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Dedicated to Professor Maria Ławrynowicz on the occasion of the 45th anniversary of her scientific activity

New localities of *Protostropharia alcis* (Basidiomycota, Agaricales) in Poland

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The present paper provides new records of *Protostropharia alcis* in Poland. So far this species was known in the country only from several latest localities in the Biebrza National Park (Biebrza Basin) and the Kampinos National Park (Warsaw Basin). The new localities are situated in the Wigierski National Park (the East Sudetian Lake District) and in the north-western slope of Mt Wierzejska (the Holy Cross Mountains), where *P. alcis* was collected on dung of herbivores (eurasian elk and red dear) within several types of forest communities. All specimens of *P. alcis* were collected in recent years, from late September to early October, in the period 2012-2013. A full description and illustration of *P. alcis* based on gathered collections are given. Its delimitation, the knowledge of its ecology, general distribution, and threat is also briefly discussed. Based on the new and known distribution data for *P. alcis* in Poland, its red list category is proposed.

Key words: *Stropharia alcis*, *S. semiglobata*, coprophilous agarics, distribution, Polish mycobiota

INTRODUCTION

Protostropharia alcis (Kytöv.) Redhead, Thorn & Malloch is a species of coprophilous fungus in the family *Strophariaceae* produces basidiocarps on faeces of herbivores, primarily on the elk dung. It was originally described by Finnish mycologist Ilkka Kytövuori in 1999, as one of six species in the "*Stropharia semiglobata* group" in northwestern Europe (Kytövuori 1999), under the name *Stropharia alcis* Kytöv. As recently as this year, this species was transferred by Redhead (2013a) to *Protostropharia* Redhead, Moncalvo, Vilgalys – a genus circumscribed to contain *Stropharia* species characterized by the formation of astrocystidia rather than acanthocytes on their mycelium (Redhead 2013b). The type locality of *P. alcis* is the rich spruce-hardwood forest situated in the eastern part of Northern Ostrobothnia region in Central Finland (Jussinlamminvaara), where it was found on dung heaps of elk (*Alces alces*) (Kytövuori 1999).

Describing *P. alcis* Kytövuori (1999) supported very close relationship of the species with elk dung, reported presence of *P. alcis* in Estonia, and emphasised its widespread occurrence in Fennoscandia (Norway, Sweden, Finland), where the elk is common and abundant. He also suggested that the distribution of *P. alcis* must continue towards the east (Russia) and to North America (Canada) owing to the presence of elk, simultaneously being rare or absent in south Europe. Contemporary mycological literature seems to confirm Kytövuori's suggestions in general (cf. Ryman 2008; Viess 2010; Noordeloos 2011; Burzynski et al. 2012), but known collection of *P. alcis* from hare pellets (Kytövuori 1999), and subsequent records of the species in Italy and Brasil (Rio Grande do Sul), from unidentified dung, probably deer (Noordeloos 2011), and cow dung, or dung-enriched soil (cf. *Stropharia alcis* var. *austrobrasiliensis* Cortez & R.M. Silveira; Da Silva et al. 2006; Cortez, da Silveira 2008), may constitute a proof of its wider substrate utilization capability and more extensive global distribution.

In Poland *P. alcis* has been reported for the first time only in 2012 from the Biebrza National Park (Biebrza Basin) (Kujawa et al. 2012). In the area the species was recorded on elk dung from merely two localities within two types of forest associations which offer different ecological conditions (*Vaccinio uliginosi-Pinetum*, *Tilio cordatae-Carpinetum betuli*). There is also the information about unpublished record of the species from the Kampinos National Park (Warsaw Basin) in the mentioned paper. However, both of these findings were issued with any critical notes and illustrations of key micro-morphological characters. During the course of our mycological research in the Wigierski National Park (the East Sudetian Lake District) and in the north-western slope of Mt Wierzejska (the Holy Cross Mountains), new locations of this rare species were noted (Fig. 1). Thus, the main aim of this work is to describe morphologically the collected specimens of *P. alcis*, and to compare the characteristics with published data. Furthermore, this paper aims to evaluate

