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Cristulariella depraedans as causal agent of leaf spots of a maple and other trees and shrubs

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Results of the first studies in Poland on *Cristulariella depraedans*, the causal agent of necroses on tree and shrub leaves, are presented. The fungus was recorded on *Acer platanoides, A. pseudoplatanus* and eight other species of trees and shrubs, including *Corylus avellana, Fagus sylvatica, Lonicera xylosteum* and *Padus avium* that were not previously known as hosts of the fungus. The disease symptoms, which depend on the host plant species, the size and number of necrotic lesions on leaves, and the morphological features of the fungal propagules were characterized.

Key words: *Cristulariella depraedans*, *Acer* spp., leaf spots, host range

INTRODUCTION

Many and various symptoms with abiotic and biotic causes occur on leaves of maple trees, *Acer platanoides* L. and *A. pseudoplatanus* L. Only some of them are easily recognizable.These include symptoms caused by fungi, e.g. *Rhytisma acerinum* (Pers.) Fr. and *R. punctatum* (Pers.) Fr. (Butin 1996; Mańka 2005) or by gall-forming insects and mites, e.g. *Harrisomyia vitrina* (Kieffer) and *Eriophyes pseudoplatani* Corti (Skrzypczyńska 2004). The joint action of fungi and gall-forming insects in the development of necroses can make the diagnosis of their causal agents difficult. Kowalski (2003) recorded 18 species of fungi within the necrotic areas accompanying the galls caused by *Drisina glutinosa* Giard. The most significant were *Colletotrichum gloeosporioides* (Penz.) Sacc., *Diplodina acerina* (Pass.) Sutton, *Discula campestris* (Pass.) Arx and *Phomopsis platanoidis* Died. Similar associations were reported by Wulf (1990), who found 12 species of fungi on leaves of *A. pseudoplatanus* within the necrotic tissues of galls caused by *Dasineura vitrina* Kieffer. A great variety of fungi can infect maple leaves and recognition of symptoms and signs caused by individual potential causal agents is necessary.

Studies on diseases of forest trees in the south of Poland led to the identification of *Cristulariella depraedans* (Cooke) Hoehn., a fungus that occurred commonly on maple leaves in a few locations. Since the species has not been recorded in Poland previously, the objective of this study was to present an analysis of symptoms and signs of infection by the pathogen on maple tree leaves. The symptoms on leaves of the other species of trees and shrubs growing in proximity to the infected maples were also analysed to indicate the pathogen's hosts range.

MATERIALS AND METHODS

The study was carried out in 1996-2006, in four localities in the south of Poland (Tab. 1). The majority of observations were made in Ojców National Park, where the trees and shrubs along a route that included the Łokietek Cave, Ojców centre, Prądnik valley, the Kraków Gate and again the Łokietek Cave were surveyed and analysed. From July to October, 1-3 times a year, 30 to 60 leaves with different disease symptoms were collected from 30 trees, mostly self-sown, of *Acer pseudoplatanus* and *A. platanoides*. Samples were either from young trees or from the lower parts of the crowns of older trees. On each occasion, 3-6 diseased leaves from each of 20 other species of trees and shrubs growing in the surrounding area were also collected and assessed (Tab. 2). Their grouping according to the type of symptoms and the presence of sporulation of *C. depraedans* was made in the laboratory. The number and size of necrotic lesions caused by *C. depraedans* on 165 maple leaves collected at random from severely affected trees were evaluated. The sizes of similar lesions on leaves of the other species of trees and shrubs and the pigmentation of the necrotic tissues in the centres of the lesions and at their borders with the living leaf tissues were also determined.

The propagules formed by *C. depraedans* were examined microscopically and a macro- and microphotographic record was made of the symptoms and signs of infection by *C. depraedans*. The nomenclature of host plants is given after Mirek et al. (2002).

