

## The genus *Fusicladium* (Hyphomycetes) in Poland

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The paper presents new and historical data on the genus *Fusicladium* verified on the base of the recently published critical monograph. Fifteen species recorded in Poland under the name *Fusicladium* and synonymous *Pollaccia* and *Spilocaea* are reported; 5 are documented by authors' materials from Central Poland while the other taxa are supported with literature data only, including three species belonging currently to *Fusicladiella* and *Passalora*. Three species, reported here for the first time in Poland: *Fusicladium convolvularum* Ondřej, *F. scribnerianum* (Cavara) M. B. Ellis and *F. virgaureae* Ondřej, are known from a few localities in the world. All the species are provided with the distribution maps and the newly reported ones are illustrated with ink drawings.

**Key words:** parasitic fungi, anamorphic fungi, Deuteromycotina, distribution, Poland

### INTRODUCTION

Worldwide 57 fungal taxa belong to the anamorphic genus *Fusicladium* Bonord. em. Schubert, Ritschel et U. Braun. They are phytopathologically relevant pathogens, causing leaf spots, necroses, scab diseases as well as leaf and fruit deformations of members of at least 52 angiospermous plant genera (Schubert, Ritschel, Braun 2003). The fungi are host specific, mostly confined to a single host genus or allied host genera in a single family, e.g. *Fusicladium pomi* parasitizing the members of *Rosaceae*. The teleomorphic stages belonging to *Venturiaceae* (Ascomycota) develop after the mycelium overwinters in plant organs.

The name *Fusicladium* was traditionally used for *Venturia* anamorphs having sympodial (denticulate) or percurrent (annellate) conidiogenous cells. Three genera were later distinguished depending on the proliferation mode: *Fusicladium* with sympodial proliferation, *Pollaccia* with monoblastic, determinate to percurrent conidiogenous cells (with few rather inconspicuous annellations) and *Spilocaea* with percurrent proliferation and numerous, conspicuous annellations

(Schubert et al. 2003). The division has been accepted in many literature reports (e.g. Ellis 1976; Brandenburger 1985; Revay 1998).

Due to the number of taxa with mixed types of conidiogenous cells, these features are insufficient for the generic separation and it was not maintained by the authors of the first monograph of *Fusicladium* (Schubert et al. 2003). They reduced names *Pollaccia* E. Bald. et Cif. and *Spilocaea* Fr. to synonymy with *Fusicladium* Bonord., postulating to preserve the name instead of the older *Spilocaea*. The decision to merge these genera is supported by light and electron microscopy research and molecular data which show that features such as the type and growth of the mycelium, arrangement of conidiophores, structure of conidiogenous loci and shape, size and formation of conidia may not be used to define various genera of anamorphs belonging to *Venturiaceae*. These features are, however, useful for distinguishing species.

Properties that enable the differentiation of *Fusicladium* from other hyphomycetous genera are as follows: mycelium and stromata usually subcuticular to intraepidermal, hyphae often radiating, forming hyphal plates, conidiophores usually erumpent through the cuticle, pigmented and with equally thickened wall, conidiogenous loci inconspicuous with always unthickened wall, conidia pigmented, mostly olivaceous, solitary or catenate, amero- to phragmosporous, 0-2(-4)-septate.

## MATERIALS AND METHODS

Available literature data were critically analysed and used to prepare a list of *Fusicladium* species recorded in Poland and maps of their distribution. Phytopathological reports of economically important species were omitted for the sake of clarity and mainly 'floristic' data were used below.

The original material consisting of plant organs affected by *Fusicladium* species was collected in Central Poland: in the region of Łódź city and in the Wyzyna Częstochowska Upland.

For microscopic examination, specimens were made in lactic acid and heated with an alcohol burner. Nikon SMZ 10 A and Nikon E 400 microscopes were used to identify fungal species which were determined according to Schubert et al. (2003). Features of these specimens correspond to those given there. The nomenclature of host plants is given after Mirek et al. (2002).

The study material is deposited in the Herbarium Universitatis Lodziensis (LOD) in the collection of *parasitic fungi* labelled as PF.

## RESULTS

According to Schubert et al. (2003) 7 taxa are known to occur in Poland, namely *Fusicladium betulae*, *F. radiosum* var. *populi-albae*, *F. radiosum* var. *radiosum*, *F. saliciperdum*, *Fusicladium* sp. and common in Europe – *F. pomi* and *F. pyrorum*. A thorough review of the Polish mycological literature has revealed that 6 other species have also been recorded in Poland under the names *Fusicladium*, *Pollaccia* and *Spilocaea*. Three of these species are currently classified in different genera: 2 belong to *Passalora* and 1 is synonymized with *Fusicladiella melaena*. The list of species occurring in Poland is supplemented with 3 species new to the country: *Fusicladium convolvularum*, *F. scribnerianum* and *F. virgaureae*.

