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SARCODONTIA CROCEA (POLYPORALES, BASIDIOMYCOTA) IN POLAND – DISTRIBUTION AND DECAY ABILITY IN LABORATORY CONDITIONS*

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Abstract. The distribution of *Sarcodontia crocea* (Schwein.) Kotl. in Poland is presented based on literature data and 20 new localities. The wood decay ability of an isolate from the Polish population of the fungus was determined in laboratory conditions and tested in seven tree species (*Acer platanoides*, *Fagus sylvatica*, *Fraxinus excelsior*, *Malus domestica*, *Pinus sylvestris*, *Pyrus communis*, *Quercus robur*). New threat categories adapted to IUCN recommendations are proposed.

Key words: *Sarcodontia crocea*, fungi, ecology, distribution, Poland, wood decay

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INTRODUCTION

Sarcodontia crocea (Schwein.) Kotl. is a widespread but infrequent species in the north Temperate Zone, and is not often recorded. It is known from Europe, North America and Asia (Breitenbach & Kränzlin 1986). *Sarcodontia crocea* parasitizes deciduous trees and can develop saprotrophically temporarily after their death. It causes white rot. The fungus usually colonizes fruit trees, mostly apple *Malus* spp., also *M. sylvestris* Mill. (Kotlaba 1953; Wojewoda 1973; Stalpers 1978, 1998; Eriksson *et al.* 1981; Breitenbach & Kränzlin 1986; Kreisel 1987; Domański 1992; Dudka *et al*. 2004; Hagara *et al.* 2004; Safonov 2006), rarely pear *Pyrus* spp. (Schröter 1889; Neuhoff 1933), and representatives of the genus *Prunus* (Eriksson *et al.* 1981; Domański 1992). It has also been reported from *Sorbus aria* (L.) Crantz, *S. domestica* L., *Fraxinus excelsior* (Bourdot & Galzin 1928), *Acer* spp. (Eriksson *et al.* 1981; Hagara *et al.* 2004), *Quercus ilex* L. (Venturella *et al.* 2006) and *Photinia serrulata* Lindl. (Dudka *et al*. 2004).

In Poland it is known from *Malus* and *Pyrus*. It was recorded on *Pyrus* only by German mycologists in the late 19th century (Schröter 1889) and early 20th century (Neuhoff 1933).

Sarcodontia crocea was earlier described as a dangerous parasite of apple orchards (Pilát 1926; Orłoś 1951; Kotlaba 1953), less and less frequent at present. It is red-listed in countries including the Czech Republic (Holec & Beran 2006), Denmark (Anonymous 2010), Estonia (Lilleleht 1998), Finland (Rassi *et al.* 2001), Germany (Benkert *et al.* 1992), the Netherlands (Arnolds & Veerkamp 2008), Poland (Wojewoda & Ławrynowicz 1986, 1992, 2006), Sweden (Gärdenfors 2005), Switzerland (Senn-Irlet *et al.* 2007) and the United Kingdom (Legon & Henrici 2005). It is also red-listed as a European threatened species (Ing 1993).

MATERIAL AND METHODS

The current distribution of *S. crocea* in Poland is described and mapped using literature data and unpublished information I collected. Descriptions of macro- and microcharacters are based exclusively on the collected material deposited in the Fungarium of the Division of Mycology and Forest Phytopathology of the

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

Table 1. Description of sampled trees.

Tree species	Forest District	Habitat	Age (years)	DBH (cm)
Acer platanoides	Henryków	alder forest	80	40
Fagus sylvatica	Wejherowo	fresh mixed/broadleaved forest	110	30
Fraxinus excelsior	Henryków	fresh broadleaved forest	100	55
Malus domestica	Ciechanów	orchard	*ca* 25	20
Pinus sylvestris	Henryków	fresh mixed/broadleaved forest	70	40
Pyrus communis	Ciechanów	garden	*ca* 25	27
Quercus robur	Krotoszyn	fresh broadleaved forest	147	43

Warsaw University of Life Sciences – SGGW (WAML). Spores and other elements of dried basidiomes were examined and measured in 5% KOH, cotton blue and Melzer's reagent, using a Nikon Eclipse 400 microscope. Plant names follow Mirek *et al*. (2002) and Erhardt *et al.* (2009). The names of geographic regions in the list of Polish localities follow Kondracki (2002).

Source of culture and wood. The isolate was obtained from a basidiome collected from a live *Malus domestica* (WAML 85). Sound wood used in the experiment was representative of seven tree species: *Acer platanoides* L., *Fagus sylvatica* L., *Fraxinus excelsior* L., *Malus domestica* Borkh., *Pinus sylvestris* L., *Pyrus communis* L. and *Quercus robur* L. (Table 1).

Decay tests. Research procedures followed the PN-EN 350-1 standard (Anonymous 2000a). Wood blocks (1.5 × 2.5 × 5.0 cm) were made from logs cut out at 0.5 m and 2 m from the base of the tree. Wood of *Quercus robur*, *Pinus sylvestris*, *Fraxinus excelsior*, *Malus domestica* and *Pyrus communis* as well as heartwood blocks had been seasoned for a few years. Blocks of wood of *Fagus sylvatica* and *Acer platanoides* were obtained from square timber cut at the half-way point along the radius of a log cross-section. The blocks were weighed to an accuracy of 0.001 g. Each species was represented by 6–10 blocks in the decay test. To determine absolute dry mass, three additional blocks of each species were used and dried to constant mass at 103±2°C before weighing. The mean moisture content of the blocks was calculated to determine absolute dry mass, the theoretical dry mass of each block being determined prior to the decay test. The blocks were not dried artificially but were sterilized twice in an autoclave at 121°C under 0.12 MPa for 20 and 10 minutes, with an interval of 24 h between the two sterilizations. Sterilized wood blocks were wetted with distilled water for over 1 h. Two blocks were placed in Kolle flasks on 35 ml of malt extract agar (MEA; 20 g/l malt extract, Difco, Sparks, MD, USA; 15 g/l agar, Difco) with growing three-week cultures of *S. crocea*. They were taken out after 16 weeks of incubation at 22°C (Fig. 1), cleaned of surface mycelium, weighed, dried preliminarily, and dried at 103±2°C to constant mass before being weighed again. The loss of dry mass and moisture content of the blocks was calculated after the decay test.

