm on the 20th of May 1941.

Danish collection:

On bark of *Prunus cerasifera*, Lyngby 1940 (C. A. Jørgensen and G. Johansen).

I wish to convey my thanks to Professor Dr. C. A. Jørgensen for valuable guidance in the execution of the work, for handing over to me the material and drawings of *Pezicula cinnamomea* from Tved Plantage and Rude Skov, and for having altogether placed his collections of *Pezicula*-species at my disposal.

Further I wish to thank Dr. N. Bolwig, who has made the drawings of the apothecia of *Pezicula Rostrupii* and *Pezicula pruinosa* var. *pruni*, and cand. mag. Tyge Christensen, who has worked out the Latin diagnoses.

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