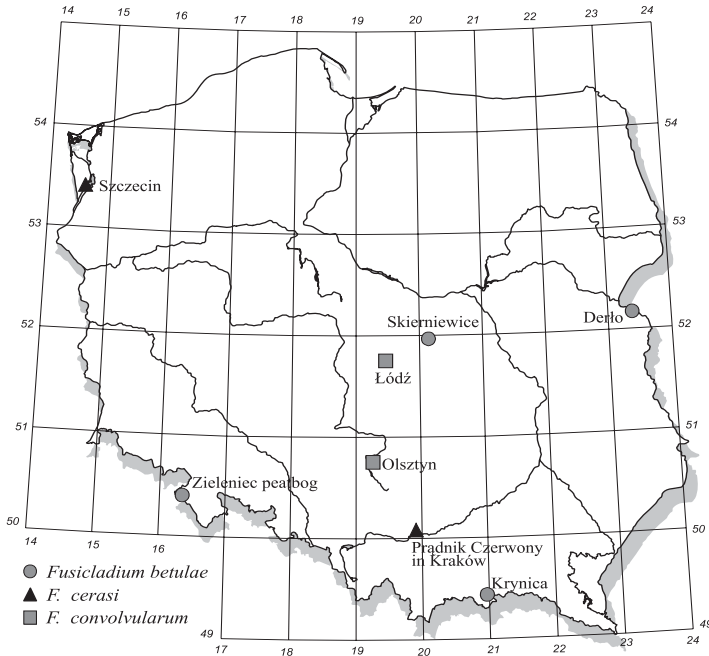


Fig. 1. Distribution of *Fusicladium* species.

***Fusicladium betulae*** Aderh., Centralb. Bakterioll., 2 Abth., 2: 57 (1896) and Hedwigia 36: 80 (1897), teleomorph: *Venturia ditricha* (Fr.) P. Karst.

**DISTRIBUTION.** On *Betula nana*: Zieloniec peat bog (Starmachowa 1964); on *Betula pendula*: Nieborów forest near Skierniewice (Zweigbaumówna 1925), Góra Krzyżowa Mt. near Krynica (Starmachowa 1966), Derło in Bug river valley (Danilkiewicz 1987) (Fig. 1). According to Schubert et al. (2003) this fungus is known from Poland on *B. pendula*.

**NOTES.** Two *Fusicladium* species are known on the members of *Betulaceae*: *F. betulae* and *F. scribnerianum*, which is characterized by darkened-refractive hila and loci (Schubert et al. 2003). *F. betulae* is common on *B. pendula*, but on *B. nana* is known from Denmark, Norway and Romania (Farr et al. 2006).

***Fusicladium cerasi*** (Rabenh.) Erikss., Meddeland. Kongl. Lantbruksakad. Exp.-fält 1: 73 (1885), teleomorph: *Venturia cerasi* Aderh.

**DISTRIBUTION.** On *Cerasus avium* [= *Prunus avium*]: Szczecin (Madej 1974); on *C. vulgaris* [= *Prunus cerasus*]: Prądnik Czerwony in Kraków (Namysłowski 1914) and Szczecin (Madej 1974) (Fig. 1).

**NOTES.** The *Prunus* species (including *Cerasus*) could be infected with 5 species of *Fusicladium*. *Cerasus vulgaris* is worldwide affected mostly by *F. cerasi*, but also 2 other species have been reported so far: *Fusicladium*-state of *Apiosporina morbosa* (Schwein.) Arx and *F. carpophilum* occurring very rarely on this host (Schubert et al. 2003). The distribution of *F. cerasi* on *C. vulgaris* is circumglobal: it is known from Asia, North and South Americas, Australia, New Zealand and numerous European countries.

