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CLADOSPORIUM EPICHLOËS, A RARE EUROPEAN FUNGUS, WITH NOTES ON OTHER FUNGICOLOUS SPECIES*

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Abstract. *Cladosporium epichloës* Lobik, associated with *Epichloë typhina* (Pers.) Tul. & C. Tul. and known from three records worldwide, is reported from Poland for the first time. The morphology and distribution data of this species as well as the first records of *Cladosporium uredinicola* Speg. and *Phoma glomerata* (Corda) Wollenw. & Hochapfel as parasites of powdery mildews in Poland are presented. Information concerning specimens of five other hyperparasitic species deposited in Herbarium Universitatis Lodziensis (LOD) is provided.

Key words: *Cladosporium*, *Phoma glomerata*, *Sphaerellopsis filum*, *Ampelomyces*, *Tuberculina*, hyperparasite, fungicolous fungi, chorology, Poland

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INTRODUCTION

The term 'fungicolous fungi' covers species that occur on other fungi as parasites, commensals or saprobionts (Kirk *et al*. 2008). The nature of the interfungal relationships is not always clear, especially for intimate mycoparasitic interactions (Jeffries & Young 1994). Opinions on the type of relations of particular species with their mycohosts vary considerably. The status of the mycoparasite *Ampelomyces quisqualis* Ces., considered to be an intracellular necrotroph vs. biotroph (Jeffries & Young 1994), is the best example. It cannot be ruled out that during infection the nature of the contact can be gradually transformed from nearly biotrophic to necrotrophic without the production of any toxins (Kiss 2003 and literature cited therein). Similarly, some recent studies indicate that species of the genus *Tuberculina* Tode *ex* Sacc., parasitizing rust fungi, are fusion biotrophs (Lutz *et al.* 2004), but this has not been confirmed by other researchers (e.g., Bartkowska 2007b). *Sphaerellopsis filum* (Biv.) B. Sutton is a biotrophic mycoparasite which remains in close trophic contact with rust spores via appresorium-like structures (Płachecka 2005 and literature cited therein).

A reliable estimate of the number of fungicolous species is not available (Kirk *et al*. 2008). Hawksworth (1981), however, traced 1100 anamorphic species recorded on other species of fungi. Fungicolous fungi include members of all higher taxa of true fungi (Chytridiomycota, Zygomycota, Ascomycota including anamorphic taxa, Basidiomycota) and chromistan fungal analogues (Hyphochytriomycota, Oomycota). This taxonomic diversity is also reflected in Polish records of fungi belonging to this ecological group (Mułenko *et al.* 2008), with most representatives belonging to the ascomycetes [e.g., the genera *Hypocrea* Fr., *Hypomyces* (Fr.) Tul. & C. Tul., *Nectria* (Fr.) Fr.], zygomycetes (mostly belonging to Mortierellales, Mucorales and Zoopagales) and anamorphic fungi. Lichenicolous fungi, recently examined in a study by Czyżewska and Kukwa (2009), are a separate ecological group, relatively numerous in species.

Fungi occupied by fungicolous species represent a broad taxonomic spectrum comprising representatives of all taxa of higher ranks belonging to the kingdom Fungi, as well as chromistan and

* This paper is dedicated to Professor Tomasz Majewski on the occasion of his 70th birthday.

protozoan fungal analogues (e.g., myxomycetes) (Hansford 1946; Ellis & Ellis 1998; Samuels *et al.* 2006; Kirk *et al.* 2008). Many species parasitize fungi closely related to them; for example, *Tuberculina* species infect members of the Pucciniales (cf. Lutz *et al.* 2004). This is also frequently observed among representatives of Oomycota, Chytridiomycota and Zygomycota (Jeffries & Young 1994). For instance, *Absidia parricida* Renner & Muscat *ex* Hesselt. & J. J. Ellis, *Chaetocladium jonesii* (Berk. & Broome) Fresen. and *Parasitella parasitica* (Bainier) Syd. were recorded on other Mucorales species in Poland (Mułenko 2008).

Rust fungi infected by *Eudarluca caricis* (Biv.) O. E. Erikss. and species belonging to *Cladosporium* Link, *Tuberculina* Tode *ex* Sacc. and *Ramularia* Unger are the most frequently observed fungi hosting other fungi in Poland (Mułenko *et al.* 2008). Specimens of the latter taxon [*Ramularia coleosporii* Sacc., *R. uredinis* (Voss) Sacc., *R. uredinearum* Hulea] were recently taxonomically verified and are discussed in a monograph by Wołczańska (2005). The parasitism of *Ramularia* species on rust spores was recently confirmed by Bartkowska (2007a).

Hosts of fungicolous fungi often recorded in Poland also include Erysiphales gen. div. and other species of ascomycetes such as *Diatrypella favacea* (Fr.) Ces. & De Not., *Diatrype* spp. and *Hypoxylon* spp., as well as agarics, boletes and polypores (Mułenko *et al.* 2008). Other species of fungi occurring on parasitic micromycetes, most probably as saprobes, have been observed sporadically (see Table 1). The majority of these records cannot be verified as they are reported in older studies, mostly phytopathological, which are rarely documented by herbarium specimens. The status of a fungus recorded by Domański *et al.* (1970) on *Plasmopara densa* (Rabenh.) J. Schroet. (a parasite of *Euphrasia* sp.), which most probably belonged to *Trichothecium plasmoparae* Viala, is also unexplained.

Table 1. Survey of micromycetes reported in association with basidiomycetous plant parasites in Poland.