Density of the tested wood. The density of each wood block was determined stereometrically (Krzysik 1978).

Description of specimens and localities

Sarcodontia crocea (Schwein.) Kotl. Fig. 2

Česká Mykologie **7**(3): 117. 1953.

Basidiomes annual, occurring in summer and autumn, at sites of injury, under bark, in tree hollows, on trunks and thicker branches of old trees. Basidiome fully resupinate, nodulose-pulvinate, attached tightly to substrate, from a few cm^2 to over 1 m^2, hymenial surface densely covered with crowded and sharp aculei (up to 17 mm long, up to 1.0 mm in diameter), first sulphureous, later darkening, wine-red, ocher-brown to rust-brown. Context up to 30 mm thick, yellow, granular, venate, consistency ceraceous. Odor characteristic, very intense, sweetish-fruity, resembling pineapple or amyl alcohol. Hyphal system monomitic, subhymenial hyphae thin-walled, subicular hyphae thick-walled, 2.5–5.0 μm wide, with clamps. Sclerocysts in the trama. Basidia clavate 20–35 × 4–6 μm, with a basal clamp. Basidiospores subglobose, drop-shaped, smooth, hyaline, with thickened walls, with drops, 4.5–6.5 × 3.5–5.0 μm, inamyloid, indextrinoid and acyanophilous.

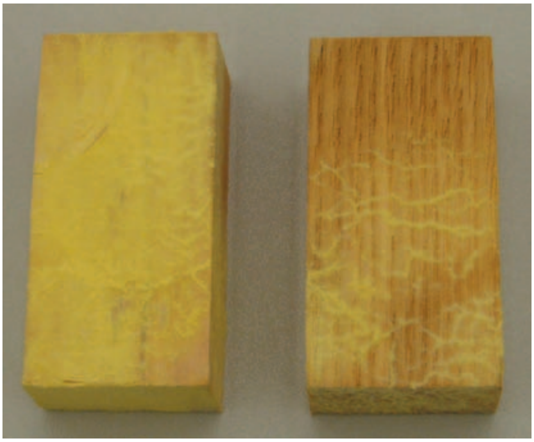

Fig. 1. Wood blocks covered with sulphureous mycelium of *Sarcodontia crocea* (Schwein.) Kotl. after the decay test. Photo A. Szczepkowski.

NEW LOCALITIES. NIZINA PÓŁNOCNOMAZOWIECKA LOWLAND: Opinogóra near Ciechanów, in old orchard, on branch of living *M. domestica* (in association with *Tyromyces fissilis*), 24 Aug. 2006, 19 July 2009, *leg. A. Szczepkowski* (WAML 251); Ciechanów, Mławska Street at roadside, on trunks and branches of two dying and dead *M. domestica*, 19 July 2009, 24 July 2010, 8 Aug. 2010, *leg. A. Szczepkowski* (WAML 539, WAML 540). NIZINA ŚRODKOWOMAZOWIECKA LOWLAND: Kampinos National Park, abandoned Narty village, on trunk and branch of living *M. domestica*, 27 Apr. 2007, 10 Sept. 2009, *leg. A. Szczepkowski* (WAML 527); Warsaw Służew, Dolina Służewiecka Street, on trunk of living *M. domestica*, 1 Sept. 2006, 23 Aug. 2008, 20 Aug. 2010, *leg. A. Szczepkowski* (WAML 189); Warsaw Służew, Fosa Street at streetside, on branch of dying *M. domestica*, 21 July 2009, 19 Aug. 2010, *leg. A. Szczepkowski* (WAML 542); Warsaw Ursynów, campus of the Warsaw University of Life Sciences – SGGW, on branch of living *M. domestica* (in association with *Hohenbuehelia fluxilis*), 10 Oct. 2007, 8 July 2010 *leg. A. Szczepkowski* (WAML 543); Warsaw Siekierki, Polska Street, remnants of old orchard, in wound on trunk of living *M. domestica*, 24 Aug. 2008, *leg. A. Szczepkowski* (WAML 403); Warsaw Siekierki, Antoniewska Street, old orchard, on branch of living *M. domestica* (in association with *Coriolopsis trogii*), 30 Aug. 2008 & 31 Aug. 2010 *leg. A. Szczepkowski* (WAML 404); near Celestynów, betwen Regut and Lasek villages, on yellow hiking trail, old orchard, on branch of living *M. domestica*, 28 Aug. 2005, *leg. A. Szczepkowski* (WAML 85); Krze Duże near Radziejowice, old orchard, on branch of living *M. domestica*, 2 Aug. 2010, *leg. A. Szczepkowski* (WAML 541); Skierniewice Forest District, near Uroczysko Bażantarnia Reserve, abandoned forester's lodge, remnants of old orchard, on branch of living *M. domestica*, 27 Oct. 2007, *vid. A. Szczepkowski*. WZNIESIENIA POŁUDNIOWOMAZOWIECKIE HEIGHTS: Gutkowice near Rawa Mazowiecka, old garden, on branch of living *M. domestica*, 9 Oct. 2009, *leg. A. Szczepkowski* (WAML 508). BRAMA KRAKOWSKA GATE: Kraków, Botanical Garden, on trunk of *Malus*?, Jan. 1933, *leg.*, *det. W. Zabłocka* (WU 031782, as *Acia*), Kraków-Nowa Huta, Ptaszyckiego Street (near Hutnik Stadium), on dying *M. domestica*, 6 Sept. 2010, *leg. M. Piątek* (KRAM F-48680), Kraków-Nowa Huta, between Bulwarowa and Wańkowicza Streets, on two dying *M. domestica*, 1 Oct. 2010, *leg. M. Piątek* (KRAM F-48681).