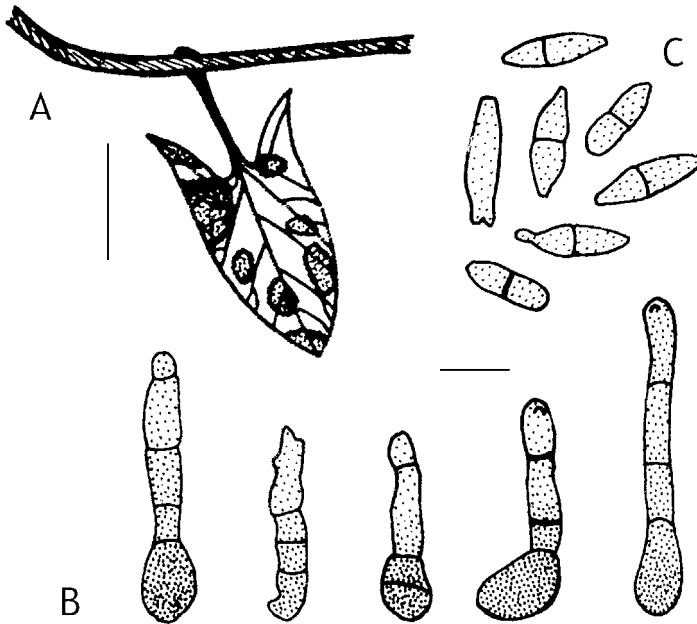


Fig. 2. *Fusicladium convolvularum* on *Convolvulus arvensis*: A – leaf with spots, B – conidiophores, C – conidia; scale bars A = 10 mm, B – C = 10  $\mu$ m.

*Fusicladium convolvularum* Ondřej, Česká Mycol. 25 (3): 171 (1971), teleomorph unknown.

Leaf spots amphigenous, 1-3 mm wide, brown, later with greyish brown centre and brown margin. Conidiophores solitary or in small groups, arising from stromatic cells, straight, or curved at the apex, subcylindrical to geniculate-sinuous, 29.4-44.1 x 4.2-4.9  $\mu$ m, 0-1(-3)-septate, pale to medium brown, smooth. Conidiogenous cells terminal with a single or several conidiogenous loci, proliferation sympodial, loci unthickened, not or often somewhat darkened-refractive. Conidia solitary or occasionally in unbranched or branched chains, ellipsoid-ovoid, fusiform, subcylindrical, 17.1-22.3 x 4.9-5.2  $\mu$ m, 0-1-septate, mostly constricted at the septa, pale olivaceous, smooth, hila 1.9-2.5  $\mu$ m wide, flat, not or somewhat darkened-refractive (Fig. 2).

**SPECIMENS EXAMINED.** On *Convolvulus arvensis*: Central Poland, Wyżyna Częstochowska Upland, at NE base of the Góra Lipówki Bliskie hill near Olsztyn, roadside, 21 Aug. 1998, leg. M. Ruszkiewicz-Michalska, LOD 885; Łódź, Botanical Garden, Sect. of medicinally and industrially important plants, weed overgrowing *Convallaria majalis*, 21 Aug. 2004, leg. E. Połec, LOD 2261; Łódź, “Sielanka” park, near Pabianicka Str., weed overgrowing *Kerria japonica*, 27 June 2005, leg. M. Ruszkiewicz-Michalska et M. Jakiel, LOD 2229 (Fig. 1).

**NOTES.** The fungus parasitizes members of the genera *Calystegia* and *Convolvulus*. It has been reported on *Calystegia soldanella* from Great Britain, on *Calystegia sepium* and *Convolvulus arvensis* from the Czech Republic, and on the latter host also from New Zealand (Farr et al. 2006). The species has been observed in Poland for the first time.

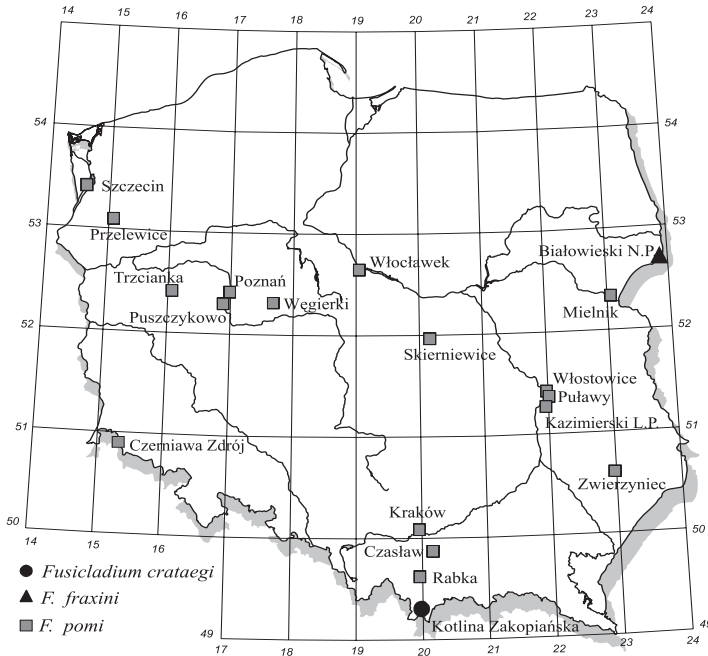


Fig. 3. Distribution of *Fusicladium* species.