Mycohost species	Fungicolous species	Source of data
Gymnosporangium sp.	*Gloeosporium roesteliicola* Bubák & Serebrian.	Jankowska-Barbacka 1931
Puccinia punctata Link	*Fusarium uredinicola* Jul. Müll.	Dominik 1936
Phragmidium rubi-idaei (DC.) P. Karst.	*Fusarium avenaceum* (Fr.) Sacc.	Mułenko *et al.* 2008
Puccinia caricina DC.	*Hymenula spermogoniopsis* (Jul. Müll.) Wollenw.	Wollenweber 1916; Mułenko 1996
Puccinia coronata Corda	*Fusarium avenaceum* (Fr.) Sacc.	Mułenko *et al.* 2008
Puccinia sessilis W. G. Schneid.	*Fusarium avenaceum* (Fr.) Sacc., *Volutella fusariispora* Dominik (on aecia)	Dominik 1934; Mułenko *et al.* 2008
Uromyces fabae (Pers.) de Bary	*Fusarium graminearum* Schwabe, *Trichothecium roseum* (Pers.) Link	Pruszyńska-Gondek 1974, 1976
Ustilago avenae (Pers.) Rostr.	*Verticillium albo-atrum* Reinke & Berthold	Pielka 1963
Ustilago nuda (C. N. Jensen) Kellerm. & Swingle	*Alternaria tenuis* Nees, *Botrytis cinerea* Pers., *Fusarium heterosporum* Nees & T. Nees, *Trichothecium roseum* (Pers.) Link, *Verticillium albo-atrum* Reinke & Berthold	Pielka 1963
Ustilago tritici (Pers.) Rostr.	*Botrytis cinerea* Pers., *Fusarium culmorum* (W. G. Sm.) Sacc., *F. javanicum* Koord. var. *radicicola* Wollenw., *F. heterosporum* Nees & T. Nees, *Nigrospora oryzae* (Berk. & Broome) Petch, *Trichothecium roseum* (Pers.) Link, *Verticillium albo-atrum* Reinke & Berthold	Pielka 1963
Exobasidium vaccinii (Fuckel) Woronin	*Fusarium graminum* Corda	Moesz 1926 (fungicolous species name with a question mark)

Cladosporium species: host range and specialization

Twenty-six species of the genus *Cladosporium* Link *s.l.* have been described as confined to fungi (Heuchert *et al.* 2005). As well as a few polyphagous saprobionts occasionally colonizing thalli of different species [e.g., *C. herbarum* (Pers.) Link, *C. tenuissimum* Cooke, *C. cladosporioides* (Fresen.) G. A. de Vries], they also include *Cladosporium s.str.* associated with specific taxa of fungi. Some, such as *C. lycoperdinum* Cooke, *C. epimyces* Cooke and *C. episclerotiale* Bubák, colonize fruitbodies of macromycetes (Agaricales, Boletales, Polyporales, Russulales). *Cladosporium episclerotiale* is also known from sclerotia of *Monilinia laxa* (Aderh. & Ruhland) Honey. *Cladosporium phyllophilum* McAlpine, a parasite of Taphrinales, and *C. exobasidii* Jaap, limited to *Exobasidium* Woronin species, exhibit a narrower host spectrum. Some species associated with rust fungi are confined to aecia (*C. aecidiicola* Thüm., *C. gallicola* B. Sutton), while others occur on different stages of a variety of genera belonging to Pucciniales (e.g., *C. uredinicola* Speg.). The latter species also includes specimens morphologically indistinguishable from *C. uredinicola* known to occur on two *Peronospora* Corda species from India, *Erysiphe euonymi-japonici* (Vienn.-Bourg.) U. Braun & S. Takam. from Iran, and *Phyllactinia angulata* (E. S. Salmon) S. Blumer and *P. guttata* (Wallr.) Lév. from the U.S.A. (Heuchert *et al.* 2005; Dugan & Glawe 2006). Finally, *C. taphrinae* Bubák, *C. gerwasiae* Heuchert, U. Braun & K. Schub. and *C. epichloës* Lobik are treated as stenotopic species in the current taxonomic approach of Heuchert *et al.* (2005).

Five species of the genus *Cladosporium* colonizing other fungi have been recorded in Poland (Heuchert *et al.* 2005; Ruszkiewicz-Michalska & Mułenko 2008). These are *Cladosporium aecidicola*, *C. uredinicola*, *C. phyllophilum* on *Taphrina pruni* (Fuckel) Tul., *C. fuligineum* Bonord. and *C. epimyces*. Although the name is at present a synonym of *Cladosporium herbarum*, the taxonomic position of specimens reported in Poland as *C. fuligineum* is uncertain because the specimens most probably represented other species of *Cladosporium*, especially the records on *Exobasidium vaccinii* (Fuckel) Woronin. These collections cannot be verified as the exsiccata documenting them are missing. Finally, the specimen of *C. epimyces* (on *Lactarius* sp., HBG herbarium) from Prószków near Opole was verified by Heuchert *et al.* (2005).

Materials and methods

The present list is based on my unpublished and published data (Ruszkiewicz-Michalska & Michalski 2005; Ruszkiewicz-Michalska 2006) and specimens deposited in the fungal collection of Herbarium Universitatis Lodziensis (LOD) in the subcollection of Parasitic micromycetes (labelled PF). The latter were collected mostly by graduate students conducting research for theses under my supervision. The majority of exsiccata were collected in central Poland, covering Łódź Province and a few sites in Silesia Province (Wyżyna Częstochowska upland, vicinity of Pszczyna). A single specimen was collected in the Bory Tucholskie forest (Fig. 1).

Papers by Heuchert *et al*. (2005) and Ellis and Ellis (1998) were used for determination of fungicolous fungi. Identification of their host species was based on monographs by Majewski (1977, 1979) and Braun (1995).

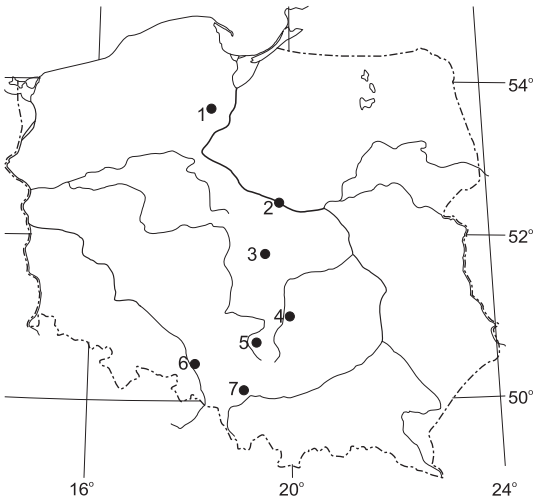

Fig. 1. Sampling sites of fungicolous micromycetes in Poland. 1 – Wierzchlas Reserve, 2 – Łuszczanów, 3 – Łódź, 4 – Przedbórz, 5 – Złoty Potok, 6 – Ligota Dolna Reserve, 7 – Wola.