POGÓRZE ŚRODKOWOBESKIDZKIE FOOTHILLS: Tuchów, near church, alt. 240 m, on trunk of living *M. domestica*, 7 July 1995, *leg. M. Piątek* (KRAM F-39447); Ryglice near Galia Górna farmstead, *ca* 2 km S of Ryglice center, alt. 240 m, on trunk of living *M. domestica*, 8 Aug. 2000, *leg. M. Piątek* (KRAM F-50294). NIZINA POŁUDNIOWOPODLASKA LOWLAND: Sarnaki, 3-Maja Street, old orchard, on trunk and branch of living *M. domestica*, 9 Aug. 2006, *leg. A. Szczepkowski* (WAML 183). EASTERN BESKIDY MTS: Western Bieszczady Mts, abandoned Łopienka village, alt. 560 m, group of fruit trees, on branch of living *M. domestica* (in association with *Phellinus alni*), 18 Aug. 2009, *leg.*

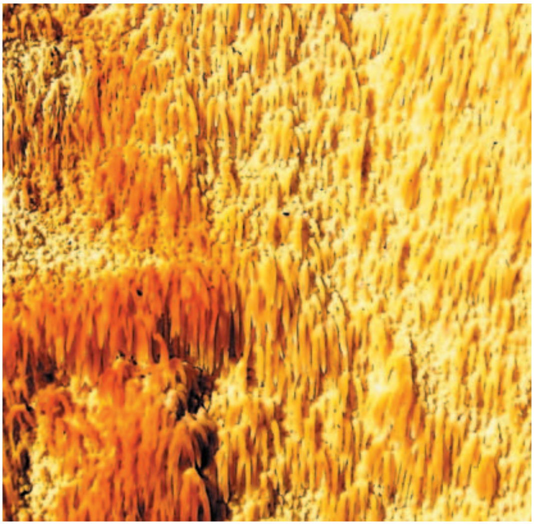

Fig. 2. Basidiome of *Sarcodontia crocea* (Schwein.) Kotl. on trunk of old apple tree in Ciechanów. Photo A. Szczepkowski.

A. Szczepkowski (WAML 525); Bieszczady National Park, abandoned Dźwiniacz village, alt. 645 m, old orchard, on trunk of living *M. domestica*, 21 Aug. 2009, *leg. A. Szczepkowski* (WAML 526).

LITERATURE DATA. POBRZEŻE SZCZECIŃSKIE LITTORAL REGION: Chlebowo, old orchard, on trunk of *M. domestica* (Kujawa & Gierczyk 2011). NIZINA ŚLĄSKO-ŁUŻYCKA LOWLAND: Dobrzejów near Legnica; Lipce near Legnica (Schröter 1889; Skirgiełło 1972; Wojewoda 1973, 2003). CENTRAL SUDETES MTS: Dzierżoniów (Schröter 1889; Skirgiełło 1972; Wojewoda 1973, 2003). NIZINA ŚLĄSKA LOWLAND: Wrocław, Botanical Garden, on *Pyrus* (as *Pirus pollveria*) (Schröter 1889); Niemodlin; Otmęt (Schröter 1889; Skirgiełło 1972; Wojewoda 1973, 2003). POBRZEŻE GDAŃSKIE LITTORAL REGION: Elbląg, on *Pyrus* sp. (as 'Birnbaum') (Neuhoff 1933; Wojewoda 1973, 2003). WYŻYNA ŚLĄSKA UPLAND: Imielin near Jaworzno, on trunk and branches of living *M. domestica* (Sokół 1997; Wojewoda 2003). WYŻYNA KRAKOWSKO-CZĘSTOCHOWSKA UPLAND: Ojców National Park, Ojców, orchard, on living and dead trunks of *M. domestica* (Wojewoda 1973, 2003, 2008); Alwernia (Wojewoda 2003). BRAMA KRAKOWSKA GATE: Kraków, garden of Jagiellonian University, on trunk of *M. domestica* (Zabłocka 1936; Skirgiełło 1972; Wojewoda 1973, 2003); Kraków, Mazowiecka Street (Wojewoda 1991, 1996, 2003); Kraków-Bieżanów (Wojewoda 1991, 1996, 2003). KOTLINA SANDOMIERSKA BASIN: Wieliczka, near a church, on *Malus* (Wojewoda 1973, 2003); Tarnów, at streetside, in wound on trunk of living *M. domestica* (Piątek 1999). WESTERN BESKIDY MTS: Niedźwiedź, at roadside, on trunk of dying *Malus* (Wojewoda 1973, 2003); Beskid Sądecki Mts (Wojewoda 2003). OBNIŻENIE ORAWSKO-PODHALAŃSKIE DEPRESSION: Pieniny National Park, Krościenko (without host given) (Anonymous 1968; Skirgiełło 1972; Wojewoda 1973, 2003). NIZINA PÓŁNOCNOMAZOWIECKA LOWLAND: Chojnowo near Przasnysz, on *Malus* (Chełchowski 1888, 1898; Skirgiełło 1972; Wojewoda 1973, 2003). NIZINA ŚRODKOWOMAZOWIECKA LOWLAND: Warsaw Mokotów, Dendrological Park of Warsaw University of Life Sciences – SGGW, on branch of living *M. domestica* (Szczepkowski 2007). BESKIDY ŚRODKOWE MTS: Łosie near Gorlice, old orchard, on trunk of dying *M. domestica* (Wojewoda 1998, 2003); Magurski National Park, on *M. domestica* (Wojewoda 2003). WYŻYNA LUBELSKA UPLAND: Włostowice near Puławy, orchard, on branch of *M. domestica* (Jankowska 1928; Wojewoda 2003); Grabówka near Annopol, old orchard, on trunk of dying *M. domestica* (Flisińska & Sałata 1991; Wojewoda 2003; Flisińska 2004); Lublin, Al. Racławickie Street, park, in wound on trunk of deciduous tree (Flisińska 1996, 2004). EASTERN BESKIDY MTS: Western Bieszczady Mts, Zatwarnica, wild orchard, on trunk of dying *M. domestica* (Wojewoda 1973, 2003). POGÓRZE ŚRODKOWOBESKIDZKIE FOOTHILLS: Bolestraszyce near Przemyśl, arboretum, on trunk of *M. domestica* (Wojewoda 2002, 2003).

RESULTS OF WOOD DECAY TESTS

DENSITY OF THE TESTED WOOD. The density of wood samples ranged from 387 kg/m^3 (*P. sylvestris*) to 797 kg/m^3 (*F. sylvatica*). Mean wood density was between 505 kg/m^3 (*P. sylvestris*) and 763 kg/m^3 (*M. domestica*). Three species (*F. sylvatica*, *M. domestica*, *P. communis*) were heavy, with mean density over 700 kg/m^3; one species (*Q. robur*) was moderately heavy, with mean density over 600 kg/m^3; and three species (*A. platanoides*, *F. excelsior*, *P. sylvestris*) were moderately light, with mean density over 500 kg/m^3 (Table 2).

