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AT: mycological collections, identification of *Disciseda verrucosa* fruit bodies, writing the manuscript; JŁ: identification of *Disciseda verrucosa* fruit bodies, writing the manuscript; GM: verification of the correctness of the *Disciseda verrucosa* fruit bodies

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ORIGINAL RESEARCH PAPER

Disciseda verrucosa (Agaricomycetes, Basidiomycota) – a species new to Poland

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Abstract

The genus *Disciseda* in Poland until now was represented by two species: *Disciseda bovista* and *D. candida*. During the mycological investigations on the macromycetes fungi in the xerothermic grasslands of the Nida Basin, a species new for Poland from this genus, namely *Disciseda verrucosa*, was recorded. The basidiocarps of this species were found in the village Gacki (50°26'41" N, 20°36'34" E; ATPOL square Fe 24), in the village Wola Zagojska (50°26'41" N, 20°36'34" E; ATPOL square Fe 24), and in the Krzyżanowice Reserve (50°27'13" N 20°33'36" E; ATPOL square Fe 14), in the Ponidzie region. The basidiocarps of *D. verrucosa* were collected in the xerothermic grass, within *Festucetum pallentis* and *Sisymbrio-Stipetum capillatae* associations in the neighborhood of *Festuca pallens*, *Stipa capillata*, and *Thymus marschalianus*. On the basis of collected basidiocarps, macro- and microscopic characteristics were described and compared with other European *Disciseda* species. An identification key to the species of *Disciseda* occurring in Poland is given.

Keywords

Agaricomycetes; xerothermic fungi; Nida Basin

Introduction

The genus *Disciseda* is in the whole world represented by 15 species [1]. In Europe, about five species were found [2,3], whereas in Poland, *Discidea* is represented by two species: *D. bovista* (Klotzsch) P. Henn. and *D. candida* (Schwein.) C. G. Lloyd [4]. Both species in Poland belong to a highly endangered fungi, and classified to the category endangered – E [5].

Due to a rather characteristic basidiocarps, fungi from genus *Discidea* are relatively easy to identify. The taxonomy of species from this genus is based on the knowledge of individual features of macro- and micromorphological structure. Such features are: the shape, size and color of the endoperidium, color of the exoperidium, degree of exoperidium incrustation by the substrate particles, the shape and size of peristome, and also the spores size and episprium ornamentation [2,5].

In terms of habitat these fungi are thermophilous, often found on the dry, warm, sunny xerothermic and psammophilous sites. The mycelium and basidiocarps develop often in the open places with a southern exposure [2,5,6].

The aim of this paper is to increase the knowledge about the richness and distribution of *Disciseda* species in Poland.

Material and methods

The basidiocarps of *Disciseda verrucosa* were collected during the mycological investigations carried out in the xerothermic sites of the Nida Basin (SE Poland). The

investigations included the communities of xerothermic plants distributed in the areas legally protected, such as: the areas of Nature 2000 (the Nida refuge, PLH 260003), the nature reserves (the Skorocice and Krzyżanowice reserve), and the landscape parks (Nida, Szaniec, Kozubów).

The field studies included the cyclic mycological observations carried out on 30 research plots and supplemented by searching for fungi using the route method. Field studies were conducted in the village Gacki (50°26'41" N, 20°36'34" E; ATPOL square Fe 24), in the village Wola Zagojska (50°26'41" N, 20°36'34" E; ATPOL square Fe 24), and in the Krzyżanowice Reserve (50°27'13" N, 20°33'36" E; ATPOL square Fe 14), in the Ponidzie region. During the survey, the number of basidiocarps of given species and the organoleptic features such as: the shape, size, color of endoperidium, and color of exoperidium were taken into consideration. The laboratory studies were carried out using the light microscope, scanning electron microscope (SEM), and the standard chemical reagents (10% KOH, JKJ). The investigations using the light microscope (LM) included the measurements of capillitium and spores, which the structure, size, and shape have significant meaning for taxonomical species identification of this genus. The preparations were made from each collected basidiocarps. In each preparation, 10 randomly selected spores were measured. All the microscopic structures were carried out using the immersion lens. The investigations using the scanning electron microscope (SEM) were carried out in the Independent Department of Environment Protection and Modelling, Jan Kochanowski University in Kielce. The electron micrographs were taken at the magnifications: ×3000, ×5000, ×10 000, and ×12 000. Description of the basidiocarps was made on the basis of own specimens. The taxonomical identification of collected fungi fruit bodies was made based on the following works: Moravec [6], Rudnicka-Jeziarska [7], Pérez-Silva et al. [8], Bates et al. [9], and Lizárraga et al. [10]. The nomenclature of plants follows Mirek et al. [11].