Associated plant species are identified according to Rutkowski (1998). Nomenclature follows Mirek *et al.* (2002) for plants and Mułenko *et al.* (2008) for fungi.

The specimens were studied with a stereomicroscope (Nikon SMZ-10A) and a light microscope (Nikon E400) with phase contrast, using a 1000× oil immersion objective. To have a representative size range, 20 pycnidia, conidiophores and conidia mounted in water were measured in each collection. Photographs were taken with a Nikon DS-L1 digital camera.

Results and discussion

Seven species of fungicolous fungi associated with parasitic micromycetes are listed. *Cladosporium epichloës*, reported from Poland for the first time, is described and illustrated. Host species, the distribution in Poland and general notes are given for each species. The specimens from LOD given in previous papers are annotated with the reference data.

Cladosporium epichloës Lobik Fig. 2A–C

Bolezni Rast. **17**(3–4): 189. 1928.

Colonies olivaceous to brown, diffuse to dense, velvety. Mycelium immersed and external, superficial hyphae sparse, creeping, branched, 2.5–5.0 µm wide, septate, cells irregularly swollen (up to 7 µm wide), pale brown, smooth. True stromata lacking. Conidiophores solitary or in loose groups, arising from swollen cells (up to 7–8 µm in diameter), erect, straight or sometimes curved, subcylindrical, geniculate-sinuous, rarely branched, (20–)30–45 × 3–5 µm, slightly swollen at base, 0–3 septate, not constricted at septa, pale to medium brown, paler towards apex, smooth, rarely with subnodulose intercalary swellings (up to 5 µm wide) often with conidiogenous loci. Conidiogenous cells integrated, terminal and rarely intercalary, 8–30 µm long, proliferation sympodial, with (1–)2–7 conspicuous, protuberant, thickened, darkened-refractive conidiogenous loci (1–2 µm in diameter) sometimes situated on small unilateral swellings resembling shoulders. Conidia mainly solitary, rarely in branched chains, straight, polymorphous, ellipsoid, obovoid, fusiform, subcylindrical, (5–)9–22 × 4–7 µm, 0–2(–5)-septate, not constricted at septa, pale brown, almost smooth, walls conspicuously thickened, apex rounded, with up to 3 hila, base truncate to convex, hila protuberant, thickened, darkened, 1–2 µm in diameter; microcyclic conidiogenesis observed sporadically. This description is in accordance with morphological characteristics given by Heuchert *et al.* (2005).

Specimen examined. POLAND. On *Epichloë typhina* (Pers.) Tul. & C. Tul. (on *Poa compressa* L.): Wzniesienia Południowomazowieckie hills: Łódź, Las Łagiewnicki forest complex, forest district 11, grassy edge of deciduous forest (*Tilio-Carpinetum typicum*), 8 June 2007, *leg. M. Ruszkiewicz-Michalska* (LOD 3088 PF).

Host range and distribution. According to Heuchert *et al.* (2005) the species is known on *Epichloë typhina* from three European countries: southwestern Russia (holotype, *E. typhina* hosted by *Bromus inermis* Leyss.), central Germany (*Dactylis polygama* Horv.) and eastern Austria (host of *E. typhina* not specified).

Notes. *Cladosporium epichloës* is barely distinguishable from *C. aecidiicola* morphologically. They are tentatively treated as separate taxa (Heuchert *et al.* 2005), as distinct ecology and host specialization are evident in these two species. Additional studies, including molecular and inoculation experiments, are needed to resolve their taxonomy. *C. epichloës* also resembles the saprobic *C. herbarum*. The main character distinguishing them is the presence of multilateral nodes of conidiophores in the latter (swellings 7–9 µm in diam.; compare illustration in Schubert *et al.* 2007: figs 17, 18b) which are absent in the former. In addition, *C. epichloës* forms characteristic geniculate conidiophores with small unilateral shoulders (Heuchert *et al.* 2005).

As *Epichloë typhina* is a common pathogen of many of the world's graminicolous species (including cereal crops), its parasites are of great importance as prospective biocontrol agents. Most of the species observed on *E. typhina* are known from a limited number of localities such as *Radulidium epichloës* (Ellis & Dearn.) Arzanlou, W. Gams & Crous (Arzanlou *et al.* 2007), *Phyllosticta epi-*