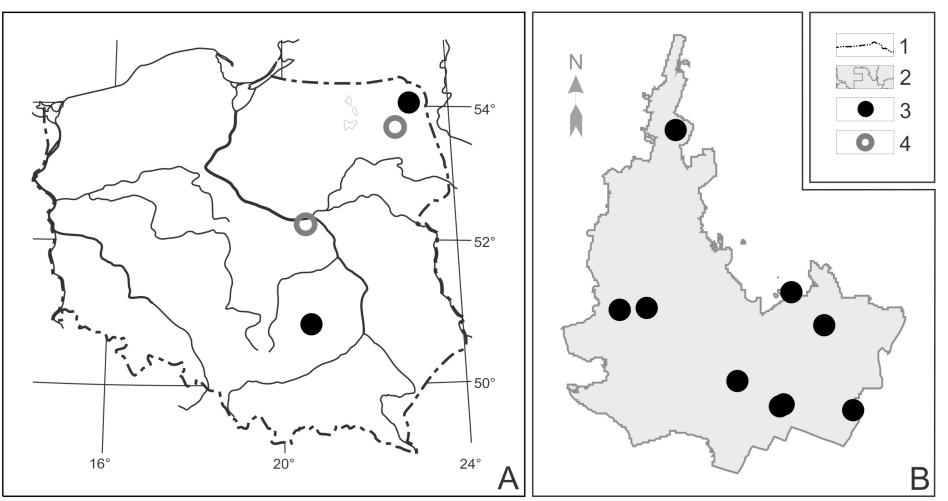

Fig. 1. Distribution of *Protostropharia alcis* in Poland (A), and in the Wigierski National Park (B): 1 – border of country, 2 – boundaries of the Park, 3 – new localities of the species, 4 – known localities of the species.

the ecology and distribution of the species in Poland in relation to the situation in Europe.

MATERIAL AND METHODS

The description of macroscopic features was based on fresh material. Microcharacters of basidiomata were observed with a Nikon Eclipse E–400 light microscope equipped with a Nikon digital camera (DS-Fi1). All microscopic structures were observed in dried material. Free-hand sections of the rehydrated pieces of basidiomata were examined in 5% NH_3 H_2O. 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 in the form of the main data range (10 – 90 percentile values). The expression (n = 100, 3, 3) means that 100 microelements from 3 basidiomata originating from 3 collections were measured. Q value refers to the length/width ratio of basidiospores. For basidiospores size measurements, randomly selected mature spores were used, and measured without hilar appendix. The lengths of basidia were measured excluding sterigmata. Leptocystidia dimensions are given as length range × width range × width range (measured at the base and at the apex of cell). Chrysocystidia dimensions are given as length range × width range × width range (measured at the base and at the central – the widest point of cell). The measurements of cystidia refer to their length, base and central width. Statistical computations employed Statistica software (StatSoft). For morphological terminology see Vellinga (1988) and Vellinga, Noordeloos (1999). The nomenclature of forest communities follows Matuszkiewicz (2001). Details of the microcharacters were figured by freehand drawing, with exact proportions and general shapes traced from photographs. The collections studied have been deposited in Museum of Natural History, Wrocław University, Wrocław, Poland (herbarium WRSL), and in the private fungaria of Barbara Kudławiec (BKF, Gniezno) and Błażej Gierczyk (BGF, Poznań).

RESULTS

Protostropharia alcis (Kytöv.) Redhead, Thorn & Malloch, *Index Fungorum*, 18: 1. 2013 (syn. *Stropharia alcis* Kytöv.) – Strophariaceae, Agaricales, Agaricomycetidae, Agaricomycetes, Basidiomycota, Dikarya, Fungi (Hibbett et al. 2007). Illustrations: Ryman, Holmåsen (1992: 441 as *Stropharia semiglobata*); Kytövuori (1999: 19, Fig. 4); Ludwig (2001a: 180, Fig. 84.12); Cortez, da Silveira (2008: 39, Fig. 15-20, 34: plate 1b, as *Stropharia alcis* var. *austrobrasiliensis*); Noordeloos (2011: 87, plate 9.17, 466-467, photo 17); Kujawa et al. (2012: 256, Fig. 9, as *Stropharia alcis*).

Basidiomata generally scattered. Pileus 5 – 35 mm, hemispherical with a very low, broad umbo, slightly expanding with age, with deflexed then straight margin, not distinctly hygrophanous, not translucently striate, yellowish cream to straw yellow, usually distinctly paler towards margin and more ochraceous at the disk, strongly viscid to glutinous when moist, shining, sticky when dry, glabrous. Lamellae, L = 15-26, I = 3-5, distant, triangular or segmentiform at first, later subventricose, broadly adnate, usually

somewhat emarginate or with small decurrent tooth, pale grey olivaceous at first then dark grey olivaceous, often clearly mottled (reminiscent a species of *Panaeolus*), with fimbriate, white edge. Stipe 30-160 × 1.5-5 mm, cylindrical or slightly evenly thickening towards the base, regularly broadened at base, hollow with a narrow cavity, with a thin, faint, glutinous annulus, 5-30 mm below the lamellae, often visible as a line darkened by ripe spores (annular zone), pale yellow in upper half, in basal part deep yellow to ochraceous, above annuliform zone dry, slightly pruinose to minutely pruinose-furfuraceous, below annuliform zone glutinous to viscid when moist or sticky when dry, sometimes faintly girdled with darker lines (Fig. 2). Context concolorous in pileus, darker in stipe (deep yellow to ochraceous). Smell not distinctive. Taste not verified. Spore print color purplish black.

