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SQUAMANITA ODORATA (AGARICALES, BASIDIOMYCOTA), NEW MYCOPARASITIC FUNGUS FOR POLAND

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Abstract. The rare and interesting fungus *Squamanita odorata* (Cool) Imbach, a parasite on *Hebeloma* species, is reported for the first time from Poland, briefly described and illustrated based on Polish specimens. Its taxonomy, ecology and distribution are discussed.

Key words: *Coolia*, distribution, fungicolous fungi, mycoparasites, Poland, *Squamanita*

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Introduction

The genus *Squamanita* Imbach is one of the most enigmatic genera of the known fungi. All described species of the genus probably are biotrophs that parasitize and take over the basidiomata of other agaricoid fungi, including *Amanita* Pers., *Cystoderma* Fayod, *Galerina* Earle, *Hebeloma* (Fr.) P. Kumm., *Inocybe* (Fr.) Fr., *Kuehneromyces* Singer & A.H. Sm., *Phaeolepiota* Konrad & Maubl. and possibly *Mycena* (Pers.) Roussel. As a result the host is completely suppressed or only more or less recognizable, and the *Squamanita* basidioma is a fusion or chimera of its tissues and those of its host (Redhead *et al.* 1994; Bas & Læssøe 1999; Kibby 2009; Matheny & Griffith 2010; Bunyard 2011). Species of *Squamanita* are extremely rare and sporadic all over the world, and finding a *Squamanita* can be quite an adventure (Henrici 2005; Cervini *et al.* 2009; Matheny & Griffith 2010). The genus comprises at least twelve known species at present (Redhead *et al.* 1994; Bas & Thoen 1998; Bas & Læssøe 1999; Kirk *et al.* 2008), seven of which have been found in Europe (Redhead *et al.* 1994; Ludwig 2001). These numbers probably reflect the level of knowledge in Europe as compared to the rest of the world rather than the true picture of the distribution of *Squamanita* species.

In Poland only one species of the genus *Squamanita* has been recorded previously. *Squamanita paradoxa* (Smith & Singer) Bas, a parasite on *Cystoderma*, was reported by Z. Domański from one locality in the Lasy Łochowskie forest near Wyszków (valley of the Lower Bug River, E Poland) in September 1973 (Domański 1997; cf. Wojewoda 2003). This collection was made in a young forest of *Pinus sylvestris* L., where *S. paradoxa* was found growing on the ground, among grass, on the edge of the forest. Recently, another species, *Squamanita odorata* (Cool) Imbach, was found in northern Poland (Fig. 1). It is reported here as new for the country.

Material and methods

The description of basidioma morphology and ecological notes are based on original material. The macroscopic features were studied from fresh material of one collection comprising several basidiomata in different stages of development. Microcharacters were observed with a Nikon Eclipse E–400 light microscope fitted with a Nikon DS-Fi1 digital camera. All microscopic structures were observed from dried material. Freehand sections of rehydrated pieces of basidiomata were examined in 5% $NH_3 \cdot H_2O$ reagent with 1% Phloxine B. Image-grabbing and biometric analyses were done with NIS-Elements D 3.1 imaging software. Dimensions of microcharacters are given as (minimum) average ± standard deviation (maximum),

and additionally as main data range (10–90 percentile values). The Q value is the length/width ratio of basidiospores. For basidiospores, randomly selected mature spores were measured without the hilar appendix. The length of basidia was measured excluding sterigmata. Statistical computations employed Statistica (StatSoft). Morphological terminology follows Vellinga (1988) and Bas (1965). The studied collections are deposited in the Museum of Natural History, Wrocław University, Wrocław, Poland (WRSL).

Results and discussion

Squamanita odorata (Cool) Imbach Fig. 2

Mitt. naturf. Ges. Luzern **15**: 83. 1946 – *Lepiota odorata* Cool, Medded. Nedl. Mycol. Ver. **9**: 47–52. 1918 – *Coolia odorata* (Cool) Huijsman, Medded. Nedl. Mycol. Ver. **28**: 60. 1943 – *Tricholoma odoratum* (Cool) Konrad & Maubl., Encyclop. Mycol. **14**: 436. 1949.