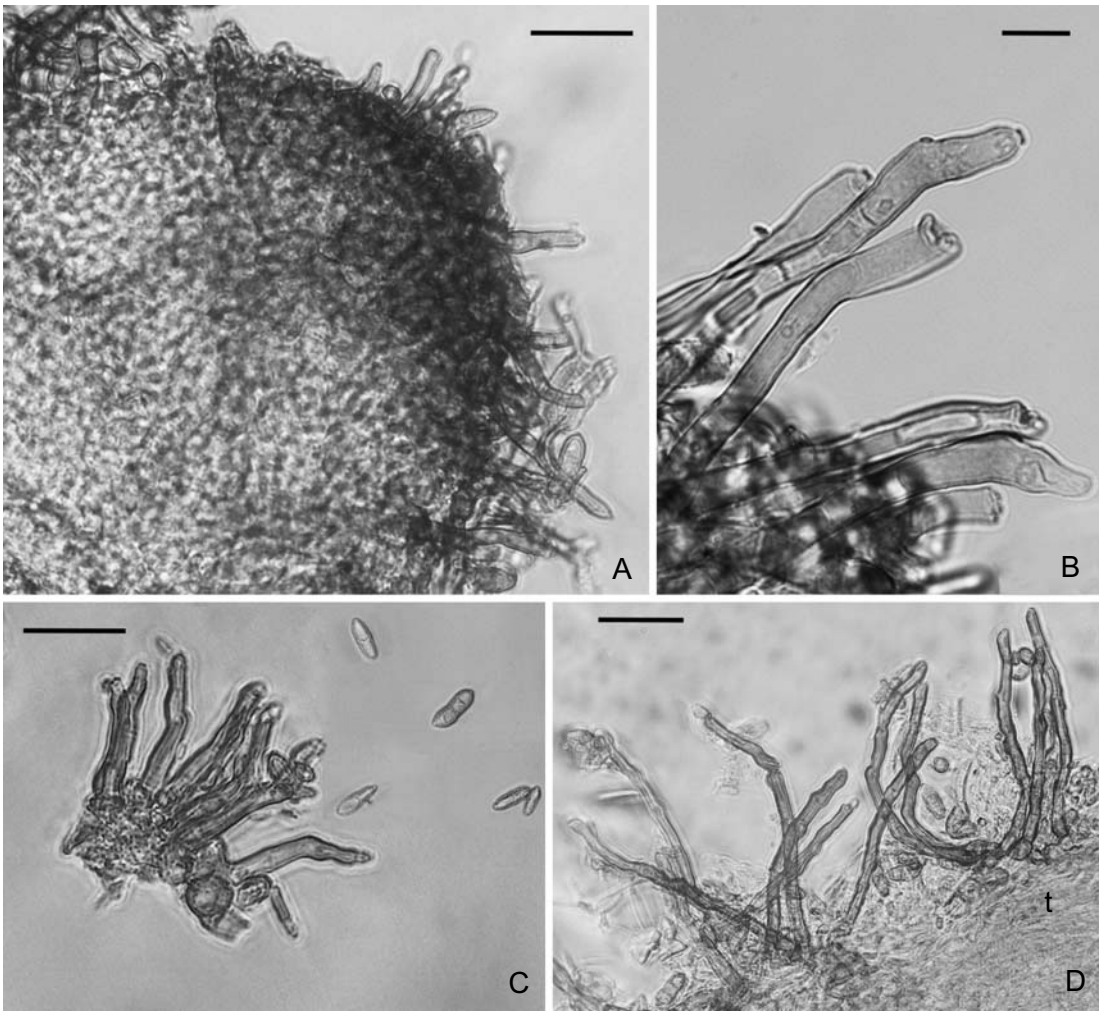

Fig. 2. Fungicolous *Cladosporium* species. A–C – *Cladosporium epichloës* (A – developing ascoma of *Epichloë typhina* covered by conidiophores of the parasite, B & C – conidiophores and conidia); D – *C. uredinicola* [conidiophores and conidia on telial column (t) of *Cronartium flaccidum*]. Scale bars: A, C, D = 25 µm, B = 10 µm.

chloës Thirum. (Aa & Vanev 2002), *Cladosporium epichloës* (Heuchert *et al.* 2005), and *Dicyma pulvinata* (Berk. & M. A. Curtis) Arx recorded on *E. typhina* for the first time only recently (Alderman *et al.* 2010). *Bionectria epichloë* (Speg.) Schroers, whose presence in the anamorph stage (*Clonostachys epichloë* Schroers) was recently confirmed by Kirschner (2006) in Europe, occurs worldwide. Only *Alternaria* sp. was observed on the stroma of *Epichloë typhina* in Poland (Mułenko *et al.* 2008).

Cladosporium aecidiicola Thümen

Mycoth. univ., Cent. IV, No. **373**. 1876.

SPECIMEN EXAMINED. POLAND. On aecia of *Puccinia coronata* Corda (on *Rhamnus cathartica* L.): WYŻYNA PRZEDBORSKA UPLAND: Murawy Dobromierskie Reserve near Przedbórz, edge of xerothermic grassland, 14 Sept. 2009, *leg. M. Ruszkiewicz-Michalska* (LOD 3090 PF).

HOST RANGE AND DISTRIBUTION. This species is known to parasitize aecial sori of numerous rust

species worldwide (Heuchert *et al.* 2005; Farr & Rossman 2010). Recently it was reported for the first time also on spermogonia (Blanz & Braun 2008). The species is very likely to be common in Poland although the published records comprise only the northern and southern parts of the country (Ruszkiewicz-Michalska & Mułenko 2008). It infected seven host species of the genera *Coleosporium* Lév., *Puccinia* Pers. and *Uromyces* (Link) Unger. See also notes on *C. uredinicola.*

NOTES. Like *C. epichloës*, *C. aecidiicola* is morphologically similar to the common saprobic *C. herbarum*, which differs in having ovoid-ellipsoid conidia that are not attenuated toward the base as observed in the former species. In addition, *C. herbarum* forms characteristic intercalary swellings round about the conidiophore, which are not present in *C. aecidiicola* (Heuchert *et al.* 2005).

Cladosporium uredinicola Spegazzini Fig. 2D

Anales Mus. Nac. Hist. Nat. Buenos Aires **23**: 122–123. 1912.

SPECIMENS EXAMINED. POLAND. On uredinia of *Ochropsora ariae* (Fuckel) Ramsb. (on *Pyrus communis* L.): WZNIESIENIA POŁUDNIOWOMAZOWIECKIE HILLS: Łódź, Las Łagiewnicki Reserve, deciduous forest (*Potentillo albae-Quercetum*), roadside, 30 Sept. 2007, *leg. K. Brózio* (LOD 3113 PF); on telia of *Cronartium flaccidum* (Alb. & Schwein.) G. Winter (on *Vincetoxicum hirundinaria* Medik.): WZNIESIENIA POŁUDNIOWOMAZOWIECKIE HILLS: Łódź, Botanical Garden, section of healing plants and plants grown for industrial purposes, 4 Sept. 2004, *leg. E. Połeć* (LOD 3089 PF); WYŻYNA ŚLĄSKA UPLAND: Ligota Dolna Nature Reserve near Opole, Kamienna Góra hill, xerothermic meadow (*Adonido-Brachypodietum*), top of hill, 16 Aug. 2000, *leg. E. Moliszewska* [as *Cladosporium aecidiicola* Thüm. (in Moliszewska 2008); voucher stored in herbarium of the Department of Biotechnology and Molecular Biology, University of Opole, and LOD 3130 PF]; on chasmothecia of *Phyllactinia fraxini* (DC.) Fuss (on *Fraxinus excelsior* L.): WZNIESIENIA POŁUDNIOWOMAZOWIECKIE HILLS: Łódź, by Jaracza Street, 10 Sept. 2010, *leg. M. Ruszkiewicz-Michalska* (LOD 3129 PF).