***Fusicladium crataegi*** Aderh., Ber. Deutsch. Bot. Ges. 20: 200 (1902), teleomorph: *Venturia crataegi* Aderh.

DISTRIBUTION. On *Crataegus coccinea* L.: Kotlina Zakopiańska basin in the Tatra Mts. (Sałata et al. 1993) (Fig. 3).

NOTES. According to Schubert et al. (2003) only this cosmopolitan fungus parasitizes the members of *Crataegus*. As *C. coccinea* or its synonyms have not been listed among the species infected with *F. crataegi* (Schubert et al. 2003; Farr et al. 2006) it is presumably a new host of the fungus.

***Fusicladium fraxini*** Aderh., Hedwigia 36: 74, 83 (1897),  $\equiv$  *Spilocaea fraxini* (Aderh.) Sivan., teleomorph: *Venturia fraxini* Aderh.

DISTRIBUTION. On *Fraxinus excelsior*: as *S. fraxini*, Białowiecki National Park, *Tilio-Carpinetum*, *Circaeo-Alnetum*, *Carici elongatae-Alnetum* plant associations (Mułenko 1994, provided with a description and ink drawing; Faliński, Mułenko 1997) (Fig. 3).

NOTES. Mixed, percurrent and sympodial proliferations of conidiogenous cells may occur in this species within a single collection and therefore the taxon is considered intermediate between *Fusicladium* s. str. and *Spilocaea*. Worldwide, members of the genus *Fraxinus* are parasitized by 2 species of *Fusicladium*: *F. fraxini* and *F. nebulosum*; the latter is known only from the type material collected in North America. These 2 species differ by the arrangement, shape and size of conidiophores as well as by the type of the conidial sculpture (Schubert et al. 2003).

***Fusicladium pomi*** (Fr.) Lind, Dan. fung.: 521 (1913),  $\equiv$  *F. dendriticum* (Wallr.) Fuckel, *F. orbiculatum* (Desm.) Thüm., *Spilocaea pomi* Fr.: Fr., teleomorph: *Venturia inaequalis* (Cooke) G. Winter.

DISTRIBUTION. As *F. dendriticum*: on *Malus pumila*, Szczecin (Zaleski, Madej 1964); on *Malus sylvestris*, Czasław, Rabka, Prądnik Czerwony and Czarna Wieś in Kraków (Namysłowski 1914), Puławy, Włostowice (Konopacka 1924), Skierniewice (Zweigbaumówna 1925), Botanical Garden in Kraków (Wróblewski 1925), near Czerniawa Zdrój (Laubert 1931), Poznań, Puszczykowo, Węgiełki, Włocławek (Dominik 1936); on *Pyrus baccata*, Trzcianka (Dominik 1935, 1936); as *F. orbiculatum*: on *Sorbus aucuparia*, Zwierzyniec (Zweigbaumówna 1925); on *Sorbus latifolia* (Dominik 1963); as *S. pomi*: on *Malus domestica*, *M. pumila*, *M. × purpurea* and *Malus* sp.: Przelevice, Szczecin (Madej 1971, 1974); on *Malus* spp.: Kazimierski Landscape Park (Romaszewska-Sałata et al. 1991-1992); on *Malus sylvestris*: Mielnik (Romaszewska-Sałata, Mułenko 1983) (Fig. 3).

NOTES. This cosmopolitan, polyphagous and economically important species has so far been noted on 12 host genera of the *Rosaceae* family, but it mainly infects representatives of *Malus*: *M. domestica*, *M. prunifolia* and *M. sylvestris* (Triebel 1999; Schubert et al. 2003).

***Fusicladium pyrorum*** (Lib.) Fuckel, Jahrb. Nassauischen Vereins Naturk. 23-24: 357 '1869' (1870), as "*F. pyrinum*", teleomorph: *Venturia pyrina* Aderh.

SPECIMEN EXAMINED. On *Pyrus communis*, Central Poland, Łódź, "Sielanka" park, near Pabianicka Str., ornamental, 27 June 2005, leg. M. Ruszkiewicz-Michalska et M. Jakiel, LOD 2206.