MOISTURE CONTENT OF WOOD BLOCKS AFTER DECAY TEST. The mean moisture content of the blocks after the decay test ranged between 38% (*F. sylvatica*) and 153% (*A. platanoides*). The maximum value (177%) at the end of the test was recorded for the wood of *A. platanoides*, and the minimum was 35% for *Fagus sylvatica* wood. The mean moisture content of the wood samples of the other tree species ranged between *ca* 60% and 90% (Table 3).

WEIGHT LOSS FROM TEST BLOCKS. The highest mean percentage loss of wood mass was 26.2% for *A. platanoides* and 24.4% for *F. sylvatica*. Wood decay was slightly less for *P. communis* (20.7%)

Table 2. Density of air-dried wood blocks used in decay tests.

Wood species	Wood density (kg/m^3)		
	Minimum	Mean	Maximum
Acer platanoides	548	561	576
Fagus sylvatica	718	751	797
Fraxinus excelsior	531	569	620
Malus domestica	743	763	777
Pinus sylvestris	387	505	590
Pyrus communis	690	722	750
Quercus robur	626	665	688

Table 3. Moisture content of wood blocks after decay tests.

Wood species	Moisture content of blocks (%)		
	Minimum	Mean	Maximum
Acer platanoides	132	153	177
Fagus sylvatica	35	38	43
Fraxinus excelsior	67	92	113
Malus domestica	80	89	103
Pinus sylvestris	42	72	136
Pyrus communis	74	90	111
Quercus robur	43	57	85

and *M. domestica* (18.8%). Decay ability was only slightly lower in wood of *F. excelsior* (4.1% mean loss of mass) and *Q. robur* (3.5%). Wood of *P. sylvestris* was not decayed, with less than 1% mean loss of mass (Table 4).

Discussion

Distribution of *Sarcodontia crocea* in Poland

Sarcodontia crocea is not often recorded in Poland. It was known from nine localities in 1972 (Skirgiełło 1972). Wojewoda (1973) reported 15 localities in 1973 and 23 localities in 2003 (Wojewoda 2003). Four more localities are given in the literature, in Tarnów (Piątek 1999), Lublin (Flisińska 1996, 2004), Warsaw (Szczepkowski 2007) and Chlebowo (Kujawa & Gierczyk 2011).

Twenty new Polish localities of *Sarcodontia crocea* have been recorded recently, five of which are in Warsaw. Several new localities have been recorded in central Poland, where the fungus was so far known from single site. Two new localities are in the Bieszczady Mts, including the highest locality of the species known at present in Poland (alt. 645 m), in Bieszczady National Park. One locality (Sarnaki) was recorded in Podlasie, where the fungus was not previously reported. Two further localities were recorded in the Sub-Carpathian region. One of the three new localities from Kraków was reported based on herbarium material in UW. The species occurred on *M. domestica* at the new localities. *S. crocea* basidiomes were accompanied by the following white-rot fungi: *Tyromyces fissilis* (Berk. & M. A. Curtis) Donk, *Phellinus alni* (Bondartsev) Parmasto, *Coriolopsis trogii* (Berkeley) Domański and *Hohenbuehelia fluxilis* (Fr.) P. D. Orton.

In total, 48 localities of *Sarcodontia crocea* in Poland have been reported so far, with six localities in Kraków and six in Warsaw. It has been recorded at 36 localities in the last 50 years, including four localities in Kraków and six in Warsaw. This corresponds to the number of trees known to be colonized by *S. crocea* at the time. The vast majority of localities (28) are in southern Poland. The localities in Lower Silesia and probably the locality in the Pobrzeże Gdańskie littoral region should be treated as historical, as they were described in the late 19th and early 20th centuries (Fig. 3).

The range of *Sarcodontia crocea* has expanded in Europe from the south northwards in the 20th century (Kreisel 2006). However, *S. crocea* has not been recorded in large-area regions in Poland (Wielkopolska, Kujawy, Góry Świętokrzyskie Mts, Central Pomerania, Masuria, Warmia). The absence of records may reflect a lack of interest in studying macrofungi growing on fruit trees and shrubs among Polish mycologists, a study by Piątek (1999) being

Table 4. Mass wood loss from samples exposed to *Sarcodontia crocea*.

Wood species	No. of samples	Corrected mass loss (%)	Mean
Acer platanoides	6	22.6; 23.3; 23.5; 28.4; 29.6; 29.7	26.2
Fagus sylvatica	10	19.7; 21.7; 22.4; 23.5; 24.5; 24.9; 25.2; 25.4; 25.6; 30.8	24.4
Fraxinus excelsior	6	2.6; 3.1; 3.5; 4.0; 5.0; 6.5	4.1
Malus domestica	6	14.5; 16.4; 18.2; 19.5; 19.9; 21.2	18.8
Pinus sylvestris	6	0.0; 0.0; 0.6; 1.0; 1.1; 2.0	0.8
Pyrus communis	6	15.4; 18.0;20.6; 20.7;23.2; 26.4	20.7
Quercus robur	10	0.7; 0.7; 2.2; 2.3; 2.8; 3.0; 5.2; 5.6; 6.0; 6.7	3.5

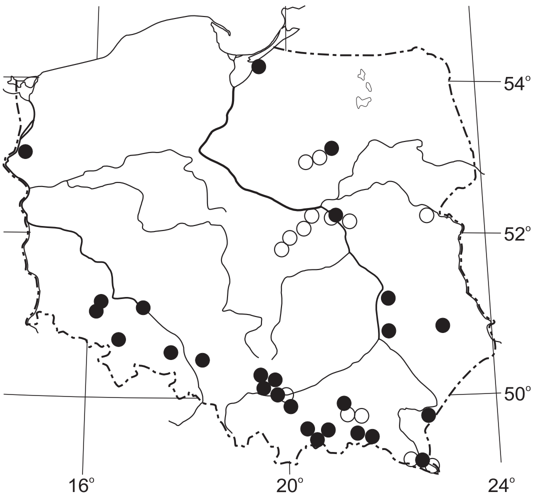

Fig. 3. Distribution of *Sarcodontia crocea* (Schwein.) Kotl. in Poland: ● – localities from literature, ○ – new localities.

an exception. Another part of the explanation is that traditional forms of fruit-tree cultivation are being replaced by modern pomological methods, old trees are disappearing, and habitats suitable for the development of *S. crocea* are in decline. Intensified field surveys of *S. crocea* on old fruit trees, especially apple trees in orchards, gardens, parks, streetside and roadside shelterbelts, may yield further records. Based on the new data, I propose threat category NT, adapted to IUCN criteria (Anonymous 2001, 2003, 2010), for the species.