The vouchers were deposited in the Fungarium (KTC), Faculty of the Mathematics and Science, Jan Kochanowski University in Kielce, Poland

Results

Disciseda verrucosa G. Cunn., Trans. & Proc. New Zealand Inst. 57: 205 (1926)

Syn. *Disciseda arida* Velenovský, Novit. Mycol. p. 169, 1939. – Moravec, Čas. čes. Houbařu 29: 15, 1952.

Description. *Disciseda verrucosa* produces the basidiocarps typical for the genus *Disciseda*. The basidiocarps globose to discoid, slightly flattened 10–15(–20) mm in diameter. Exoperidium whitish, strongly encrusted with the particles of substratum. Endoperidium smooth, gray-brown, rigid, leathery and permanent (Fig. 1). The endoperidium dehiscing by an mambose lacinate and toothed stoma about 1 mm diam. Gleba brown to dark brown. Subgleba absent. Spores globose 7.0(–8.0)–8.5 µm (measurement with warts), with short colorless sterigmata. Under LM, the spores have bright brown color and are from distinctly verrucose to delicately spiny. Under SEM, the ornamentation of these structures appears formed by thick verrucae 1.6 µm long (Fig. 1b–d). Capillitium septate, threads thick-walled, (up to 0.8 µm thick). Capillitium wavy, fragile (2.5–5.5 µm thick), with very small pores, the walls brightly brown (Fig. 1).

Specimens examined. POLAND. 1 – Nida Basin, Gacki village, 45 km south from Kielce (50°26'41" N, 20°36'34" E; ATPOL square Fe 24), two basidiocarps in xerothermic plant associations of *Festucetum pallentis*, September 2015; 2 – Nida Basin, Wola Zagojska village, 45 km south from Kielce (50°26'41" N, 20°36'34" E; ATPOL square Fe 24), two basidiocarps in xerothermic plant associations of *Festucetum pallentis*, October 2015; 3 – Nida Basin, Krzyżanowice Reserve (50°27'13" N, 20°33'36" E; ATPOL square Fe 14), in the vicinity of the Pińczów town in the Nida Basin, 48 km south from Kielce, one basidiocarp in xerothermic plant associations of *Sisymbrio-Stipetum capillatae*, September 2016.