DISTRIBUTION. As *F. pyrinum*: on *Pyrus communis*, without precised locality (Chełchowski 1902), Czarna Wieś and Prądnik Czerwony in Kraków (Namysłowski 1914), Puławy, Kazimierz (Konopacka 1924), Skierniewice (Zweigbaumówna 1925), near Czerniawa Zdrój (Laubert 1931), Włocławek (Dominik 1935, 1936), Szczecin (Zaleski, Madej 1964), Łeba, Cetniewo (Michalski 1967), Neple, Gnojno in the Bug river valley (Danilkiewicz 1987); as *F. pyrorum*: on *Pyrus domestica*, Przelevice and Szczecin (Madej 1974) (Fig. 4).

NOTES. The fungus infects mainly *Pyrus communis*, but it may also be found on the members of 4 other genera belonging to the *Pomoideae*, including *Malus* species, which are above all parasitized by *F. pomi* (Schubert et al. 2003). The latter differs from *F. pyrorum* by the proliferation type of conidiogenous cells (percurrent vs. sympodial) and width of loci (4-5  $\mu$ m vs. 1-3  $\mu$ m).

***Fusicladium radiosum*** (Lib.) Lind var. *populi-albae* (M. Morelet) Ritschel et U. Braun, Ann. Mycol. 3: 340 (1905),  $\equiv$  *Pollaccia radiosa* (Lib.) E. Bald. et Cif., teleomorph: *Venturia tremulae* Aderh.

SPECIMEN EXAMINED. On *Populus alba*: Central Poland, Chechło II near Łódź, near the railroad, 13 Sept. 2000, leg. M. Ruszkiewicz, LOD 2501. The dimensions of conidia (1-septate, 8.6-9.1  $\mu$ m wide) correspond to the range given for this variety in the *Fusicladium* monograph (Schubert et al. 2003).

DISTRIBUTION. For the list of Polish localities of the fungus on *Populus alba*, *P. nigra* and *P. tremula* see Mułenko (1996) (Fig. 4). According to the data of Schubert et al. (2003) two varieties of this species are known from Poland: var. *radiosum* (on *P. tremula*) and var. *populi-albae* (on *P. alba*).

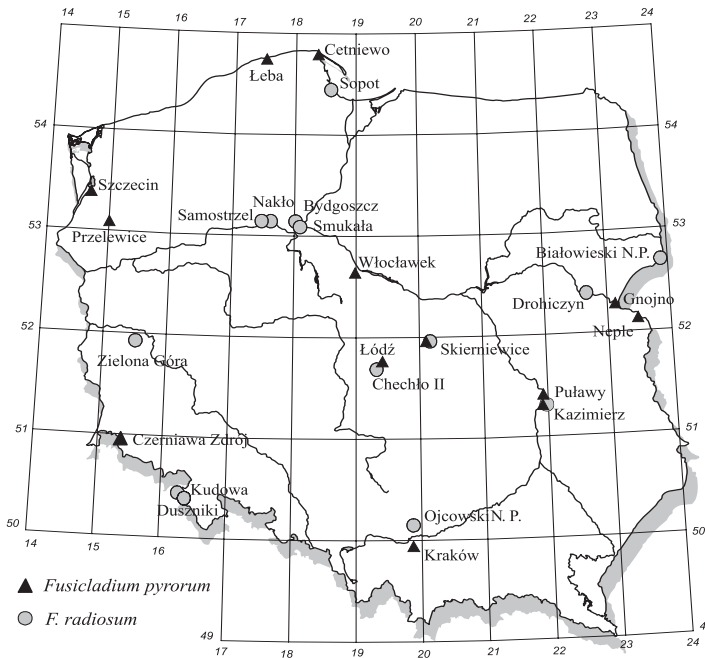


Fig. 4. Distribution of *Fusicladium* species.

NOTES. The members of the genus *Populus* could be infected with 8 taxa belonging to 6 *Fusicladium* species. The diversification of one of them, *Fusicladium radiosum*, into varieties is based on the septation, width and shape of conidia (Schubert et al. 2003). As the records in the Polish literature are not provided with morphological descriptions of the fungus, they may not be assigned to any of the varieties of *F. radiosum*. Morphological and morphometric analyses of the *F. radiosum* complex (Schubert et al. l.c.) have shown, however, that differences in the conidial size observed among varieties are not distinct. A strict host-based separation is not evident either as *Populus alba* is infected by all varieties of this species. The molecular approach is needed to re-assess this complex.