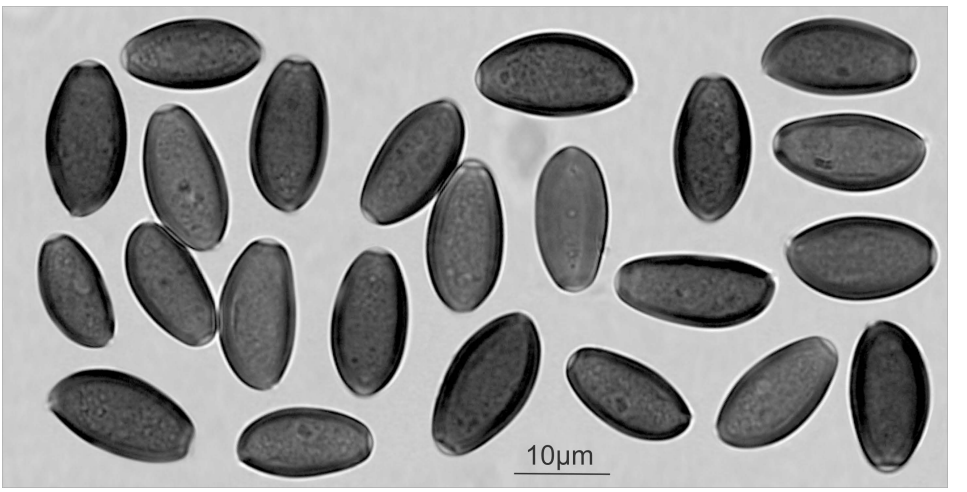

Fig. 1. Basidiospores of *Protostropharia alcis* (WRSL-26092012.495; Photo M. Halama).

Fig. 2. Basidiospores of *Protostropharia semiglobata* (WRSL-14102011.314; Photo M. Halama).

Fig. 2. *Protostropharia alcis*. Side and bottom views of basidiomata: A: WRSL-20120927.463; B-C: WRSL-20120926.495 (Photo by M. Halama).