HOST RANGE AND DISTRIBUTION. This species is known worldwide on aecia, uredinia and telia of numerous genera of the rust families Phragmidiaceae, Pucciniaceae and Uropyxidiaceae; it has not been reported on *Ochropsora* species (Heuchert *et al.* 2005; Farr & Rossman 2010). The specimen of *C. uredinicola* on *Ochropsora ariae* (LOD 3113) concerns a rust species very rare on this host plant in Poland (Majewski 1977; Majewski & Ruszkiewicz-Michalska 2008) and in the world (Farr & Rossman 2010). *Cladosporium uredinicola* on *Phyllactinia guttata* is the first Polish report of this species on a powdery mildew.

NOTES. A parasite of *Cronartium ribicola* J. C. Fisher assigned by Madej (1965) to *C. aecidicola* most probably belongs to *C. uredinicola*. This record is provisionally included (exsiccatum not available) in *C. uredinicola* due to its occurrence on telial sori, as *C. aecidicola* is confined to the aecial stage of rusts, similarly to *C. gallicola* associated with members of the Cronartiaceae. Although *C. uredinicola* was already reported in association with telial columns of *Cronartium* Fr. species (Morgan-Jones & McKemy 1990), it cannot be ruled out that Madej's record (1965) represents the recently described *C. gerwasiae*, which is at present known only from *Gerwasia* sp. from the Phragmidiaceae (Heuchert *et al*. 2005).

Tuberculina persicina (Ditmar) Saccardo

Fungi italica autogr. del. **17–28**: tab. 964. 1881.

SPECIMENS EXAMINED. POLAND. On aecia of *Puccinia coronata* Corda (on *Frangula alnus* Mill.): KOTLINA OŚWIĘCIMSKA BASIN: Wola village near Pszczyna, edge of coniferous forest (*Molinio-Pinetum*), 11 June 2007, *leg. A. Myszka* (LOD 2828 PF); on *Puccinia poarum* E. Nielsen (on *Tussilago farfara* L.): KOTLINA OŚWIĘCIMSKA BASIN: Wola village near Pszczyna, edge of coniferous forest (*Molinio-Pinetum*), 11 June 2007, *leg. A. Myszka* (LOD 2929 PF); on *Puccinia sessilis* W. G. Schneid. [on *Polygonatum odoratum* (L.) Mill.]: Bory Tucholskie forest: Cisy Staropolskie Reserve in Wierzchlas near Tuchola, deciduous forest (*Tilio-Carpinetum*), 26 June 2006, *leg. M. Ławrynowicz* (LOD 3094 PF).

HOST RANGE AND DISTRIBUTION. Three commonly recognized *Tuberculina* species [*T. maxima*

Rostr., *T. persicina* (Ditm.) Sacc. and *T. sbrozzii* Cavara & Sacc.] parasitize more than 150 species of 15 genera of Pucciniales worldwide (Lutz *et al.* 2004). In Poland, two of the three species were reported on aecial sori of rusts: *T. maxima* on *Cronartium flaccidum* and *T. persicina* on 12 species belonging to six genera (Mułenko *et al.* 2008). The latter species was wrongly reported on *Coleosporium tussilaginis* (Pers.) Berk. also present in the specimen from the Wyżyna Częstochowska upland (Ruszkiewicz-Michalska 2006). My verification of the specimen (LOD 1002 PF) revealed the parasite associated with aecia of *Puccinia poarum*.

The taxonomy of *T. cracoviae* Pielka and *T. ustilaginum* Pielka, two *Tuberculina* species described by Pielka (1963) from Poland parasitizing smut fungi [*Ustilago avenae* (Pers.) Rostr., *U. nuda* (Jens.) Kellerm. & Swingle and *U. tritici* (Pers.) Rostr.], is unclear. The species probably do not belong to *Tuberculina s.str.*, as in the opinion of Lutz *et al.* (2004) the genus should be restricted to rust species. Parasites of smut fungi are barely noted in the available professional literature. Among the species reported as parasites of smuts, *Sphaerellopsis filum* and *Pythium vexans* de Bary are listed (Jeffries & Young 1994). SEM observations of an unidentified ascomycete parasitizing spores of *Vankya vaillantii* (Tul. & C. Tul.) Ershad were given by Protzenko (1989). The ability of *Stephanoma phaeosporum* Butler & McCain to parasitize *Ustilago avenae* (Pers.) Rostr. and *U. maydis* (DC.) Corda in culture was also reported (Rakvidhyasastra & Butler 1973).

NOTES. Based on molecular and ultrastructural studies, Lutz *et al*. (2004) recently showed that members of the genus are closely related to their hosts (rust species), sharing with them features including the uredinalean architecture of septal pores. Lutz *et al.* (2004) and Bauer *et al.* (2004) also reported the lack of haustoria and other intracellular structures of *T. persicina*, and its interaction with the host via large fusion pores in the frame of which *Tuberculina* nuclei and other organelles are horizontally transferred to the rust cells. In contrast, observations by Bartkowska (2007b) do not confirm such fusion of host and parasite via large pores. She observed direct penetration of aeciospores by *Tuberculina* hyphae (presumably vegetative) and invasion of plant tissue by the hyperparasite causing rapid destruction of plant cells infected with the rust.

Ampelomyces quisqualis Cesati *s.l.* Fig. 3A

Bot. Ztg. **10**: 301. 1852.