Illustrations (selected): Kops *et al*. (1924: plate 2039a), Pearson (1952: plate 3, fig. 2), Bas (1965: 343, figs. 11–20), Stuntz and Isaacs (1967: 286, fig. 39), Læssøe (1985: 67, fig. 3), Gueny and Chiaffi (1994: 22, figs 1–8; 24, figs 1–6), Breitenbach and Kränzlin (1995: 223, fig. & photo 261), Ludwig (2000: 174, plate 172, fig. 81.4), Sutter and Klarer (2000: 60–63), Ludwig (2001: 657), Kasparek (2002: 68–69, photos), Roux (2006: 483), Leach (2013: 53, fig. 1, 54, fig. 3, back cover).

Basidiomata springing from tuber-like, galled tissue, forming clusters of 2–4 basidiomata (the association with *Hebeloma mesophaeum* was not observed). Pileus 5–20 mm, initially hemispherical, then convex to low-convex, not hygrophanous, dry, radially fibrillose, covered with slightly pointed, darker and flat or recurved scales (especially at margin) and flat obtuse-angular felted patches (especially in center), greyish violet to dark violet. Lamellae rather distant, L = 20–30, l = 1–2, broadly adnate, slightly paler than pileus, pale greyish violet, rather thick, with concolorous, entire edge. Stipe 8–15 × 2.0–3.5 mm, cylindrical or slightly widening below, dry, concolorous with pileus, minutely loosely longitudinally fibrillose, with 2–4 incomplete belts of more or less erect and recurved floccose-fibrillose, dark violaceous grey-brown scales (especially at base). Amorphous gall (transformed host tissue), 10–20 mm diam., pale brownish yellow. Context pale dingy violaceous to whitish in pileus and stipe, ochraceous buff in gall. Smell of basidioma fruity to nauseous (unpleasant). Taste not verified. Spore deposit not obtained.

Fig. 1. Known distribution of *Squamanita odorata* (Cool) Imbach in Poland.

Basidiospores (5.5–) 6.8 ± 0.5 (–8.3) × (4.1–) 5.1 ± 0.4 (–6.2) µm, 6.1–7.4 × 4.6–5.5 µm, Q = (1.1–) 1.3 ± 0.1 (–1.6), Q = 1.2–1.4 (n = 161), ellipsoid, broadly ellipsoid to ovoid, rarely obovoid and subreniform, thin-walled, colorless to slightly dingy in ammonia, smooth, with small hilar appendix, not reacting with Melzer's solution. Basidia (23.8–) 33.7 ± 4.2 (–40.9) × (5.7–) 7.5 ± 0.7 (–8.9) µm, 28.5–39.0 × 6.5–8.2 µm (n = 48), narrowly clavate, in majority 4–spored, but also with 2–3 sterigmata. Cheilocystidia and pleurocystidia not observed. Chlamydospores of irregular shape (7.6–) 11.4 ± 2.1 (–18.9) × (3.9–) 5.2 ± 0.6 (–6.6) µm, 8.9–13.7 × 4.5–6.0 µm (n = 118), arthrosporic or at times aleurosporic, produced by clamped hyphae, thin-walled to moderately thickened, colorless to yellowish in ammonia, smooth, not reacting with Melzer's solution, formed within an abortive host tissue. Pileipellis a trichoderm grading to a cutis, consisting of 6–16 µm wide and 25–55 µm long, violaceous grey to brownish grey hyphae. Pigment parietal and in places minutely encrusting.