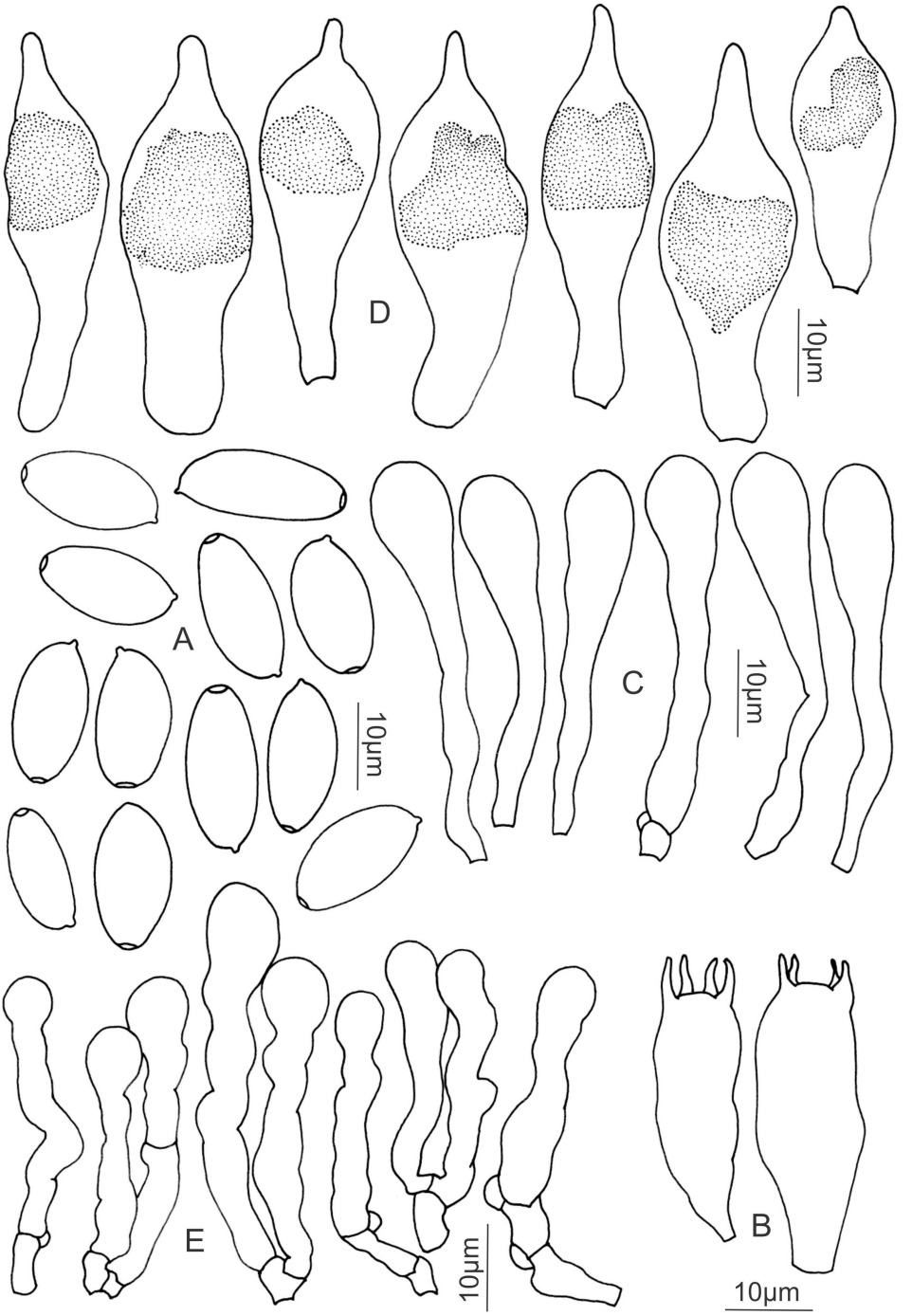

Fig. 3. Microcharacters of *Protostropharia alcis* (WRSL-26092012.495): A – basidiospores, B – basidia, C – leptocheilocystidia, D – pleurochrysocystidia, E – leptocaulocystidia (Drawings by M. Halama).

Basidiospores (11.8) 14.4 ±1.0 (17.4) × (6.4) 7.5 ±0.4 (8.7) μm, 13.3 – 15.6 × 7.1 – 8.0 μm, Q = (1.6) 1.9 ± 0.1 (2.3), Q = 1.8 – 2.0 (n = 272, 9, 9), oblong to subcylindrical in side-view, oblong-ovoid in frontal view, somewhat flattened ventrally (adaxially), smooth, umber in Melzer's reagent, thick-walled, with distinct, central germ pore, 1.5-2.1 μm. Basidia (24.7) 32.6 ±2.7 (38.4) × (9.4) 11.3 ±0.9 (13.2) μm, 29.1 – 35.8 × 9.9 – 12.3 μm (n = 60, 3, 3), 4-spored, broadly clavate, clamped. Lamella edge sterile. Cheiloleptocystidia (17.6) 38.3 ±7.2 (58.9) × (2.4) 3.9 ±0.8 (5.8) × (3.9) 7.6 ±1.3 (10.7) μm, 29.0 – 47.5 × 2.8 – 5.1 × 5.7 – 9.1 μm (n = 123, 5, 5), narrowly clavate with more or less swollen apex (not distinctly capitate), middle part often flexuosus, thin-walled, very abundant. Cheilochrysocystidia not seen. Pleurochrysocystidia rare to not very abundant, (22.8) 37.9 ±8.5 (60.0) × (3.1) 4.8 ±1.2 (8.3) × (9.4) 13.3 ±1.8 (17.4) μm, 28.8 – 49.9 × 3.4 – 6.6 × 11.4 – 16.1 μm (n = 60, 3, 3), fusiform to lageniform, typically with mucronate to rostrate apex. Caulocystidia (16.9) 32.0 ±6.0 (47.3) × (2.5) 4.0 ±0.7 (5.5) × (4.0) 6.5 ±1.1 (9.4) μm, 23.9 – 38.2 × 3.0 – 4.9 × 5.1 – 8.0 μm (n = 60, 3, 3), present at apex (above the ring zone), similar to cheiloleptocystidia, cylindrical to narrowly clavate, more flexuous (Fig. 3, Fig. 4). Pileipellis a thick ixocutis, made up of narrow, 2-4(-7) μm wide, cylindrical hyphae, pigment abundant, yellow-brown, membranal and incrusting. Stipitipellis a dry cutis in upper part of stipe, an ixocutis (as in the pileus) in lower part of stipe, made up of cylindrical, 2.0-5 μm wide hyphae, with pale yellow, hardly incrusted walls. Clamp-connections abundant in all tissues.