RESULTS

Cristulariella depraedans was recorded in four localities in the south of Poland (Tab. 1). It was common in Ojców and Tatra National Parks and Wolski Forest (Tab. 3) but occurred only sporadically in Świerklaniec Forest District. In Ojców National Park, most infection was recorded in 1996-1998, when more than 80% of trees growing along the route surveyed had local necrotic lesions caused by *C. depraedans* on their leaves. In a few young maple trees, up to 1 m high, all leaves in the crowns were infected (Fig. 1).

In Tatra National Park, Świerklaniec Forest District and Wolski Forest, *C. depraedans* occurred only on leaves of *A. pseudoplatanus*, and in Ojców National Forest it occurred on both species of *Acer* and on eight species of other trees and shrubs, viz. *Carpinus betulus, Cornus sanguinea, Corylus avellana, Fagus sylvatica, Lonicera xylosteum, Padus avium, Quercus robur* and *Tilia cordata*. There were no symptoms of infection by *C. depraedans* on a further 12 species of trees and shrubs growing in the area surrounding the infected maples (Tab. 2).

Table 1
Locations and periods of study and plant species examined
(E, examined; N, no symptoms and not examined)

Area studied	Period of studies	Number of observations in a year	Species of plants studied		
			Acer platanoides	*Acer pseudoplatanus*	Other species of tress and shrubs
Ojców National Park	1996-2002, 2006	2 - 3	E	E	E
Tatra National Park	1999-2002, 2005	1	N	E	E
Świerklaniec Forest District	1999-2002, 2006	1 - 2	N	E	E
Wolski Forest	2001-2002	1	N	E	E

List of species is given in Table 2

Some differences were observed in the symptoms caused by *C. depraedans* on *A. pseudoplatanus* and *A. platanoides*, and on other plant species.

Up to 438 necrotic lesions per leaf, with lesion diameters up to 22 mm, occurred on *A. pseudoplatanus* (Tabs 2, 3). Single lesions were almost round, greyish-white in the centre and dark grey at the edge (Tab. 2; Figs 1, 2).

Table 2
Presence, size and appearance of lesions caused by *Cristulariella depraedans*
on different trees and shrubs

Species of plant	Size of necrotic spots (mm)	Colour of centre	Colour of edge
A. Plants with *Cristulariella depraedans*			
Acer platanoides L.	1-33	light grey to light brown	dark grey to dark brown
Acer pseudoplatanus L.	1-22	greyish-white	dark grey
Carpinus betulus L.	1-3	grey to light brown	dark grey brownish-grey
Cornus sanguinea L.	1-3	grey	violet
Corylus avellana L.	1-3	light brown	greyish-brown
Fagus sylvatica L.	1-2	grey	grey or greyish-green
Lonicera xylosteum L.	1-5	whitish-grey	dark grey
Padus avium Mill.	1-3	whitish-grey	greyish-brown or greyish-green sometimes with a purplish tint
Quercus robur L.	1-6	light beige	light brown
Tilia cordata Mill.	1-2	light grey	dark grey
B. Plants with no *Cristulariella depraedans*			
Aesculus hipocastanum L.		*Salix fragilis* L.	
Alnus glutinosa (L.) Gaertn.		*Sambucus nigra* L.	
Betula pendula Roth.		*Sorbus aucuparia* L.	
Fraxinus excelsior L.		*Spiraea salicifolia* L.	
Populus tremula L.		*Symphoricarpos albus* (L.) S.F. Blake	
Quercus rubra L.		*Ulmus glabra* Huds.	

Germinating *C. depreadans* propagules were often seen within the initial and smallest lesions. Disintegration of the necrotic tissues caused irregular perforations between the leaf veins in a few of the more advanced lesions. Single, adjacent lesions sometimes merged and the severely infected leaves rolled up, died and were shed prematurely, often as early as August. Up to 338 local lesions per leaf occurred on *A. platanoides* (Tab. 3). Small lesions were 2–5 mm in diameter and larger lesions reached up to 33 mm in diameter (Tab. 3, Fig. 3). The lesions were light grey to light brown in the centre and dark grey to dark brown at the edge. As on leaves of *A. pseudoplatanus*, germinating propagules of *C. depraedans* were often seen within the initial and smallest lesions (Fig. 4). Lesions caused by *C. depraedans* on leaves of *A. pseudoplatanus* at Ojców National Park were larger than those recorded at the same time at Tatra National Park (Tab. 3).