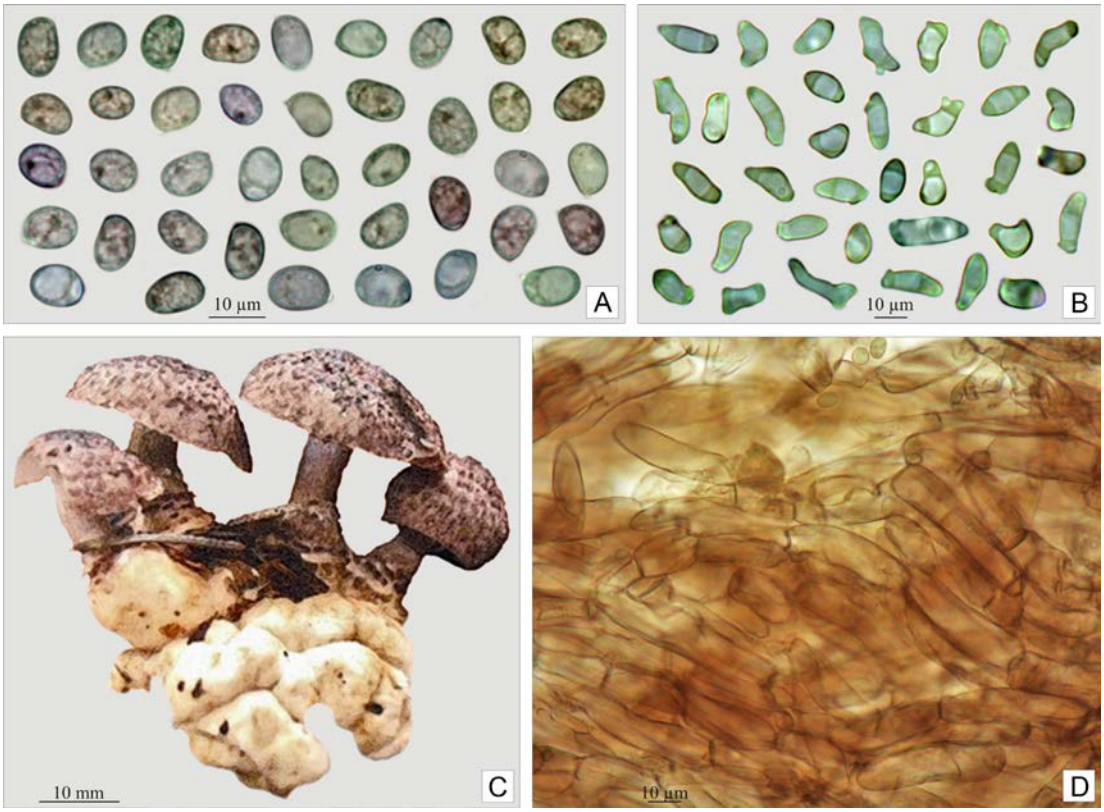

Fig. 2. *Squamanita odorata* (Cool) Imbach. A – basidiospores, B – chlamydospores, C – side view of basidiomata (photo courtesy of E. Fałtynowicz), D – hyphae of pileipellis (all from WRSL EF-2009-0001).

Clamp-connections abundant in pileipellis (also observed at base of basidia).

Specimens examined: POLAND, Kashubian Lake District: Zbychowo, Narcyzowa Street 11, sandy soil – among scattered coniferous litter, allotment with scattered *Pinus sylvestris* trees, alt. 132 m, 54°33′31″N, 18°18′41″E, 13 Oct. 2009, *leg. E. Fałtynowicz* (WRSL EF-2009-0001).

The macro- and microscopic features of the collected specimens of *Squamanita odorata* are characteristic of the species. Parameters such as basidioma size and color, basidiospore measurements and shape, and the remaining microcharacters match well the description and iconography of *S. odorata* given by other authors (e.g., Cool 1918; Bas 1965; Gueny & Chiaffi 1994; Breitenbach & Kränzlin 1995). However, the specimens from Poland differ slightly in chlamydospore size from other well-described ones. Both Bas (1965) in his description based on rich material (including type material) and Wasser (1993) describe somewhat smaller conidia (9–13 × 4.5–6.0 µm, 7–13 × 4.0–6.5 µm). These differences are not significant and probably should be considered within the variability of the species. Chlamydospores of *S. odorata* are formed by the mycelium in tuber-like, galled tissue (‘protocarpic tuber’, ‘cecidiocarp’) provoked by infection of the host basidiomata, and according to Redhead *et al.* (1994) are a developmental characteristic presumably to be noted as the transformed host ages or decays. This may be why chlamydospores were not reported by a number of authors in their collections (Münzmay 1990; Breitenbach & Kränzlin 1995; Sutter & Klarer 2000; Kasparek 2002). Bas (1965) and Redhead *et al.* (1994) reported the presence of ‘dingy’ basidiospores among more abundant hyaline ones

in *S. odorata*. This feature was also confirmed by observations on the basidiospores from the Polish collection of the species.