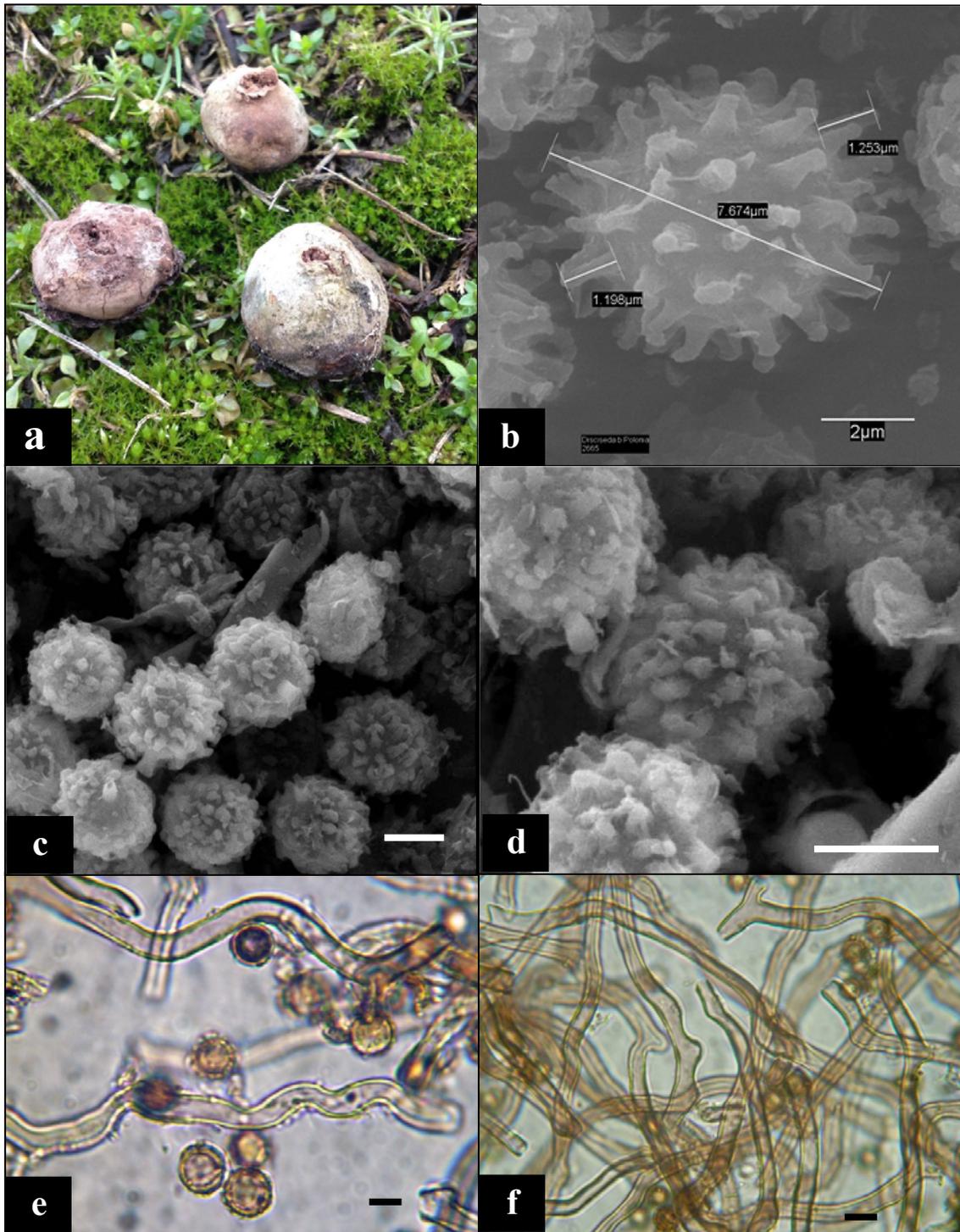


Fig. 1 *Disciseda verrucosa* – mature basidiocarps (photo by A. Tomaszewska) (a). *Disciseda verrucosa* – spores (SEM; scale bar: 2 μm ; photo by G. Moreno) (b). *Disciseda verrucosa* – spores (SEM; scale bar: 5 μm) (c). *Disciseda verrucosa* – spores (SEM; scale bar: 5 μm) (d). *Disciseda verrucosa* – capillitium with spores (LM; scale bar: 5 μm) (e). *Disciseda verrucosa* – capillitium (LM; scale bar: 5 μm) (f).

Five basidiocarps of *Disciseda verrucosa* were collected during the mycological investigations (Tab. 1). The basidiocarps of *D. verrucosa* were recorded in the village Gacki (50°26'41" N, 20°36'34" E; ATPOL square Fe 24), in the village Wola Zagojska (50°26'41" N, 20°36'34" E; ATPOL square Fe 24), and in the Krzyżanowice Reserve (50°27'13" N, 20°33'36" E; ATPOL square Fe 14), in the vicinity of the Pińczów town in the Nida Basin, 48 km south from Kielce (Fig. 2). The specimens were collected in the xerothermic grass, in the patches of *Festucetum pallentis* and *Sisymbrio-Stipetum capillatae*

Tab. 1 Comparison of structure features of *Disciseda* species recorded in Poland (according to: ⁽¹⁾ Moravec [6]; ⁽²⁾ Rudnicka-Jeziarska [7]; ⁽³⁾ Bates et al. [9]; ⁽⁴⁾ Lizárraga et al. [10]; ⁽⁶⁾ Dörfelt, Nowak [3]).