***Fusicladium saliciperdu*** (Allesch. et Tubeuf) Tubeuf, Arbeiten Biol. Reichsanst. Land-Forstw. 2: 568 (1902), ≡ *Fusicladium saliciperdu* (Allesch. et Tubeuf) Lind, teleomorph: *Venturia saliciperda* J. Nüesch.

DISTRIBUTION. On *Salix babylonica*: near Duszniki (Laubert 1931) (Fig. 5). According to Schubert et al. (2003) this species occurs on *Salix americana* in Poland. We have found no literature data confirming this record.

NOTES. *F. saliciperdu* is one of the 4 species of *Fusicladium* known to parasitize the members of the genus *Salix*. The host range of this fungus is the broadest: worldwide it infects 28 host taxa, including hybrids (Schubert et al. l.c.). It has been recorded on *S. babylonica* in Canada, China, Germany, Great Britain, Russia and the United States of America (Farr et al. 2006).

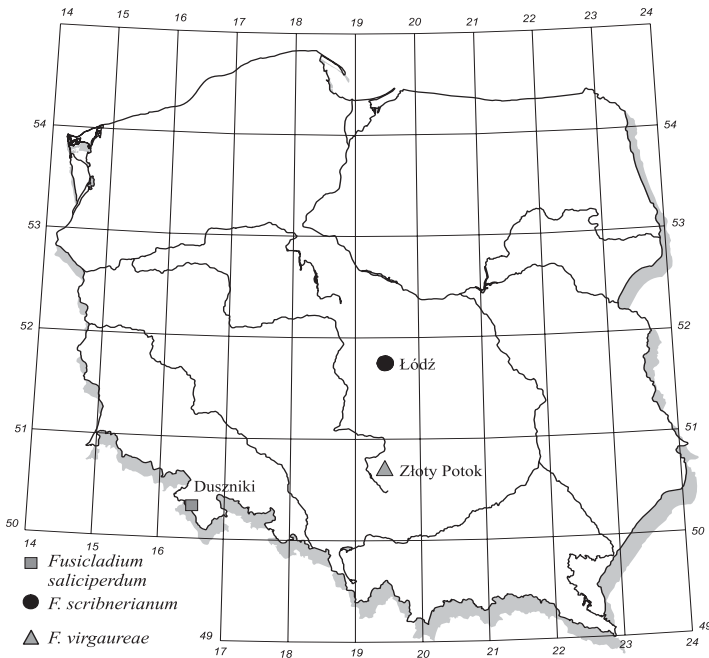


Fig. 5. Distribution of *Fusicladium* species.

***Fusicladium scribnerianum*** (Cavara) M. B. Ellis, More Dematiaceous Hyphomycetes: 238 (1976), teleomorph unknown.

Leaf spots amphigenous, subcircular, on the upper leaf surface olivaceous-greyish to dark brown, centre of the spot darker. Stromata composed of brown, thick-walled cells. Conidiophores solitary or loosely to densely fasciculate, arising from stromata, erect, straight to slightly flexuous, unbranched, 19.8-41.7 x 4.2-4.9  $\mu\text{m}$ , 0-1-septate, olivaceous to pale brown, smooth. Conidiogenous cells terminal with a single or several conidiogenous loci, proliferation sympodial, loci unthickened, but somewhat darkened-refractive. Conidia solitary or sometimes catenate, fusiform to cylindrical, straight, 14.7-27.0 x 4.7-6.1  $\mu\text{m}$ , 0-3 septate, pale olivaceous, smooth, hila unthickened, but somewhat darkened-refractive (Fig. 6).

**SPECIMEN EXAMINED.** On *Betula pendula*: Central Poland, Łódź, Botanical Garden, Sect. of Arboretum, 20 July 2004, leg. E. Połec, LOD 2262 (Fig. 5). Morphological features of the specimen correspond to those described by Schubert et al. (2003).

**NOTES.** The species is known on *B. pendula*, *B. populifolia* and *Betula* sp. from Australia, Germany, Italy, Kazakhstan (Dugan et al. 2004; Farr et al. 2006). The species is reported from Poland for the first time.

***Fusicladium* sp.**, anamorph of *Venturia chlorospora* (Ces.) P. Karst.

**DISTRIBUTION.** According to Schubert et al. (2003) the species occurs on *Salix fragilis* in Poland. We did not find any record in the available literature to confirm this information.