SPECIMENS EXAMINED. POLAND. On *Erysiphe artemisiae* Grev. [= *Golovinomyces artemisiae* (Grev.) V. P. Heluta] (on *Artemisia vulgaris* L.): WZNIESIENIA POŁUDNIOWOMAZOWIECKIE HILLS: Łódź city, Bolesław Chrobry Municipal Park, children's playground, 9 Oct. 2006, *leg. D. Papierz* (LOD 3049 PF); on *Erysiphe cichoracearum* DC. var. *cichoracearum* [= *Golovinomyces*

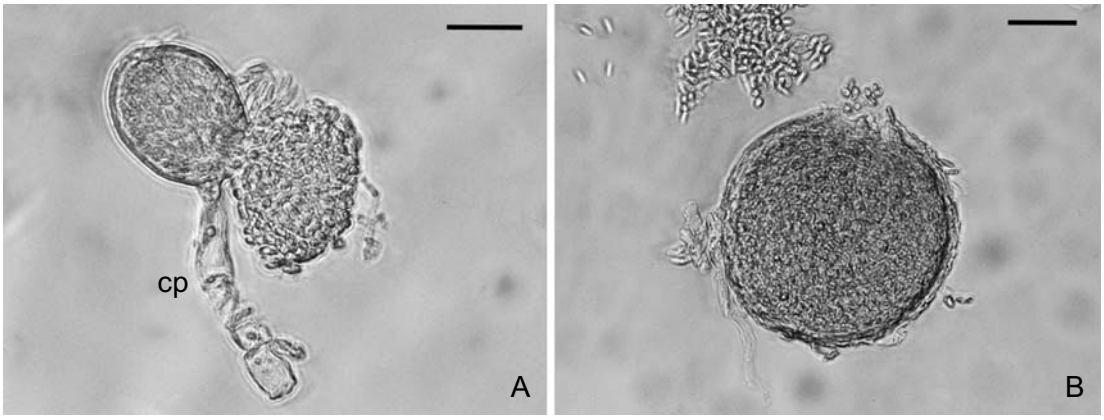

Fig. 3. Pycnidial fungicolous fungi. A – *Ampelomyces quisqualis* [pycnidium in conidiophore (cp) of *Sphaerotheca spireae*]; B – *Phoma glomerata* (globose pycnidium). Scale bars = 25 μm.

cichoracearum (DC.) V. P. Heluta var. *cichoracearum*] (on *Centaurea scabiosa* L.): WYŻYNA PRZEDBORSKA UPLAND: Murawy Dobromierskie Reserve near Przedbórz, xerothermic grassland, 14 Sept. 2005, *leg. M. Ruszkiewicz-Michalska* (LOD 3116 PF); (on *Tanacetum vulgare* L.): WZNIESIENIA POŁUDNIOWOMAZOWIECKIE HILLS: Łódź, Bolesław Chrobry Municipal Park, children's playground, 16 Sept. 2006, *leg. D. Papierz* (LOD 3050 PF); on *Erysiphe cruciferarum* Opiz *ex* Junell [on *Sisymbrium officinale* (L.) Scop.]: WZNIESIENIA POŁUDNIOWOMAZOWIECKIE HILLS: Łódź, Bolesław Chrobry Municipal Park, children's playground, 12 Oct. 2006, *leg. D. Papierz* (LOD 3048 PF); on *Erysiphe heraclei* DC. [on *Petroselinum crispum* (Mill.) A. W. Hill]: NIZINA ŚRODKOWOMAZOWIECKA LOWLAND: Łuszczanów village near Pacyna, vegetable garden, 17 Sept. 2004, *leg. W. Kaczmarek* (LOD 3115); on *Erysiphe sordida* (L.) Junell [= *Golovinomyces sordidus* (L. Junell) V. P. Heluta] (on *Plantago intermedia* Gilib.): WZNIESIENIA POŁUDNIOWOMAZOWIECKIE HILLS: Łódź, Las Łagiewnicki forest complex, deciduous forest, 21 Oct. 2007, *leg. M. Ruszkiewicz-Michalska* (LOD 3117 PF); (on *Plantago major* L.): NIZINA ŚRODKOWOMAZOWIECKA LOWLAND: Łuszczanów village near Pacyna, vegetable garden, weed, 17 Sept. 2004, *leg. W. Kaczmarek,* (LOD 3114 PF); KOTLINA OŚWIĘCIMSKA BASIN: Wola village near Pszczyna, boggy meadow (community of *Molinion caeruleae* alliance), 28 Aug. 2006, *leg. A. Myszka* (LOD 2780 PF); on *Microsphaera trifolii* (Grev.) U. Braun [= *Erysiphe trifoliorum* (Wallr.) U. Braun] (on *Melilotus alba* Medik.): WZNIESIENIA POŁUDNIOWOMAZOWIECKIE HILLS: Łódź, Las Łagiewnicki forest complex, rest stop/parking lot, lawn, 21 Oct. 2007, *leg. M. Ruszkiewicz-Michalska* (LOD 3118 PF); on *Podosphaera tridactyla* (Wallr.) de Bary [on *Padus serotina* (Ehrh.) Borkh.]: KOTLINA OŚWIĘCIMSKA BASIN: Wola village near Pszczyna, edge of coniferous forest (*Molinio-Pinetum*), 11 June 2007, *leg. A. Myszka* (LOD 2825 PF); WZNIESIENIA POŁUDNIOWOMAZOWIECKIE HILLS: Łódź, Las Łagiewnicki Reserve, deciduous forest (*Potentillo albae-Quercetum*), 19 Aug. 2007, *leg. K. Brózio* (LOD 3119 PF); deciduous forest (*Tilio-Carpinetum calamagrostietosum*), roadside, 8 Sept. 2007, *leg. K. Brózio* (LOD 3120 PF); same locality and collector, 30 Sept. 2007 (LOD 3121 PF); Las Łagiewnicki forest complex, deciduous forest (*Tilio-Carpinetum*), roadside, 30 Sept. 2007, *leg. A. Kuchnik* (LOD 3122 PF); same locality, deciduous forest (*Calamagrostio-Quercetum typicum*), roadside, 22 July 2007, *leg. A. Kuchnik* (LOD 3123 PF); on *Sphaerotheca balsaminae* (Wallr.) Kari (on *Impatiens noli-tangere* L.): KOTLINA OŚWIĘCIMSKA BASIN: Wola village near Pszczyna, edge of coniferous forest (*Molinio-Pinetum*), 11 July 2006, *leg. A. Myszka* (LOD 2777-2779 PF); on *Sphaerotheca fusca* (Fr.) Blumer [= *Podosphaera fusca* (Fr.) U. Braun & Shishkoff] (on *Solidago canadensis* L.): WZNIESIENIA POŁUDNIOWOMAZOWIECKIE HILLS: Łódź, Las Łagiewnicki forest complex, deciduous forest (*Calamagrostio-Quercetum typicum*), roadside, 28 July 2007, *leg. A. Kuchnik* (LOD 3124 PF); on *Sphaerotheca spiraeae* Sawada [= *Podosphaera filipendulae* (Z. Y. Zhao) T. Z. Liu & U. Braun] [on *Filipendula ulmaria* (L.) Maxim.]: WYŻYNA CZĘSTOCHOWSKA UPLAND, Parkowe Reserve near Złoty Potok, forest district no. 270, shaded thickets at Wiercica stream, 14 July 1998, *leg. M. Ruszkiewicz* (LOD 1799 PF).