The most recent key to European species of *Squamanita* was published by Henrici (2013). A microscopic study does not seem to be needed to recognize *S. odorata* within the limits of the genus. This species is very well characterized by its strong and heavy, sweetish aromatic (aromatic-fruity) odor, recalling that of *Hebeloma sacchariolens* Quél., and by the conspicuous, ochraceous tuber-like gall from which comparatively small, short-stipitate, scaly and more or less violaceous basidiomata arise (often more than one from each tuber). *Squamanita paradoxa* and *S. pearsonii* Bas produce similar basidiomata, but they differ by the absence of a tuber-like gall (basidiomata springing from only somewhat inflated galled host tissue and usually singly) and their not so distinctive odor. In addition, both *S. pearsonii* and *S. paradoxa* produce dextrinoid basidiospores, though sometimes very weakly (Læssøe 2012; Henrici 2013).

Squamanita odorata grows on the strongly deformed and unrecognizable basidiomata of its host. The Polish collection is consistent with this characteristic as well. An unusual feature of the majority of recent Danish collections of *S. odorata* is that they were accompanied by *Hebeloma mesophaeum* (Pers.: Fr.) Quél (Vesterholt 1991). That circumstance (not recorded at the location in Zbychowo), together with the distinct raphanoid smell and taste of the basal bulb of the *S. odorata*, supported the reasonable suspicion of a parasitic relationship with this species (Vesterholt 1991). Suggestions of the possible biotrophic status of other *Squamanita* species were published even earlier (Reid 1983; Harmaja 1988; Nagasawa *et al.* 1990). Molecular studies by Mondiet *et al.* (2007) finally confirmed the prior suspicion and revealed *H. mesophaeum* as host of *S. odorata*. According to Henrici (2013), future collections on other *Hebeloma* species remain a possibility for this fungus.

Squamanita odorata occurs in a variety of habitats, including coniferous and broadleaved woodland, forest plantations, and wooded areas with mossy patches, sand dunes and urban spaces (parks, gardens), just as the presumed host occurs. The Polish site of *S. odorata* seems to confirm that this fungus is found mainly in anthropogenically disturbed and ruderal environments; an important share of its records are from sites along paved roads or paths on disturbed soil (e.g., Bas 1965, 1966; Daams 1966; Mondiet *et al.* 2007; Senn-Irlet *et al.* 2007; Læssøe 2012; Henrici 2013). The habitat preferences of *S. odorata* seem easy to explain: *H. mesophaeum* is well adapted to successional or disturbed environments, so the parasite is found at similar sites.

In Europe *S. odorata* has *ca* 60 known locations in Belgium, Denmark, Finland, France, Germany, Italy, Norway, Sweden, Switzerland and the Netherlands (e.g., Cool 1918; Lange 1953; Bas 1965, 1966; Daams 1966; Gulden *et al.* 1977; Glowinski & Gumbinger 1982; de Vries 1985; Læssøe 1985, 2012; Münzmay 1990; Krieglsteiner 1991; Vesterholt 1991; Chrispijn & Douwes 1993; Gueny & Chiaffi 1994; Stridvall & Stridvall 1994; Wanningen 1995; Walleyn 1998; Watling & Turnbull 1998; Sutter & Klarer 2000; Arnolds & Keizer 2001; Kasparek 2004; Onofri 2005; Walleyn *et al.* 2006; Courtecuisse & Duhem 2007; Senn-Irlet *et al.* 2007; Siepe & Kasparek 2009; Brandrud *et al.* 2010; Glaser 2010; Henrici 2013; Leach 2013; Kytöharju 2015). The finding in Poland extends the known distribution of the species to Eastern Europe. Most likely *S. odorata* is more widespread on the continent than records indicate. According to Wasser (1993), this species is expected to grow also in the Baltic States, CIS States and Ukraine (cf. Vishnevskiy 1998). Outside Europe *S. odorata* has been found in western North America (Stuntz & Isaacs 1967; Arora 1986; Redhead *et al.* 1994).

Squamanita odorata is considered threatened in several countries. It is on the red list of fungi in Denmark under category NT (near threatened), in Germany under category R (rarity; of latent threat), in Norway under category VU (vulnerable), in Switzerland under category CR (critically endangered), and in the Netherlands as endangered (BE) (Benkert *et al.* 1992; Senn-Irlet *et al.* 2007; Arnolds & Veerkamp 2008; Brandrud *et al.* 2010; Anonymous 2012).

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