**NOTES.** The species is known in the anamorphic stage only from *in vitro* cultures formed by *Venturia chlorospora* ascospores. It is characterised by: conidiophores



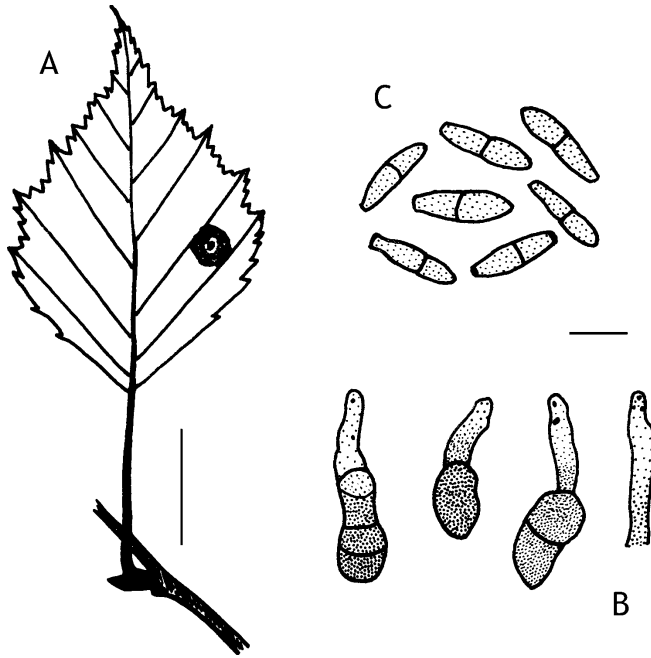


Fig. 6. *Fusicladium scribnerianum* on *Betula pendula*: A – leaf with spot, B – conidiophores, C – conidia; scale bars: A = 10 mm, B – C = 10  $\mu$ m.

arising as lateral branches of brown hyphae, conidiogenous cells polyblastic, sympodial, terminal or intercalary, with numerous conidiogenous loci and conidia in unbranched chains, 5–8  $\mu$ m wide (Schubert et al. 2003). *V. chlorospora* is known on 7 *Salix* species from Poland (Farr et al. 2006).

*Fusicladium virgaureae* Ondřej, Česká Mycol. 25 (3): 170 (1971), teleomorph unknown.

Leaf spots amphigenous, shape and size variable, irregular, yellowish, olivaceous to brown. Conidiophores solitary or in small, loose fascicles, erect, straight to somewhat flexuous, subcylindrical to slightly sinuous, unbranched or rarely branched, 36.8–63.7  $\times$  4.9–5.4  $\mu$ m, septate, yellowish or olivaceous-brown to medium brown, smooth. Conidiogenous cells terminal with a single or up to four loci, proliferation sympodial. Conidia in unbranched chains, cylindrical to fusiform or obclavate, straight, 13.5–15.9  $\times$  4.4–5.2  $\mu$ m, 0–1-septate, yellowish or olivaceous-brown, smooth, hila neither thickened nor darkened (Fig. 7).

**SPECIMEN EXAMINED.** On *Solidago serotina*: Central Poland, Wyżyna Częstochowska Upland, Złoty Potok near Częstochowa, manor park, roadside, 25 Aug. 1998, leg. M. Ruszkiewicz, LOD 886 (Fig. 5).

**NOTES.** *F. virgaureae* is the only species of this genus parasitizing plants belonging to the *Asteraceae*. It infects only the members of the genus *Solidago* and is known from 3 countries. Occurrence of the fungus has been reported on *S. gigantea* from Austria and on *S. virgaurea* from the Czech Republic and Slovakia (Schubert et al. 2003; Farr et al. 2006). The species is new to the Polish mycobiota.