Table 3
Numbers and size ranges of lesions caused by *Cristulariella depraedans* on leaves of *Acer platanoides* and *A. pseudoplatanus* at different periods of study

Studied area	Period of studies	Number of leaves	Summary number of necroses with diam (mm) (minimal and maximal number on a leaf)		
			< 5	6-10	> 10
Acer platanoides					
Ojców National Park	VIII.1997	10	706	63	73
			(2-308)	(2-16)	(2-14)
Ojców National Park	VIII.2000	10	710	146	30
			(32-113)	(8-26)	(1-6)
Ojców National Park	VIII.2001	10	340	52	46
			(4-91)	(0-11)	(1-9)
Acer pseudoplatanus					
Ojców National Park	VIII.1997	30	4435	122	11
			(12-373)	(0-25)	(0-6)
Ojców National Park	VIII.2000	30	5863	423	12
			(18-399)	(1-37)	(0-2)
Ojców National Park	VIII.2001	30	4501	172	14
			(42-321)	(1-14)	(0-3)
Tatra National Park	VIII.2000	15	557	0	0
			(9-107)	(0-0)	(0-0)
Tatra National Park	VIII.2002	15	1721	46	2
			(0-219)	(0-11)	(0-1)
Wolski Forest	X.2001	15	442	155	57
			(3-104)	(4 29)	(0-8)

Leaves of other species of plants were infected by *C. depraedans* to different extents. The largest numbers of necrotic lesions per leaf were recorded on *Cornus sanguinea* (up to 582) and on *Quercus robur* (up to 286) (Figs 7, 9). Lesions diameters were between 1 and 6 mm (Tab. 2). The necrotic tissues showed more or less distinctive differences in pigmentation of the central and peripheral parts in all the species of plants studied (Tab. 2). The near-violet pigmentation of the lesion edges on leaves of *Cornus sanguinea* and greyish-green pigmentation on leaves of *Padus avium* and *Fagus sylvatica* were the most characteristic (Tab. 2, Fig. 9). Differences in pigmentation of these tissues were not species-specific. A similar range of pigmentation was observed during these studies on leaves of *C. sanguinea* infected by *Septoria cornicola* Desm., of *P. avium* infected by *Stigmina carpophila* (Lev.) M.B. Ellis, and on a few leaves of *F. sylvatica* in the necrotic tissue surrounding galls caused by *Mikiola fagi* (Hartig) and inhabited by *Apiognomonia errabunda* (Rob.) Hoehn.

The whitish propagules of *C. depraedans*, which were clearly discernible against the greyish background of the lesions, were observed in the necrotic areas on the undersides of leaves and sometimes also on the upper surface of the leaf blades (Fig. 5). Propagules were bulb-shaped, round, slightly flatten or slightly elongated 60 – 140 μm in diameter, mounted on a septate, hyaline stipe, 120 – 180 μm long and 10 – 15 μm wide (Fig. 6). The bulb, which consisted of many single, round cells, 6 – 9 μm in diameter, was readily separated from the stipe.

DISSCUSION

The fungus *Cristulariella depraedans* has been known since the end of 19th century, when it was described as *Polyactis depraedans* Cooke (Cooke 1885). It is not a commonly occurring species. It has been recorded previously only in the United Kingdom, Germany, Austria and the USA (Cooke 1885; Saccardo 1908; Sydow 1912; Bowen 1930; Batko 1974; Butin 1981a; Cech, Donaubauer 1990; Wulf 1994). The present studies show that it also occurs in the south of Poland, where it was first recorded in Ojców National Park. Its occurrence in abundance was associated mainly with heavy rainfall in the growing season of 1996-1997 (Feliksik et al. 2002; Saramak 2005). The significance of wet conditions for the development of the fungus was also noticed and emphasized by Bowen (1930), Butin (1981b), Cech and Donaubauer (1990), Wulf (1994) and Lang (2000). Favorable moisture conditions can be also found on the leaves of susceptible young trees regenerated naturally and growing under the canopy of older stands. In Ojców and Tatra National Parks, favourable moisture conditions occur in the numerous depressions and valleys.