Wood decay ability

Wood density is an important property that affects other properties, including wood's resistance to decay by fungi. The wood density values obtained in this study are consistent with the ranges given in other sources (Vorreiter 1949; Wagneführ & Schreiber 1974; Krzysik 1978; Anonymous 2000b; Godet 2008). Only the density of *F. excelsior* wood was lower than that reported in the literature. Fine-ringed wood was used in the test. The smaller contribution of summer wood recorded in it is a factor having a considerable effect on the density of ring-porous species such as *F. excelsior* (Kubiak & Laurow 1994), and most probably influenced the result.

The moisture content of the wood samples after the decay test was high and the experimental conditions were good. *S. crocea* exhibits considerable tolerance to the moisture level of decayed wood, depending on the species. High loss of wood mass was observed both in samples with the highest moisture (*A. platanoides*, 153%) and in samples with the lowest water content (*F. sylvatica*, 38%). The difference in moisture content is due to differences in the wood structure and properties of the two species. The lighter and more porous wood of *A. platanoides* has greater absorbability than *F. sylvatica* wood.

The considerable loss, over 24% on average, of beech wood mass (a control/comparison species in investigations of this type), shows that the *S. crocea* isolate has good decay abilities and is capable of effectively decaying diffuse-porous wood.

The isolate of *S. crocea* from a Polish population decayed the wood of six species of deciduous trees to different extents. Coniferous wood of *P. sylvestris* was almost completely resistant to decay by the fungus. Mass loss in pine wood did not exceed 2%, and was due to loss of volatile compounds in the resin and sap during the experiment, rather than decay of individual wood components. Wood decay by *S. crocea* may have been inhibited by the mechanical and chemical activity of resin in the pine wood samples.

The ability to decay deciduous species was greater for diffuse-porous wood (*A. platanoides*, *F. sylvatica*, *M. domestica*, *P. communis*) than for ring-porous wood (*Q. robur*, *F. excelsior*). Among the trees with diffuse-porous wood, mean mass loss was greater for sapwood species (*A. platanoides*, *F. sylvatica*) than for heartwood species (*M. domestica*, *P. communis*). On the one hand, heartwood, rich in phenol compounds that are toxic to some organisms including fungi, is known to be more resistant to biodegradation than sapwood (Krzysik 1978; Kubiak & Laurow 1994). On the other hand, *S. crocea* mainly parasitizes *Malus* spp., belonging to a heartwood genus. However, heartwood in *Malus* spp. is thought not to be resistant to fungi (Krzysik 1978). That low resistance may be due to its relatively low content of substances inhibiting the development of fungi in apple wood, and/or due to easier decomposition of these substances by fungi including *S. crocea*.

In vitro decay of wood by *S. crocea* was high both for trees known to be its hosts in nature and for beech, which has not been reported as its host. In laboratory studies aimed at protection of wood against fungi-caused destruction, *Trametes versicolor* (L.) Lloyd strains are used, which cause at least 25% loss of beech wood weight (Anonymous 1993). The mean mass loss of beech wood caused by *S. crocea* in the present study was 24.4%. In similar studies, beech wood decay caused by *Fomes fomentarius* (L.) J. J. Kickx, another white-rot fungus, ranged from *ca* 10% to almost 30% (Szczepkowski 2010a). The mean mass loss of beech and ash wood caused by *Ganoderma pfeifferi* Bres. in wood samples taken from the same tree species as used in this study was 20.5% and 4.2% respectively (Szczepkowski & Konsencjusz 2006), and the mean wood loss of oak wood caused by *Laetiporus sulphureus* (Bull.) Murrill, *Coniophora puteana* (Schumach.) P. Karsten and *T. versicolor* was 14%, 2.2% and 0.2% respectively (Szczepkowski 2010b).

Sarcodontia crocea was recently reported on *Fagus* in England (Legon & Henrici 2005) but this host is unverified. In laboratory conditions, however, some fungi decay well the wood of trees on which they do not occur in nature, such as *Piptoporus betulinus* associated exclusively with the genus *Betula* (Cartwright & Findlay 1958) or representatives of the genus *Ganoderma* (Adaskaveg & Gilbertson 1986; Szczepkowski & Konsencjusz 2006). The anatomical and chemical structure of maple and beech wood, in which toxic components do not occur (Krzysik 1978; Kubiak & Laurow 1994), makes them attractive to fungi including *S. crocea*.

Among the deciduous trees, wood of *Q. robur* and *F. excelsior* showed the greatest resistance to decay by *S. crocea*. Due to its high content of tanning agents, mostly tannins, oak is classified as a very durable species resistant to wood-decomposing fungi (Anonymous 2000b; Szczepkowski 2010b), although the occurrence of *S. crocea* was recorded on *Q. ilex* stumps in nature (Venturella *et al*. 2006). Wood of *Q. ilex* is denser than *Q. robur* wood (Vorreiter 1949) and usually has greater tannin content (Zenkteler & Woźniak 1966; Doat 1978). This makes it exceptionally resistant to biodegradation and also to decay by fungi (Bärner 1942; Hart & Hillis 1972; Blanchette & Biggs 1992; Aloui *et al.* 2004). The occurrence of *S. crocea* on *Q. ilex* in nature and its ability to decay wood of *Q. robur* observed in this study may suggest that *S. crocea* produces enzymes that disable phenol compounds.

The small mass loss recorded for *F. excelsior* wood samples may be due to its anatomical structure (heartwood species) and relatively high contribution of extractive substances reaching *ca* 5% (Prosiński 1984), rich in compounds inhibiting fungal development.