Published reports of this species from Central Poland (Ruszkiewicz-Michalska & Michalski 2005; Ruszkiewicz-Michalska 2006) are based on the following specimens from LOD (PF): nos 784, 1227 (*Erysiphe cichoracearum*), no. 816 (*E. cruciferarum*), no. 392 (*E. galii* Blumer) [= *Neoerysiphe galii* (S. Blumer) U. Braun], no. 791 (*E. heraclei* DC.), no. 762 (*E. magnicellulata* U. Braun var. *magnicellulata*) [= *Golovinomyces magnicellulatus* (U. Braun) V. P. Heluta], no. 515 (*E. orontii* Castagne) [= *G. orontii* (Castagne) V. P. Heluta], nos 140, 141, 150, 151, 1317, 1785, 1797, 2553 (*E. sordida*), no. 1900 (*Microsphaera alphitoides* Griffon & Maubl. var. *alphitoides*) [= *Erysiphe alphitoides* (Griffon & Maubl.) U. Braun & S. Takam.], no. 803 [*M. berberidis* (DC.) Lév. var. *berberidis*] [= *E. berberidis* (DC.) U. Braun & S. Takam.], no. 676 [*Phyllactinia guttata* (Wallr.) Lév.], no. 780 [*Sawadaea bicornis* (Wallr.) Homma], nos 710, 2104 [*Sphaerotheca aphanis* (Wallr.) U. Braun var. *aphanis*] [= *Podosphaera aphanis* (Wallr.) U. Braun & S. Takam.], nos 896, 916, 1346 [*Sphaerotheca ferruginea* (Schltdl. *ex* Fr.) L. Junell] [= *P. ferruginea* (Schltdl. *ex* Fr.) U. Braun & S. Takam.], no. 1998 [*Sphaerotheca fusca* (Fr.) Blumer *emend*. U. Braun], nos 602, 620 (*Sphaerotheca spiraeae* Sawada).

HOST RANGE AND DISTRIBUTION. The name *A. quisqualis* is traditionally applied to all pycnidial intracellular hyperparasites of powdery mildews although more than 40 species are validly described in the genus in the older literature. *A. quisqualis s.l.* infects *ca* 66 species belonging to nine genera, including the rarely attacked *Blumeria graminis* (DC.) Speer, worldwide (Kiss 1998; Szentiványi & Kiss 2003). Linnemann (1968) reported also *A. quisqualis* as a parasite of Mucorales species. Recent studies on the taxonomy of the species revealed that it is an assemblage of several

distinct lineages rather than a single species (Kiss & Nakasone 1998; Szentiványi *et al.* 2005). Some groups of *A. quisqualis* isolates show differences in ITS rDNA and actine gene sequences reflecting their association with certain taxa of mycohosts (Szentiványi *et al.* 2005; Park *et al.* 2010).

According to Mułenko *et al.* (2008; erysiphacean nomenclature following Braun 1995) *A. quisqualis s.l.* commonly occurring in Poland was noted on species of *Erysiphe* (21 taxa), *Microsphaera* (6), *Oidium* (1), *Podosphaera* (2), *Sawadaea* (1), *Sphaerotheca* (10) and *Uncinula* (2). The only record of the parasite on *Phyllactinia* concerns *P. mali* (Duby) U. Braun (Czerniawska 2005). The list of Polish hosts of *A. quisqualis* is supplemented here with four new species: *Microsphaera berberidis*, *Phyllactinia guttata*, *Sphaerotheca balsaminae* and *S. spiraeae*. *Ampelomyces quisqualis* often accompanies alien expansive species of powdery mildews such as *Erysiphe elevata* (Burrill) U. Braun & S. Takam., *E. flexuosa* (Peck) U. Braun & S. Takam. and *E. platani* (Howe) U. Braun & S. Takam. (Pastirčáková 2007) and taxa newly spreading on a host [e.g., *Phyllactinia guttata* on *Padus serotina* (Ehrh.) Borkh.; Ruszkiewicz-Michalska & Michalski 2005].

NOTES. Some of the *Ampelomyces* species [*A. heraclei* (Dejeva) Rudakov, *A. humuli* (Fautrey) Rudakov and *A. quercinus* (Syd.) Rudakov] isolated from powdery mildews (*Microsphaera* and *Sphaerotheca*) and a downy mildew fungus [*Plasmopara viticola* (Berk. & M. A. Curtis) Berl. & De Toni] were recognized as closely related to *Phoma glomerata* (Corda) Wollenw. & Hochapfel (Kiss & Nakasone 1998; Sullivan & White 2000). One of those fast-growing *Ampelomyces* species (*A. quercinus*) was recently reallocated to *Phoma fungicola* Aveskamp, Gruyter & Verkley based on molecular studies (Aveskamp *et al.* 2010).

Phoma glomerata (Corda) Wollenweber & Hochapfel Fig. 3B

Z. ParasitKde **3**(5): 592. 1936.

SPECIMENS EXAMINED. POLAND. On *Phyllactinia fraxini* (DC.) Fuss (on *Fraxinus excelsior* L.): WZNIESIENIA POŁUDNIOWOMAZOWIECKIE HILLS: Łódź, by Jaracza Str., 12 Oct. 2008, *leg. M. Ruszkiewicz-Michalska* (LOD 3091 PF); same locality, host and collector, 10 Sept. 2010 (LOD 3128 PF).