For more than 100 years the host range of *C. depraedans* has been known to include various species of *Acer*, *Bucida buceras* L. and *Aruncus dioicus* (Walt.) Fern. (Redhead 1975; Lang 2000). Only recently studies in Germany in 1996-1999 showed that *C. depraedans* has a much broader potential host range than known previously. Lang (2000) reported its occurrence on 21 woody and herbaceous plants other than *Acer* species**.** The present studies also confirmed that the host range of *C. depraedans* is not limited to plants within genus of *Acer*. In Ojców National Park, the fungus was observed on eight other species of plants growing in the areas around the infected *A. platanoides* and *A. pseudoplatanus*. Four of them, *Corylus avellana*, *Fagus*

sylvatica, *Lonicera xylosteum* and *Padus avium*, are new additions to the host range of *C. depraedans*.

Lang (2000) showed that the size and pigmentation of necrotic lesions and their edges, next to the living leaf tissues, depend on the species of host plant and are related to differences in their susceptibility. Lesions were different in size on leaves of *A. pseudoplatanus*, *A. platanoides* and the other plant species studied. This undoubtedly resulted from the interval of time between infection and observation. It should be mentioned that propagules formed within lesions were transferred to other leaves and to other parts of the leaf that had the primary infection, and caused secondary infections at different times in the same growing season. Occasionally, germinating fungal propagules were observed on the initial necroses, with diameters not exceeding 1 mm, in the second half of the growing season. Despite the differences in lesion sizes resulting from the period of infection, effects of host plant on the lesion dimensions were also observed. The larger lesions on leaves of *A. platanoides* seem to suggest that it is more susceptible than *A. pseudoplatanus*.

The propagules of *C. depraedans* found in Poland did not differ morphologically from those found in other countries (Redhead 1975; Willetts 1997; Butin 1981b; Wulf 1994). Their presence is essential for the identification of *C. depraedans* because the lesions are not specific and are very similar to those caused by other fungi or insects and mites causing galls (Kowalski 2003; Skrzypczyńska 2004).

The present studies confirm that, on the plants examined, there was no co-occurrence of a related species, *Cristulariella moricola* (Hino) Redhead (syn. *C. pyramidalis* Waterman & Marshall), which has propagules that are of different shape (Redhead 1975; Trolinger et al. 1978).

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Cristulariella depreadens jako sprawca plamistości liści klonów oraz innych drzew i krzewów

Streszczenie

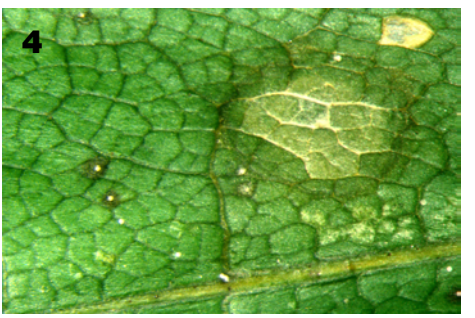
Badania prowadzono w okresie 1996-2006 na terenie Ojcowskiego PN, Tatrzańskiego PN, Nadl. Świerklaniec i w Lesie Wolskim koło Krakowa (Tab. 1). W okresie od lipca do października, z 30 powstałych zwykle w wyniku samosiewu młodych drzew oraz dolnych partii koron drzew starszych *Acer pseudoplatanus* i *A. platanoides* pobierano 1 – 3-krotnie 30 do 60 liści wykazujących różne objawy chorobowe oraz po 3 do 6 liści z objawami chorobowymi dwudziestu innych gatunków drzew i krzewów rosnących w sąsiedztwie badanych klonów (Tab. 2). W laboratorium dokonywano analizy nekroz i oznak etiologicznych *C. depraedans*.