In nature, *S. crocea* usually colonizes apple trees. Although the properties of apple wood are very similar to those of pear wood (Wagenführ & Schreiber 1974; Surmiński 1990), the fungus is infrequently recorded on the latter, probably because many more apple trees than pear trees are cultivated in orchards. Pear trees undergo tree surgery and pruning much less than apple trees do, so they should be expected to have fewer cuts and *S. crocea* infections. Interestingly, more pear trees (7) than apple trees (2) grow at one of the localities in Warsaw. Basidiomes of *S. crocea* have been recorded only on one apple tree for the last few years there. Both the apple and pear trees there undergo tree surgery and pruning. If the fungus spreads mostly during branch cutting and not by spores as some authors suggest (Kotlaba 1953; Legon & Henrici 2005), basidiomes should be expected to occur on the pear trees as well, but this has not been observed at that locality. It is possible that spore germination in *S. crocea* requires some specific substances present in apple wood in quantities greater than in other tree species, predisposing *Malus* to be one of the main hosts of the fungus. Pear wood is also more durable than apple wood, whose heartwood is especially susceptible to decay by fungi (Krzysik 1978). The greater content of extractive substances in *P. communis* wood (3.7%) than in *M. domestica* wood (no data) (Fengel & Grosser 1975) and/or differences in the composition of antifungal substances in the wood of these two genera (Harborne 1967; Kokubun & Harborne 1995) may be implicated here. Greater resistance to *S. crocea* of pear wood than apple wood was not confirmed in laboratory conditions. Pear wood (mass loss 20.7%) was slightly more intensively decayed by *S. crocea* than apple wood was (mass loss 18.8%). Sound wood of *M. domestica* and *P. communis* at the age of full physiological maturity is difficult to obtain; wood of relatively young trees was used (*ca* 25 years). Both this and the resulting lack of fully developed heartwood in the two tree species may have had such an influence. The intensity of wood decay by *S. crocea* in laboratory conditions is not reported in the literature, precluding a comparative analysis of these results.

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REFERENCES

ADASKAVEG J. E. & GILBERTSON R. L. 1986. *In vitro* decay studies of delignification and simultaneous decay by the white rot fungi *Ganoderma lucidum* and *G. tsugae*. *Canad. J. Bot.* **64**: 1611–1619.

ALOUI F., AYADI N., CHARRIER F., CHARRIER B. 2004. Durability of European oak (*Quercus petraea* and *Quercus robur*) against white rot fungi (*Coriolus versicolor*): relations with phenol extractives. *Holz Roh- Werkstoff* **62**: 286–290.

ANONYMOUS 1968. Compte-rendu du IV-éme Congrés des Mycologues Européens Warszawa 1966. *Acta Mycol*. **4**(2): 181–198.

ANONYMOUS 1993. PN-EN 113. Wood preservatives. Determination of the toxic values against wood destroying Basidiomycetes cultured on an agar medium. Polski Komitet Normalizacji, Miar i Jakości, Warszawa (in Polish with English summary).

ANONYMOUS 2000a. PN-EN 350-1. Durability of wood and wood-based products – Natural durability of solid wood – Part 1. Guide to the principles of testing and classification of the natural durability of wood. Polski Komitet Normalizacji, Miar i Jakości, Warszawa (in Polish with English summary).

ANONYMOUS 2000b. PN-EN 350-2. Durability of wood and wood-based products – Natural durability of solid wood – Part 2. Guide to natural durability and treatability of selected species of importance in Europe. Polski Komitet Normalizacji, Miar i Jakości, Warszawa (in Polish with English summary).

ANONYMOUS 2001. IUCN Red List Categories and Criteria: Version 3.1. IUCN Species Survival Commission. IUCN, Gland, Switzerland and Cambridge, UK. http://www.iucnredlist.org/documents/redlist_cats_crit_en.pdf.

ANONYMOUS 2003. Guidelines for Application of IUCN Red List Criteria at Regional Levels: Version 3.0. IUCN Species Survival Commission. IUCN, Gland, Switzerland and Cambridge, UK. http://www.iucnredlist.org/documents/reg_guidelines_en.pdf.

ANONYMOUS 2010. IUCN Standards and Petitions Subcommittee. Guidelines for Using the IUCN Red List Categories and Cryteria. Version 8.0. http://www.iucnredlist.org/documents/RedListGuidelines.pdf.

ANONYMOUS 2010. Rødlistede svampearteri Danmark. Danish Mycological Society. http://130.225.211.158/mycosoc/roddatasearch.htm.

ARNOLDS E. & VEERKAMP M. 2008. Basisrapport Rode Lijst Paddenstoelen. Nederlandse Mycologische Vereniging, Utrecht.

BÄRNER J. 1942. Die Nutzhölzer der Welt. **1**. Verlag J. Neumann, Neudamm.

BENKERT D., DÖRFELT H., HARDTKE H.-J., HORSCH G., KREISEL H., KRIEGLSTEINER G. J., LÜDERITZ M., RUNGE A., SCHMID H., SCHMITT J. A., WINTERHOFF W., WÖLDECKE K, ZEHFUSS H.-D., EINHELLINGER A., GROSS G., GROSSE-BRAUCKMANN H., NUSS I. & WÖLFEL G. 1992. Rote Liste der gefährdeten Großpilze in Deutschland. Deutsche Gesellschaft für Mykologie e.V. Naturschutzbund Deuschland e.V. (NABU), Eching.

BLANCHETTE R. A. & BIGGS A. R. (eds) 1992. Defense mechanisms of woody plants against fungi. Springer-Verlag, Berlin.

BOURDOT H. & GALZIN A. 1928. *Hymenomycètes* de France. Marcel Bry, Sceaux.

BREITENBACH J. & KRÄNZLIN F. 1986. Fungi of Switzerland. **2**. Heterobasidiomycetes, Aphyllophorales, Gasteromycetes. Verlag Mykologia, Switzerland.

CARTWRIGHT K. S. G. & FINDLAY W. P. K. 1958. Decay of timber and its prevention. Her Majesty's Stationery Office, London.

CHEŁCHOWSKI S. 1888. Bazidial'nye griby okrestnostnej Varshavy. *Varsh. Univers. Izvestia* **2–5**: 1–112.

CHEŁCHOWSKI S. 1898. Grzyby podstawkozarodnikowe Królestwa Polskiego (Basidiomycetes Polonici). Część 1. Autobasidiomycetes. Podstawczaki. *Pamiętn. Fizjogr.* **15**(3): 32–85.

DOAT J. 1978. Tannins in tropical woods. *Bois Forêts Trop.* **182**: 37–54 (in France with English summary).