Material examined: *Protostropharia alcis*: POLAND, the East Sudetian Lake District, Wigierski National Park: 1: 54.050695°N 23.030041°E, phytocoenosis of *Vaccinio uliginosi-Pinetum* Kleist: terrestrial on faeces of herbivore (elk), 26.09.2012, *leg.* M. Halama (WRSL: 495); 2: 54.053932°N 23.161188°E, phytocoenosis of *Sphagno squarrosi-Alnetum* Sol.-Górn.: terrestrial on faeces of herbivore (elk), 28.09.2012, *leg.* M. Halama (WRSL: 498); 3: 54.050223°N 23.050730°E, phytocoenosis of *Sphagno girgensohnii-Piceetum* Polak.: terrestrial on faeces of herbivore (elk), 27.09.2012, *leg.* M. Halama (WRSL: 463); 4: 54.050216°N 23.030363°E, phytocoenosis of *Vaccinio uliginosi-Pinetum* Kleist: terrestrial on dung of herbivore (red deer?), 26.09.2012, *leg.* M. Halama (WRSL: 496); the Augustów Plane, Wigierski National Park: 5: 54.003910°N 23.147060°E, phytocoenosis of *Vaccinio uliginosi-Pinetum* Kleist: terrestrial on faeces of herbivore (elk), 26.09.2012, *leg.* M. Halama (WRSL: 494); 6: 54.000057°N 23.201526°E, phytocoenosis of *Tilio-Carpinetum* Tracz.: terrestrial on faeces of herbivore (red deer), 03.10.2012, *leg.* M. Halama (WRSL: 493); 7: 54.038418°N 23.183497°E, phytocoenosis of *Serratulo-Pinetum* (W. Mat.) J. Mat.: terrestrial on faeces of herbivore (elk), 28.09.2012, *leg.* M. Halama (WRSL: 497); 8: 54.004093°N 23.149730°E, phytocoenosis of *Serratulo-Pinetum* (W. Mat.) J. Mat.: terrestrial on faeces of herbivore (elk), 26.09.2012, *leg.* M. Halama (WRSL: 500); 9: 54.015560°N 23.115213°E, phytocoenosis of *Dryopteridi thelypteridis-Betuletum pubescentis* Czerw.: terrestrial on faeces of herbivore (elk), 28.09.2012, *leg.* M. Halama (WRSL: 499); POLAND, the Holy Cross Mountains, Mt Wierzejska (its northwestern slope): 10: 50.92700°N 20.64773°E, peat swamp margin enclosed within coniferous forest – phytocoenosis of *Abietetum polonicum* (Dziub.). Br.-Bl. & Vlieg.: terrestrial on faeces of herbivore (red deer), 06.10.2012, *leg.* B. Kudławiec, det. B. Gierczyk (BGF/BF/BK/121006/0001); 11: 50.92183°N 20.64683°E, peat swamp margin enclosed within coniferous forest – phytocoenosis of *Abietetum polonicum*

(Dziub.). Br.-Bl. & Vlieg.: terrestrial on faeces of herbivore (red deer), 27.09.2013, *leg.* B. Kudławiec, *det.* B. Gierczyk (BKF/05/27.09.2013/EE-64).

Additional material examined: *Protostropharia semiglobata*: POLAND, The Śnieżnik Mountains: 1. 50.261870°N 16.809288°E, mountain grassland (912 m a.s.l.): terrestrial among rotting, wet remains of grasses (i.e.: *Deschampsia* sp. and others), on buried dung of herbivore (sheep?) and heavily manured plant debris, 06.10.2010, *leg.* M. Halama (WRSL: 215); 2. 50.264876°N 16.802884°E, mountain grassland (890 m a.s.l.): terrestrial among rotting, wet remains of grasses (i.e.: *Deschampsia* sp. and others), on buried dung of herbivore (sheep?) and heavily manured plant debris, 06.10.2010, *leg.* M. Halama (WRSL: 216); 3. 50.266481°N 16.797464°E, mountain grassland (858 m a.s.l.), terrestrial among rotting, wet remains of grasses (i.e.: *Deschampsia* sp. and others), on buried dung of herbivore (sheep?) and heavily manured plant debris, 16.09.2011, *leg.* M. Halama (WRSL: 329); 4. 50.265116°N 16.803140°E, mountain grassland (895 m a.s.l.), terrestrial among rotting, wet remains of grasses (i.e.: *Deschampsia* sp. and others), on buried dung of herbivore (sheep?) and heavily manured plant debris, 14.10.2011, *leg.* M. Halama (WRSL: 314).