HOST RANGE AND DISTRIBUTION. The species is reported from Poland as a parasite of powdery mildews for the first time although it is known to occur as a saprotroph on different substrates, including plant tissues (Mułenko *et al.* 2008). It is very likely that either *P. glomerata* or another fungicolous *Phoma* species on *Phyllactinia mali* was also observed by Czerniawska (2005) in Gorzów Wielkopolski (western Poland), as suggested by the notes on the size of spores produced by a parasite of *Phyllactinia* (Czerniawska 2005). The size range considerably exceeds values reported for *A. quisqualis* (Sutton 1998) and the range observed on other hosts in the study by Czerniawska (2005), but it is within the range reported for *P. glomerata* (Boerema *et al.* 2004). The presence of *P. glomerata* (probably in a combined infection with *Ampelomyces quisqualis*) on the mycelium of *P. mali* also seems to be confirmed by the photographs (Czerniawska 2005: Fig. 1a, d), which show globose pycnidia with a multi-layered wall resembling pycnidia of *Phoma.*

NOTES. *Phoma glomerata* is a cosmopolitan, ubiquitous species associated with a wide range of substrates, and a secondary invader, probably feeding on fungal saprotrophs and parasites of diseased tissues of plants (White & Morgan-Jones 1987; Sullivan & White 2000). *P. glomerata* is frequently confused with *Ampelomyces quisqualis* (Sullivan & White 2000), but the two species are distinguishable on the basis of pycnidial morphology (pycnidia sessile and formed mainly on the leaf surface vs. stipitate pycnidia formed mainly within the host's hyphae and conidiophores). These two species also differ by their growth rates in culture: average growth on PDA for *P. glomerata* isolates is 8±1 mm/day and for *A. quisqualis* it is 0.8±0.1 mm/day (Sullivan & White 2000). Occasionally the conidia of *P. glomerata* are 1-septate (White & Morgan-Jones 1987), as observed in a single pycnidium in one of the specimens mentioned above (LOD 3091 PF). Additionally, in culture *P. glomerata* produces generally multicellular

alternarioid dictyochlamydospores formed in branched or unbranched chains of 2–20 elements (Boerema *et al.* 2004).

Sphaerellopsis filum (de Bivona-Bernardi) B. Sutton

Mycol. Pap. **141**: 196. 1977.

SPECIMENS EXAMINED. POLAND. On telia of *Puccinia chaerophylli* Purton [on *Torilis japonica* (Houtt.) DC.]: WZNIESIENIA POŁUDNIOWOMAZOWIECKIE HILLS: Łódź city, Las Łagiewnicki forest complex, deciduous forest (*Tilio-Carpinetum calamagrostietosum*), roadside, 25 Aug. 2007, *leg. A. Kuchnik* (LOD 3125 PF); on uredinia of *Puccinia menthae* Pers. (on *Mentha citrata* Ehrh. subsp. *citrata*): WZNIESIENIA POŁUDNIOWOMAZOWIECKIE HILLS: Łódź, Botanical Garden, section of healing plants and plants grown for industrial purposes, 29 Sept. 2002, *leg. M. Siennicka* (LOD 2286 PF); on telia of *Puccinia punctata* Link [on *Galium odoratum* (L.) Scop.]: WZNIESIENIA POŁUDNIOWOMAZOWIECKIE HILLS: Łódź, Las Łagiewnicki forest complex, deciduous forest (*Tilio-Carpinetum typicum*), roadside, 30 Sept. 2007, *leg. A. Kuchnik* (LOD 3126 PF); same host and locality, 21 Oct. 2007, *leg. M. Ruszkiewicz-Michalska* (LOD 3127 PF).

Published reports of this species from Central Poland (Ruszkiewicz-Michalska 2006) are based on the following specimens from LOD (PF): no. 960 (uredinia and telia of *Puccinia asperulae-cynanchicae* Wurth), no. 1174 (telia of *P. behenis* G. H. Otth), no. 409 (telia of *P. calcitrapae* DC.), no. 393 [telia of *P. maculosa* (Str.) Rohl.], nos 982, 1003 (uredinia of *P. obscura* Schroet.), nos 1007, 1008 (uredinia of *P. poae-nemoralis* G. H. Otth), nos 395, 999, 1000 (uredinia of *P. punctata* Link), nos 978, 981, 983, 1004–1006 (telia of *P. violae* DC.), no. 959 (telia of *Uromyces anthyllidis* Schroet.), no. 1960 [telia of *U. fallens* (Arth.) Kern *ex* Barthol.], nos 422, 432 (telia of *U. striatus* Schroet.).

HOST RANGE AND DISTRIBUTION. This most common parasite of uredinial and occasionally of aecial and telial sori of rust fungi was reported on 369 species belonging to 30 genera worldwide (after Płachecka 2005). In Poland it has been observed in uredinia and telia of members of seven genera: *Chrysomyxa* Unger (1 species), *Coleosporium* (1), *Cumminsiella* Arthur (1), *Melampsora* Castagne (6), *Phragmidium* Link (1), *Puccinia* (36) and *Uromyces* (9) (Nowak & Majewski 2005; Mułenko *et al.* 2008). Recently, *S. filum* was also reported to destroy aeciospores of *Puccinia caricina* and *P. dioicae* Magnus parasitizing *Carex* sp. (Adamska *et al.* 2010). However, these records are doubtful, as on that host genus both *Puccinia* species form uredinial and telial stages exclusively (Majewski 1979). The present paper lists one new host species for *S. filum*, namely *Puccinia chaerophylli.*

Specimens reported as *Darluca dianthi* (Alb. & Schwein.) Migula on *Puccinia arenariae* (Schumach.) G. Wint. and *Darluca genistalis* (Fr.) Sacc. var. *hypocreoides* Fuckel on *Melampsora epitea* Thüm. and *Melampsora* sp. probably also belong to *S. filum s.l.* (Mułenko *et al.* 2008).

NOTES. Although *S. filum* has been assumed to be a nonspecific rust hyperparasite, molecular studies revealed genetic diversity within the species, suggesting that it either comprises more than one species or shows host specialization (Liesebach & Zaspel 2004; Nischwitz *et al.* 2005; Bayon *et al.* 2006). Some studies based on ITS sequence data indicate that *S. filum* and *Ampelomyces quisqualis*, both placed among the pleosporalean genera, evolved from a common ancestor (Nischwitz *et al.* 2005).

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