DOMAŃSKI S. 1992. Basidiomycetes (Podstawczaki), Aphyllophorales (Bezblaszkowce). **1**. Corticiaceae. 7. *Sarcodontia – Ypsilonidium*, *Christiansenia* & *Syzygospora*. Polska Akademia Nauk, Instytut Botaniki im. W. Szafera, Kraków.

DUDKA I. O., HELUTA V. P., TYKHONENKO Y. Y., ANDRIANOVA T. V., HAYOVA V. P., PRYDIUK M. P., DZHAGAN V. V. & ISIKOV V. P. 2004. Fungi of the Crimean Peninsula. M. G. Kholodny Institute of Botany, National Academy of Sciences of Ukraine, Kiev (in Ukrainian with English summary).

ERHARDT W., GÖTZ E., COOMBES A. J., BÖDEKER N. & SEYBOLD S. 2009. The Timber Press Dictionary of Plant Names. Timber Press, Portland London.

ERIKSSON J., HJORTSTAM K. & RYVARDEN L. 1981. The Corticiaceae of North Europe. *Phlebia – Sarcodontia*. **6**. Fungiflora, Oslo.

FENGEL D. & GROSSER D. 1975. Chemische Zusammensetzung von Nadel und Laubhölzern. *Holz Roh-Werkstoff* **33**: 32–34.

FLISIŃSKA Z. 1996. Studies on the macromycetes of Lublin. *Ann. Univ. Mariae Curie-Skłodowska, Sect. C, Biol.* **51**: 13–39 (in Polish with English summary).

FLISIŃSKA Z. 2004. Grzyby Lubelszczyzny. Wielkoowocnikowe podstawczaki (Basidiomycetes). **2**. Lubelskie Towarzystwo Naukowe, Lublin.

FLISIŃSKA Z. & SAŁATA B. 1991. The materials for the study of the macromycetes flora of a few regions of South-Eastern Poland. *Ann. Univ. Mariae Curie-Skłodowska, Sect. C, Biol.* **46**: 13–19 (in Polish with English summary).

GÄRDENFORS U. (ed.) 2005. The 2005 Red List of Swedish Species. ArtDatabanken, SLU, Uppsala.

GODET J. D. 2008. Atlas drewna. Multico, Warszawa.

HAGARA L., ANTONÍN V. & BAIER J. 2004. Houby. Ed. 6. Aventinum, Praha.

HARBORNE J. B. 1967. Comparative biochemistry of the flavonoids. Academic Press, London.

HART J. H. & HILLIS W. E. 1972. Inhibition of wood-rotting fungal by ellagitannins in the heartwood of *Quercus alba. Phytopathology* **62**: 620–626.

HOLEC J. & BERAN M. (eds) 2006. Red list of fungi (macromycetes) of the Czech Republic. *Příroda* (*Praha*) **24**: 1–282 (in Czech with English summary).

ING B. 1993. Towards a Red List of Endangered European Macrofungi. In: D. N. PEGLER, L. BODDY, B. ING & P. M. KIRK (eds), *Fungi of Europe*: *investigation, recording and conservation*, pp. 231–237. Royal Botanic Gardens, Kew.

JANKOWSKA K. 1928. Observations on the appearance of the diseases of cultivated plants in the district of Lublin during the years 1927 and 1928. *Mémoires de l'Institut National Polonais d'Économie Rurale á Puławy* **137**: 574–595 (in Polish with English summary).

KOKUBUN T. & HARBORNE J. B. 1995. Phytoalexin induction in the sapwood of plants of the Maloideae (Rosaceae): biphenyls or dibenzofurans. *Phytochemistry* **40**(6): 1649–1654.

KONDRACKI J. 2002. Geografia regionalna Polski. Państwowe Wydawnictwo Naukowe, Warszawa.

KOTLABA F. 1953. Nebezpečný parasit jabłoni – *Sarcodontia crocea* (Schweinitz) c. n. *Česka Mykol*. **7**(3): 117–123 (in Czech with English summary).

KREISEL H. (ed.) 1987. Pilzflora der Deutschen Demokratischen Republik. Basidiomycetes (Gallert-, Hut-, und Bauchpilze). VEB Gustav Fischer Verlag, Jena.

KREISEL H. 2006. Global warming and mycoflora in the Baltic Region. *Acta Mycol*. **41**(1): 79–94.

KRZYSIK F. 1978. Nauka o drewnie. Państwowe Wydawnictwo Naukowe, Warszawa.

KUBIAK M. & LAUROW Z. 1994. Surowiec drzewny. Fundacja Rozwój SGGW, Warszawa.

KUJAWA A. & GIERCZYK B. 2011. Register of protected and endangered fungi species. Part IV. A list of species recorded in 2008 year. *Przegląd Przyrodniczy* (in press) (in Polish with English summary).

LEGON N. W. & HENRICI A. (eds) 2005. Checklist of the British & Irish Basidiomycota. Kew Publishing, Kew.

LILLELEHT V. (ed.) 1998. Red Data Book of Estonia. Estonian Red List of Threatened Species. http://elurikkus.ut.ee/prmt.php?lang=eng&redgr_id=4&dangercat_id=3.

MIREK Z., PIĘKOŚ-MIRKOWA H., ZAJĄC A. & ZAJĄC M. 2002. Flowering plants and pteridophytes of Poland. A checklist. W. Szafer Institute of Botany, Polish Academy of Sciences, Kraków.

NEUHOFF W. 1933. Die Hymenomyceten Ostpreussens. Eine systematische Zusammenstellung. *Unser Ostland* **2**(7): 317–397.

ORŁOŚ H. 1951. Przewodnik do oznaczania chorób drzew i zgnilizny drewna. Państwowe Wydawnictwo Rolnicze i Leśne, Warszawa.

PIĄTEK M. 1999. Parasitic macrofungi (*Basidiomycetes*) on fruit shrubs and trees in the Tarnów town (S Poland). *Acta Mycol.* **34**(2): 329–344.

PILÁT A. 1926. *Dryodon setosum* (Pers.) Bourdot et Galzin – lošák štetinatý, nebezpečný škůdce jabloni. *Mykologia* **5–6**: 73–75.

PROSIŃSKI S. 1984. Chemia drewna. Państwowe Wydawnictwo Rolnicze i Leśne, Warszawa.