DISCUSSION

For the sake of outward appearance and general habit of basidiomata, there is no doubt that *Protostropharia alcis* is a conspicuous member of the *semiglobata*-group. According to Noordeloos (2011), in this group the species can be macroscopically distinguished by rather stout basidiomata, and by the somewhat more intensely coloured pileus and stipe. Moreover, Kytövuori (1999) takes note of dried basidiomata of *P. alcis*, that in his opinion they are regularly marked by the characteristic white lumps covering the edge of lamellae (e.g. compared with *Protostropharia semiglobata* (Batsch: Fr.) Redhead, Moncalvo, Vilgalys, where the gill edge looks uniformly minutely white echinate or hairy). The Polish specimens of *P. alcis* seen by us are somewhat diverse as regards their size, external habit, and colour saturation of pileus and stipe. Some basidiomata are fairly large and sturdy, while others are exceptionally small and frail when compared. Moreover, they vary between themselves in the paler – yellowish cream to darker – straw yellowish colors, and various stipe length to pileus width ratios. Nevertheless, we consider that these morphological differences are not taxonomically significant and can be explained by one or more of the following factors concerning the accompanying weather conditions, the amount of nutrients in the material on which the fungus is growing, and the development stage. It seems that *P. alcis* can be more easily recognized in the field by its substrate preferences. Most of the occurrences of the species in this study were found on more or less decayed dung heaps of elk (*Alces alces*). Only few specimens of the material studied has been collected from dung of another herbivore – most probably strongly decayed droppings of red deer (*Cervus elaphus*), including whole material from Mt Wierzejska and some of those from the Wigierski National Park. These observations confirm a noticeable preference of the species for elk dung. It is worthy to notice that within the studied area of the Wigierski

National Park, *P. alcis* seems to be widely distributed in various forest communities (see above). It appears, from September to October, mostly occurring in wetland forests with conifers (*Picea abies, Pinus sylvestris*) together with *Alnus glutinosa, Betula pendula*, and *B. pubescens* – dominated woodlands on swamp peat and wet acid-mineral soils. Its habitat tendency appears to be obviously determined by the areas in which the elk is present and engaged in the specific activity (e.g. feeding, resting) in general. However, at the same time it is not clear if the species is the only member of the *semiglobata*-group on the area, since so far none of the other has been recorded there. Nonetheless, it can be assumed that like in the northern part of Fennoscandia, *P. alcis* is nowadays distinctly commoner in woodlands of the Park and perhaps even the whole of north-eastern Poland than *P. semiglobata* (syn. *Stropharia semiglobata* (Batsch: Fr.) Quél., *S. stercoraria* (Schum.: Fr.) Quél., *Psilocybe semiglobata* (Batsch: Fr.) Noordel.). The second of the mentioned species occurs on all kinds of dung, especially horse, cattle and sheep, is widespread and probably cosmopolitan (Watling, Gregory 1987; Noordeloos 1999; Gminder 2003), but according to Kytövuori (1999), it is currently somewhat reverted in most areas due to the changes in the countryside living. It is assumed that diminishing and disappearance of woodland pastures and disappearing of horses in forestry and agricultural work may be the reason that, in regions characterised by the fairly higher elk density, *P. semiglobata* is rarer and replaced by *P. alcis* within forest communities. Nevertheless, in the case of north-eastern Poland this hypothesis is preliminary and should be tested in the future.

Microscopically the identification of *P. alcis* is very easy and more certain. In this case a confirmation is based on the basidospore size, the general shape of cheilocystidia, and the presence of chrysocystidia. The smaller and narrower spores (less than 8.5 μm wide) with a relatively large germ pore are sufficient distinctive in comparison with other members of the *semiglobata*-group, including *P. semiglobata* (Figs 3–5). Micromorphological features of the examined specimens are in good agreement with the previous descriptions of *P. alcis* (Kytövuori 1999; Noordeloos 2011), although it is worth emphasizing here that various authors have reported somewhat different measurements of given microcharacters (cf. Table 1). Nevertheless, we suppose that this insignificant discrepancy probably is attributable to a difference in sample size.

Since *P. alcis* is rather characteristic in substrate preference, it has probably not been much overlooked, but a kind of substrate may have caused less attention from macro-mycologists. Problems with simple – unambiguous recognition of decayed dung of elk may be also of a great importance. In our opinion, it is a real chance to find further even more rich localities of this agaric in the regions characterized by the relatively higher density of *Alces ales* (cf. Ratkiewicz 2011). Therefore, it appears especially reasonable to pay attention to *P. alcis* within the areas act as the crucial refuges and/or corridors for many rare macrofauna species, certainly including elk (e.g. The Biebrza Marshes; cf. Kujawa et al. 2012). Unlike in Mt Wierzejska, in the Wigierski National Park *P. alcis* seems not to be rare (Fig. 1). It seems, based on available data, that it should be classified in Poland at least as "vulnerable" and placed on the red list. It is to be hoped that future collectors will be able to extend the present sparse observations, so that this interesting species can be assigned its correct threat status in the Polish area.