No.	Structure features	<i>Disciseda bovista</i>	<i>D. candida</i>	<i>D. nigra</i>	<i>D. hyalothrix</i>	<i>D. verrucosa</i>
1.	Exoperidium	White, whitish yellow, mature brown pale grey	Dirty whitish yellowish, mature from brownish to earth colored	Dark brownish	White, whitish yellow.	White, mature grey-orange
2.	Endoperidium	Rigid, pergamineous, color of hazel nut	Strong, leathery, pergamineous, brown-grey	Thin, papyraceous, blackish brown to black, very fine-grained	Thin, papyraceous, brownish gray to dark brown,	Permanent, leathery, color of “mouse”-grey brown
3.	Peristome	Frayed	Frayed, fimbriate	Irregularly round, sometimes blown radially	Frayed	Slightly frayed at edges
4.	Gleba	Red brown	Brightly brown, rusty brown	Blackish brown	Greyish brown or somewhat purplish	Brown-orange, brightly brown
5.	Spores	⁽¹⁾ (5–)6.5–7.8(–8.6) µm; ⁽²⁾ 5–6(–7.1) µm; (4)4–7 µm in diameter. Distinctly strongly verrucose (verrucae 1–1.5 µm).	⁽¹⁾ 3.0–4.2 µm; ⁽²⁾ 3.8–4.5–5 µm; ⁽³⁾ 4.0–5.6(–6.4) × 4.0–5.6(–6.4) µm; ⁽⁴⁾ 4–5 µm in diameter. Smooth or puncticulate, very fine verrucose.	⁽⁶⁾ 7.5–8.5 µm in diameter with ornamentation. Strongly verrucose, verrucae 1.8 µm.	⁽⁴⁾ 8–11 µm in diameter, with spines.	⁽¹⁾ 8.5–11.5 µm; ⁽³⁾ (8.0–)8.8–12.0(–12.8) × (8.0–)8.8–12.0(–12.8) µm; ⁽⁴⁾ 7–8(–8.5) µm in diameter. Strongly verrucose, verrucae 1.6 µm.
6.	Sterigmata	Present	Present	Very often the lack, if present, up to 1.5 µm long	Present	Short sterigma 0.8 µm long
7.	Capillitium	Wavy, fragile, 2.7–3.5 µm thick, without the pores	Wavy, fragile, 2.5 µm thick, without the pores	Wavy, fragile, 3.5–4.5 µm thick, without the pores	Little branched, fragmentable, 3–5 µm diam., without pores	Wavy, fragile, 2.4–5.6 µm thick, with small pores

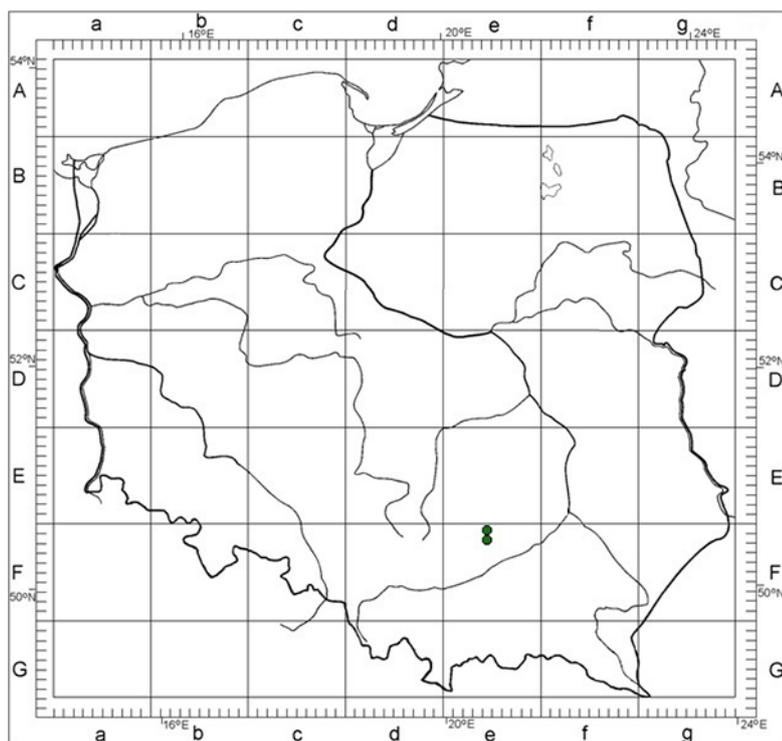


Fig. 2 Distribution of *Disciseda verrucosa* in Poland.