RASSI P., ALANEN A., KANERVA T. & MANNERKOSKI I. (eds) 2001. The 2000 Red List of Finnish species. Ministry of the Environment & Finnish Environment Institute, Helsinki.

SAFONOV M. A. 2006. Wood-inhabiting aphyllophoroid fungi of the Southern Preurals (Russia). *Mycena* **6**: 57–66.

SCHRÖTER J. 1889. Die Pilze Schlesiens. Erste Hälfte. In: F. COHN (ed.), *Kryptogamen-Flora von Schlesien*. **3**. Band. **1**. Hälfte. J. U. Kern's Verlag, Breslau.

SENN-IRLET B., BIERI G. & EGLI S. 2007. Rote Liste Grosspilze. Herausgegeben vom Bundesamt für Umwelt BAFU und der Eidgenössischen Forschungsanstalt für Wald, Schnee und Landschaft WSL, Bern.

SKIRGIEŁŁO A. 1972. Matériaux á la connaissance de la distribution géographique des champignons supérieurs en Europe. IV. *Acta Mycol*. **8**(2): 191–218 (in Polish with French summary).

SOKÓŁ S. 1997. *Sarcodontia crocea* (Schw.: Fr.) Kotl. in Oberschlesien. *Acta Biologica Silesiaca* **30**(47): 173–176.

STALPERS J. A. 1978. Identification of wood-inhabiting Aphyllophorales in pure culture. *Stud. Mycol.* **16**: 1–248.

STALPERS J. A. 1998. On the genera *Sarcodontia*, *Radulodon* and *Pseudolagarobasidium*. *Folia Cryptogamica Estonica* **33**: 133–138.

SURMIŃSKI J. 1990. Technical properties and possibilities of use of wood of forest fruit trees. In: S. BIAŁOBOK (ed.), *Dzikie drzewa owocowe*, pp. 451–459. PAN, Instytut Dendrologii & Arkadia, Poznań (in Polish with English summary).

SZCZEPKOWSKI A. 2007. Macromycetes in the Dendrological Park of the Warsaw Agricultural University. *Acta Mycol.* **42**(2): 179–186.

SZCZEPKOWSKI A. 2010a. Resistance of wood of European beech (*Fagus sylvatica* L.) trees representing various health conditions to decay caused by fungi. *Leśne Prace Badawcze* **71**(1): 29–38 (in Polish with English summary).

SZCZEPKOWSKI A. 2010b. Resistance to decay caused by fungi of common oak (*Quercus robur* L.) wood from trees of different health status. *Leśne Prace Badawcze* **71**(2): 125–133 (in Polish with English summary).

SZCZEPKOWSKI A. & KONSENCJUSZ M. 2006. The intensity of wood decay caused by *Ganoderma pfeifferi* Bres., and the influence of temperature on the growth of its mycelia in laboratory conditions. *Annals of Warsaw Agricultural University – SGGW, Forestry and Wood Technology* **60**: 65–73.

VENTURELLA G., BERNICCHIA A. & SAITTA A. 2006. Three rare lignicolous fungi from Sicily (S Italy). *Acta Mycol.* **41**(1): 95–98.

VORREITER L. 1949. Holztechnologisches Handbuch. Allgemeines, Holzkunde, Holzschutz und Holzvergütung. **1**. Verlag Georg Fromme & Co., Wien.

WAGENFÜHR R. & SCHREIBER C. 1974. Holzatlas. VEB Fachbuchverlag, Lipsk.

WOJEWODA W. 1973. *Sarcodontia setosa* (Pers.) Donk in Poland. *Fragm. Florist. Geobot.* **19**(4): 469–473 (in Polish with English summary).

WOJEWODA W. 1991. Changes in macrofungal flora of Cracow (S. Poland). *Veröff. Geobot. Inst. ETH, Stiftung Rübel, Zürich* **106**: 150–161.

WOJEWODA W. 1996. The fungi of Cracow city in the years 1883–1994 with particular interest in macrofungi. *Studia Ośrodka Dokumentacji Fizjograficznej PAN* **24**: 75–111 (in Polish with English summary).

WOJEWODA W. 1998. The macrofungi (Basidiomycotina) of the Beskid Niski Mts (the Polish Carpathians). *Studia Ośrodka Dokumentacji Fizjograficznej PAN* **25**: 295–334 (in Polish with English summary).

WOJEWODA W. 2002. Macrofungi of the Bolestraszyce Arboretum near Przemyśl (SE Poland). *Arboretum Bolestraszyce* **9**: 15–39 (in Polish with English summary).

WOJEWODA W. 2003. Checklist of Polish larger Basidiomycetes. W. Szafer Institute of Botany, Polish Academy of Sciences, Kraków.

WOJEWODA W. 2008. Macrofungi of the Ojców National Park. W: A. KLASA & J. PARTYKA (eds), *Monograph of the Ojców National Park. Nature*, pp. 317–334. Ojcowski Park Narodowy, Muzeum im. Prof. Władysława Szafera, Ojców (in Polish with English summary).

WOJEWODA W. & ŁAWRYNOWICZ M. 1986. Red list of threatened macrofungi in Poland. In: K. ZARZYCKI, W. WOJEWODA & Z. HEINRICH (eds), *List of threatened plants in Poland*, pp. 45–82. W. Szafer Institute of Botany, Polish Academy of Sciences, Kraków.

WOJEWODA W. & ŁAWRYNOWICZ M. 1992. Red list of threatened macrofungi in Poland. In: K. ZARZYCKI, W. WOJEWODA & Z. HEINRICH (eds), *List of threatened plants in Poland*, pp. 27–56. W. Szafer Institute of Botany, Polish Academy of Sciences, Kraków.

WOJEWODA W. & ŁAWRYNOWICZ M. 2006. Red list of the macrofungi in Poland. In: Z. MIREK, K. ZARZYCKI, W. WOJEWODA & Z. SZELĄG (eds), *Red list of plants and fungi in Poland*, pp. 53–70. W. Szafer Institute of Botany, Polish Academy of Sciences, Kraków.

ZABŁOCKA W. 1936. Kolczak jabłoniowy (*Acia setosa*) niebezpieczny pasożyt jabłoni. *Ogrodnictwo* **1**: 25–27.

ZENKTELER M. & WOŹNIAK H. 1966. Some incidental wood constituents in native tree species. *Sylwan* **5**: 45–54 (in Polsh with English summary).

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