Table 1
Comparison of selected morphological features of *Protostropharia alcis* (Kytöv.) Redhead, Thorn & Malloch according to different studies

Authors	Basidiospores		Basidia	Cheilolepto-cystidia	Pleurochryso-cystidia
	length × width	Q	length × width	length × width	length × width
Kytövuori (1999)	12.5 – 16.3 × 7.0 – 8.6	1.7 – 2.0	27 – 35 × 9.5 – 11.5	25 – 45 × 5 – 7.5	31 – 48 × 9.5 – 13
Noordeloos (2011)	12 – 17 × (6.5) 7 – 8.5 (9)	1.6 – 1.9	25 – 44 × 8 – 16	20 – 50 × 3 – 9	30 – 50 × 6 – 12
Ludwig (2001b)	10 – 14 (16.5) × (6.5) 7 – 7.5 (8.5)	.	.	? – 45 × ? – ?	? – 55 × ? – ?
This study	13.3 – 15.6 × 7.1 – 8.0	1.8 – 2.0	29.1 – 35.8 × 9.9 – 12.3	29.0 – 47.5 × 5.7 – 9.1	28.8 – 49.9 × 11.4 – 16.1
This study	11.8 – 17.4 × 6.4 – 8.7	1.6 – 2.3	24.7 – 38.4 × 9.4 – 13.2	17.6 – 58.9 × 3.9 – 10.7	22.8 – 60.0 × 9.4 – 17.4

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REFERENCES

Burzynski M., Voitk A., Malloch D. 2012. Annotated cumulative species list 2003-2012: 1417 species of fungi (including 144 species of lichenized ascomycetes), plus 17 species of slime molds. http://nlmushrooms.ca/species_lists/anncum.pdf [Accessed: 2013-10-07].

Cortez V.G., da Silveira R.M.B. 2008. The agaric genus *Stropharia* (*Strophariaceae, Agaricales*) in Rio Grande do Sul State, Brazil. Fungal Diversity 32: 31-57.

Da Silva P.S., Cortez V.G., Da Silveira R.M.B. 2006. The mycobiota of Itapua Park, Rio Grande do Sul, Brazil. I. Species of *Strophariaceae* (Agaricales). Mycotaxon 97: 219-229.

Gminder A. 2003. *Strophariaceae* Singer & Smith. (In:) G.J. Krieglsteiner (ed). Die Großpilze Baden-Württembergs. 4. Ständerpilze: Blätterpilze. II (4). Verlag Eugen Ulmer GmbH & Co., Stuttgart: 346-426.

Hibbett S.A., Binder M., Bischoff J.F., Blackwell M., Cannon P.F., Eriksson O.E., Huhndorf S., James T., Kirk P.M., Lücking R.H., Lumbsch T., Lutzoni F., Matheny P.B., Mclaughlin D.J., Powell M.J., Redhead S.A., Schoch C.L., Spatafora J.W., Stalpers J.A., Vilgalys R., Aime M.C., Aptroot A., Bauer R., Begerow D., Benny G.L., Castlebury L.A., Crous P.W., Dai Y.-C., Gams W., Geiser D.M., Griffith G.W., Gueidan C., Hawksworth D.L., Hestmark G., Hosaka K., Humber R.A., Hyde K.D., Ironside J.E., Kõljalg U., Kurtzman C., Larsson K.-H., Lichtwardt R., Longcore J., Mądlikowska J., Miller A., Moncalvo J.-M., Mozley-Standridge S., Oberwinkler F., Parmasto E., Reeb V., Rogers J.D., Roux C., Ryvarden L., Sampaio J.P., Schüßler A., Sugiyama J., Thorn R.G., Tibell L., Untereiner W.A., Walker C., Wang Z., Weir A., Weiss M., White M.M., Winka K., Yao Y.-J., Zhang N. 2007. A higher-level phylogenetic classification of the Fungi. Mycological Research 111 (5): 509-547.

Kujawa A., Wrzosek M., Domian G., Kędra K., Szkodzik J., Rudawska M., Leski T., Karliński L., Pietras M., Gierczyk B., Dynowska M., Ślusarczyk T., Kałucka I., Ławrynowicz M. 2012. Preliminary studies of fungi in the Biebrza National Park (NE Poland). II. Macromycetes. Acta Mycol. 47 (2): 235-264.

Kytövuori I. 1999. The *Stropharia semiglobata* group in NW Europe. Karstenia 39: 11-32.