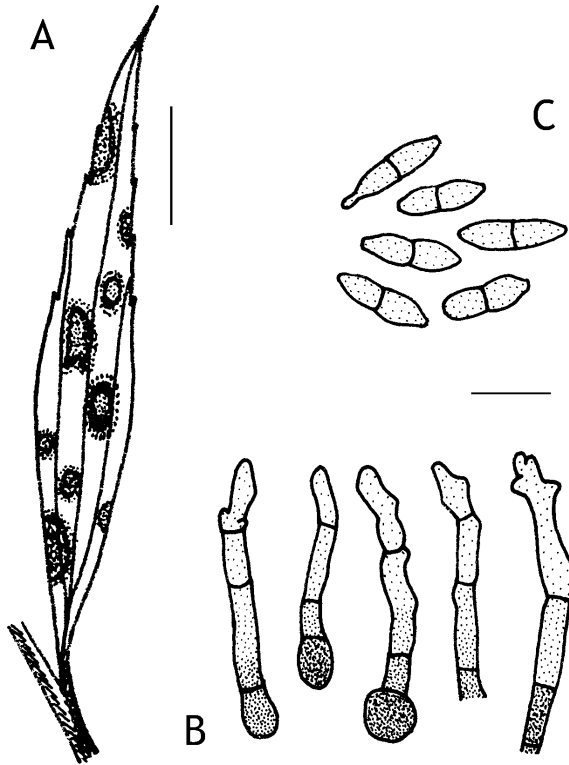


Fig. 7. *Fusicladium virgaureae* on *Solidago serotina*: A – leaf with spots, B – conidiophores, C – conidia; scale bars A = 10 mm, B – C = 10 µm.

#### EXCLUDED SPECIES

*Fusicladium aronici* Sacc., *Michelia* 2: 171 (1880).

DISTRIBUTION. On *Doronicum austriacum* and *D. clusii*: numerous localities in the Tatra Mts. (Starmachowa 1963; Mułenko et al. 2004).

NOTES. This species currently belongs to *Fusicladiella melaena* (Fuckel) S. Hughes (Schubert et al. l. c.). The genus *Fusicladiella* differs from *Fusicladium* by forming membranaceous mycelium and stromata, having older conidiophores usually curved and conidiogenous loci thickened and darkened.

*Fusicladium depressum* (Berk. et Broome) Roum., *Fungi gall. exs.* 86 (1879).

DISTRIBUTION. For the list of host species and Polish localities see Mułenko (1996).

NOTES. According to Schubert et al. (2003) and Crous & Braun (2003) this name is now synonymized with *Passalora depressa* (Berk. et Broome) Sacc.

*Fusicladium heterosporum* Höhn., *Ann. Mycol.* 3: 337 (1905).

DISTRIBUTION. On *Chamaenerion angustifolium*: Włoszczowa (Moesz 1926).

NOTES. The species is currently considered to be *Passalora heterospora* (Höhn.) Höhn. (Schubert et al. l.c.; Crous, Braun l.c.).

## FINAL REMARKS

The first Polish records of taxa currently belonging to *Fusicladium* are dated back to the beginning of 20th century (Chełchowski 1902). The most of the older findings come from floristic or phytopathological investigations (Namysłowski 1914; Laubert 1921, 1931; Konopacka 1924; Wróblewski 1925; Zweigbaumówna 1925; Dominik 1936, 1963; Starmachowa 1964, 1966; Zaleski, Madej 1964; Michalski 1967; Madej 1971, 1974). The more recent data are provided by mycocoenological studies carried out in a few Polish regions of a special floristic value: Białowieża National Park (Mułenko 1994, 1996), Tatra Mts. (Sałata et al. 1993) and Wyżyna Lubelska Upland (Romaszewska-Sałata, Mułenko 1983; Danilkiewicz 1987; Romaszewska-Sałata et al. 1991-1992).

The best documented is occurrence of common, economically important species – *Fusicladium pomi* and *F. pyrorum* (compare Figs 3, 4). The other species are known from a few localities in Poland, mainly from more intensively investigated areas. Many other regions of the country, are still less studied and therefore the listed localities of these species do not present their comprehensive distribution.

The 3 newly recorded taxa are known from a few countries only, on different continents, e.g. *Fusicladium scribnerianum* has been reported from Europe, Asia and Australia. This distribution implies that actually they are not very rare or restricted to certain areas. The assumption is supported with our findings, especially that of *Fusicladium convolvularum*, which has been repeatedly collected in Central Poland since its discovery on the Wyżyna Częstochowska Upland in 1998.

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Przegląd krajowych gatunków z rodzaju *Fusicladium*

## Streszczenie

Lista stwierdzonych dotąd w Polsce przedstawicieli rodzaju *Fusicladium* [= *Pollaccia*, *Spilocaea*] obejmuje 12 gatunków, z których 3 należą obecnie do *Passalora* i *Fusicladiella*. Dane dotyczące 7 gatunków *Fusicladium* pochodzą wyłącznie ze źródeł publikowanych. Wykaz uzupełniono o 3 gatunki nowe dla kraju: *Fusicladium convolvularum*, *F. scribnerianum* i *F. virgaureae* oraz nowe stanowiska 2 taksonów notowanych uprzednio. Dla wszystkich gatunków sporządzono mapy rozmieszczenia w Polsce, a dla gatunków nowo stwierdzonych również opisy i rysunki struktur morfologicznych.