associations. The specimens were recorded on the slope with a southern exposure and 45° inclination angle. The phytocoenosis of *Festucetum pallentis* (location: Gacki village) of the investigated xerothermic plant association is as follow: cover of herb layer – 60%, size of the area – 80 m², *Allium montanum* 1.2, *Anthericum ramosum* +.2, *Anthyllis vulneraria* +, *Artemisia campestris* 1.2, *Calamintha acinos* +, *Carex humilis* 1.2, *Festuca pallens* 2.2, *Festuca sulcata* +.2, *Galium verum* +.2, *Gypsophila fastigiata* 2.2, *Koeleria glauca* +.2, *Potentilla arenaria* 2.2, *Sedum sexangulare* 2.2, *Silene otites* +, *Stipa capillata* +.2, *Thymus marschalianus* 2.2. The phytocoenosis of *Sisymbrio-Stipetum capillatae* (location: Krzyzanowice Reserve) of the investigated xerothermic plant association is as follow: cover of herb layer – 80%, size of the area – 100 m², *Stipa capillata* 4.4, *Artemisia campestris* 1.2, *Asperula cynanchica* +.2, *Astragalus dannicus* +.2, *Campanula sibirica* 1.1, *Carex humilis* 2.2, *Centaurea stoebe* +.2, *Euphorbia cyparissias* 1.2, *Festuca rupicola* 1.2, *Thymus marschalianus* 2.2.

Key for species identification of the genus *Disciseda* recorded in Poland

- 1 Spores delicately verrucose or smooth.....
Mature basidiocarps discoid. Endoperidium strong, matt, color from brown-grey to pale grey. Spores globose, 3.8–4.5 μm. Capillitium brightly yellow, hyaline, thick-walled, without the pores.
Disciseda candida (Schwein.) Lloyd
- 1* Spores thickly verrucose.....2
- 2 Spores 8.0–12.0(–12,8) × (8.0–)8.8–12.0(–12.8) μm in diameter.....
Basidiocarps globose, discoid, slightly flattened. Endoperidium grey-brown, rigid. Spores globose, distinctly thickly verrucose, with verrucae up to 1.6 μm long. Capillitium brightly yellow, hyaline, thick-walled, with small pores.
Disciseda verrucosa G. Cunn., Trans. & Proc. New Zealand Inst. 57: 205 (1926)
- 2* Spores with diameter 5–6.5–7.8(–8.6) μm.....
Fruitbodies globose, rarely flattened. Endoperidium with hazel nut color, pergameneous like, spores with verrucae 1–1.5 μm long. Capillitium brightly yellow, hyaline, rather thick-walled, without the pores.
Disciseda bovista (Klotzsch) Henn.

Discussion

During the taxonomical identification of collected *Disciseda verrucosa* basidiocarps, a large similarity of this species to *D. bovista* was observed. Some authors [8] also point out the possibility of misidentifying *D. verrucosa* with other species of this genus, in particular with *D. bovista*. The feature distinguishing *D. verrucosa* from *D. bovista* is, first of all, the size of spores. The differences between these species are also due to a different ornamentation of these structures. Strongly verrucose of episporium is a characteristic feature for *D. verrucosa*. Examination of the morphology of the spore ornamentation of *D. verrucosa* shows no considerable differences in spore structures of *D. verrucosa* and *D. hyalothrix*. However, the examined spores of *D. verrucosa* were smaller than *D.*

hyalothrix and had significantly smaller warts on the episporium surface [10]. *Disciseda verrucosa* and *D. nigra* have very similar spores in terms of size and ornamentation but both species differ very clearly in the color of the basidiocarps and gleba [3]. The list of macro- and micromorphological features of *Disciseda* species recorded in Poland is presented in Tab. 1. *Disciseda verrucosa* in Europe was up to now recorded in the Czech Republic and Slovakia [6], Spain [10], and recently also in Germany [12]. Outside of Europe, the species is known from: North America [8–10,13–18], Australia, New Zealand [19,20], South Africa [9,21], and South America [22–24]. *Disciseda verrucosa* is a thermophilous species. This species produces the mycelium and basidiocarps mostly in the open, sandy areas [6,9], but it was also found in the tropical deciduous forests under the plantings: *Ceiba* sp., *Cercidium microphyllum*, *Olneya* sp., *Juniperus* sp., *Pinus edulis*, and *Prosopis* sp. [8,9].

The following conclusions can be drawn from our studies:

- Xerothermic plant communities developing in the area of the Nida Basin are characterized by an extraordinary high richness of gasteroid fungi species from warmer climates. An example described in this work is *Disciseda verrucosa*, a species new to the Polish mycobiota.
- In the context of the obtained results, we suggest the need of the revision of the national herbarium collections of fungi of the genus *Disciseda*, including molecular taxonomic studies.
- The authors are expecting that further field studies will help to find the new localities of the others European species of *Disciseda* in Poland.

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