Ludwig E. 2001a. Pilzkompendium. 1: Abbildungen. Die kleineren Gattungen der Makromyzeten mit lamelligem Hymenophor aus den Ordnungen *Agaricales, Boletales* und *Polyporales*. IHW-Verlag, Eching, 192 pp.

Ludwig E. 2001b. Pilzkompendium. 1: Beschreibungen. Die kleineren Gattungen der Makromyzeten mit lamelligem Hymenophor aus den Ordnungen *Agaricales, Boletales* und *Polyporales*. IHW-Verlag, Eching, 758 pp.

Matuszkiewicz J.M. 2001. Zespoły leśne Polski. Wydawnictwo Naukowe PWN, Warszawa, 358 pp.

Noordeloos M.E. 1999. Family *Strophariaceae*. (In:) C. Bas, T.W. Kuyper, M.E. Noordeloos, E.C. Vellinga (eds). Flora Agaricina Neerlandica. Critical monographs on families of agarics and boleti occurring in the Netherlands. 4. A.A. Balkema Publishers, Rotterdam: 27-107.

Noordeloos M.E. 2011. *Strophariaceae* s.l. Fungi Europaei. 13. Edizioni Candusso, Alassio, 648 pp.

Ratkiewicz M. 2011. Strategia ochrony i gospodarowania populacją łosia w Polsce. Białystok: Narodowy Fundusz Ochrony Środowiska i Gospodarki Wodnej, 1-69 pp.

Redhead S.A. 2013a. Nomenclatural novelties. Index Fungorum 18: 1. (PDF document).

Redhead S.A. 2013b. Nomenclatural novelties. Index Fungorum 15: 1-2. (PDF document).

Ryman S. 2008. *Stropharia* (Fr.) Quél. (In:) H. Knudsen, J. Vesterholt (eds). Funga Nordica. Agaricoid, boletoid and cyphelloid genera. Nordsvamp, Copenhagen: 851-855.

Ryman S., Holmåsen I. 1992. Pilze. Über 1500 Pilzarten ausführlich beschrieben und in natürlicher Umgebung fotografiert. Bernhard Thalacker Verlag, Braunschweig, 718 pp.

Vellinga E.C. 1988. Glossary. (In:) C. Bas, T.W. Kuyper, M.E. Noordeloos, E.C. Vellinga (eds). Flora Agaricina Neerlandica. Critical monographs on families of agarics and boleti occurring in the Netherlands. 1. A.A. Balkema Publishers, Rotterdam: 54-64.

Vellinga E.C., Noordeloos M.E. 1999. Glossary. (In:) C. Bas, T.W. Kuyper, M.E. Noordeloos, E.C. Vellinga (eds). Flora Agaricina Neerlandica. Critical monographs on families of agarics and boleti occurring in the Netherlands. 4. A.A. Balkema Publishers, Rotterdam: 6-12.

Viess D. 2010. Kenai Peninsula fungal species list: August 6-13, 2010. Soma News 23 (3): 6-7.

Watling R., Gregory N.M. (eds). 1987. *Strophariaceae* & *Coprinaceae* pp.: *Hypholoma, Melanotus, Psilocybe, Stropharia, Lacrymaria* & *Panaeolus*. British fungus flora agarics and boleti. 5. Royal Botanic Garden, Edinburgh, 121 pp.

Nowe stanowiska *Protostropharia alcis* (Basidiomycota, Agaricales) w Polsce

Streszczenie

Protostropharia alcis jest koprofilnym grzybem znanym głównie z obszaru Północnej Europy, ale posiada również stanowiska w Ameryce Płn. i Ameryce Płd. Gatunek ten najczęściej wytwarza owocniki na odchodach łosia (*Alces alces*). Znacznie rzadziej pojawia się na odchodach innych roślinożerców (np. jeleni, zajęcy, krów). Pierwsze stanowiska *P. alcis* w Polsce podali Kujawa i in. (2012) z terenu Biebrzańskiego Parku Narodowego i Kampinoskiego Parku Narodowego. W pracy przedstawiono nowe stanowiska *P. alcis*, stwierdzone w latach 2012 i 2013 na terenie Wigierskiego Parku Narodowego oraz na północno-zachodnim stoku góry Wierzejskiej w Górach Świętokrzyskich. Zaprezentowano opis stanowisk, synonimikę, ikonografię oraz charakterystykę najważniejszych cech budowy morfologiczno-anatomicznej tego gatunku. Podano również uwagi dotyczące ekologii i chorologii *P. alcis.* Autorzy dyskutują ponadto zmienność morfologiczną odnotowanych okazów *P. alcis*, a także taksonomię i wzajemne relacje tego grzyba z podobnym gatunkiem – *Protostropharia semiglobata*.