C. depraedans stwierdzony został we wszystkich czterech rejonach, gdzie pobierano materiał do badań, przy czym na terenie Nadleśnictwa Świerklaniec *C. depraedans* występował tylko sporadycznie. Na terenie Tatrzańskiego PN, Nadl. Świerklaniec i w Lesie Wolskim *C. depraedans* stwierdzono tylko na liściach *Acer pseudoplatanus*, natomiast w Ojcowskim PN na obu badanych gatunkach klonów oraz na 8 innych gatunkach drzew i krzewów: *Carpinus betulus, Cornus sanguinea, Corylus avellana, Fagus sylvatica, Lonicera xylosteum, Padus avium, Quercus robur* i *Tilia cordata*. Na 12 innych gatunkach drzew i krzewów rosnących w sąsiedztwie porażonych klonów nie stwierdzono objawów porażenia przez *C. depraedans* (Tab. 2).

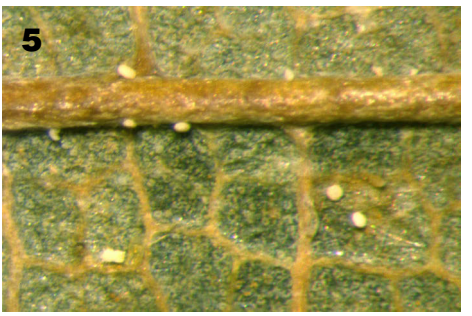
Występowały pewne różnice w objawach porażenia zarówno pomiędzy *A. pseudoplatanus* i *A. platanoides,* jak i pomiędzy pozostałymi gatunkami roślin. Na jednym liściu *A. pseudoplatanus* występowało od 9 do 438 nekroz. Osiągały one do 22 mm średnicy (Tab. 3). Pojedyncze nekrotyczne plamy były prawie okrągłe, w części środkowej szarobiałe, w części przyobwodowej ciemnoszare (Tab. 2; Figs 1, 2). Na jednym liściu *A. platanoides* występowało do 338 lokalnych nekroz (Tab. 3). Oprócz nekroz małych 1 do 5 mm średnicy, obecne były nekrozy do 33 mm średnicy (Tab. 3; Fig. 3). Nekrotyczne plamy miały barwę jasnoszarą do jasnobrunatnej w części centralnej, oraz ciemnoszarą lub brunatnoszarą w strefie graniczącej z tkankami żywymi. Liście pozostałych gatunków roślin porażone były przez *C. depraedans* w różnym stopniu. Najwięcej nekrotycznych plam stwierdzono na liściach *Cornus sanguinea* i *Quercus robur*, odpowiednio do 582 i do 286 plam (Figs 7, 9). Średnica nekrotycznych plam u roślin spoza rodzaju *Acer* wahała się w granicach od 1 do 6 mm (Tab. 3). U wszystkich gatunków roślin

nekrotyczne tkanki wykazywały mniej lub bardziej wyraźne różnice w zabarwieniu pomiędzy częścią środkową i przyobwodową (Tab. 3).

Propagule miały postać kulistej lub lekko spłaszczonej względnie nieco wydłużonej, wielokomórkowej główki o średnicy 60 do 140 μm osadzonej na septowanym, hyalinowym trzonku o długości 120–180 μm i grubości 10–15 μm.



Figs 1-4. 1. A young sycamore (*A. pseudoplatanus*) with symptoms of infection by *C. depraedans* on all leaves in the crown; 2. A leaf of *A. pseudoplatanus* with numerous necrotic spots caused by *C. depraedans*; 3. A leaf of *A. platanoides* with numerous necrotic spots caused by *C. depraedans*; 4. A leaf of *A. platanoides* with the local lesions of different size resulting from different infection times by *C. depraedans*.



Figs 5-9. 5. Propagules of *C. depraedans* on the underside of a leaf lesion on *A. platanoides*; 6. Propagulas of *C. depraedans* (magnified); 7. Leaves of *Quercus robur* with symptoms of infection by *C. depraedans*; 8. Leaf developed on sprout of *Carpinus betulus* with symptoms of infection by *C. depraedans*; 9. Leaf of *Cornus sanguinea* with symptoms of infection by *C. depraedans*.