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Octopus stinkhorn *Clathrus archeri* (Berk.) Dring, an alien stinkhorn fungus (Phallaceae), in north-eastern Poland

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Abstract

Distribution of an alien fungus, octopus stinkhorn *Clathrus archeri*, has been studied in north-eastern Poland. The closest earlier known localities of this species, situated north of the new ones, were reported near the village of Dymnica (Lębork County) in Poland and near the town of Kartena in Lithuania. Field research was conducted in May–November in 2019–2020 and information from naturalists and foresters was verified, to map this species and draw attention to the problem of appearance of alien fungal species in forests. In the locality, where the largest number of basidiomata was found, they were measured every day from 12 October till 2 November 2020: height and width of young ones at the egg phase, height of mature ones, and length of their longest arms. Additionally, arms of individual basidiomata were counted. We have documented 7 localities of *C. archeri*, including 5 situated in forests and 2 in other habitats. In total, we found 63 basidiomata of this species. In the localities outside forests, basidiomata of *C. archeri* appeared in places where timber was stored, and the soil was covered with sawdust and pieces of bark. The other 5 localities were situated in broadleaved forests with a small proportion of coniferous species. It seems that *C. archeri*, when moisture level is suitable, finds favourable living conditions in fertile broadleaved forests of north-eastern Poland. It is sometimes moved from forest areas, e.g. with wood, to open and urbanized areas. Considering the observed climate change, we can expect a further spread of *C. archeri* to the north-eastern of Poland and an increase in the number of its localities in the Baltic Sea region. Spore dispersal of this species is facilitated not only by humans but also by insects. No negative impact of *C. archeri* on wooded habitats was noticed.

Keywords: Phallaceae, *Clathrus archeri*, octopus stinkhorn, alien species, ecology, distribution, forest, Poland

Introduction

Octopus stinkhorn *Clathrus archeri* (Berk.) Dring is a member of the family Phallaceae, order Phallales, class Agaricomycetes (IF 2021). Young basidiomata are obovate or slightly elongate, up to 6 cm high. The peridium (the outer wall of the basidiocarp) is off-white or sometimes fawn-coloured on the surface, with furrows corresponding to the arms of the receptacle (the spongy part of the basidioma), with a gelatinous layer visible inside. During maturation, the peridium bursts at the top. The receptacle is composed of a cylindrical, white-pink stem and 3–8 arms, which are 3–10 cm long, coloured orange-red from the inside and pink on the outside. Sometimes in mature basidiomata the arms are not separated at the end. Gleba (the spore-bearing part of the angiocarpous basidioma) is initially olive-coloured, later black, gelatinous, located on the inner side of the arms. The drying gleba is visible as scattered droplets or cracked network, along the whole length of the arms. Spores are smooth, cylindrical-elliptical, 4–8.5 µm long and 2–3.5 µm wide (Dring 1980, Rudnicka-Jezierska 1991, Szczepkowski and Obidziński 2012, Bîrsan et al. 2014, Læssøe and Petersen 2019). Basidiomata smell unpleasantly, like rotten meat, which attracts flies and other insects leading to spore dispersal (Tuno 1998, Bîrsan et al. 2014).

Clathrus archeri occurs in broadleaved forests, parks, and gardens on litter, wood pieces, and compost, sometimes also on meadows (Læssøe and Petersen 2019). It is a saprotrophic fungus, growing on humus-rich soil or rotten wood. Basidiomata are found from May till November, sometimes even in December (Réblová 2006, Wojewoda and Wojewoda 2007, Szczepkowski and Obidziński 2012).

The species is reported from Australia, New Zealand, Tasmania, southern and eastern Africa, on Saint Helena (Dring 1980), Mauritius, islands of the Malay Archipelago (Stengl-Rejthar and Wojewoda 1985), in Europe, Asia, South America (Rudnicka-Jezierska 1991), and North America (Arora and Burk 1982).

It appeared in Europe in the 20th century, initially in France in 1914. Probably it was transported because of human activity with wool from Australia or with military supplies at the beginning of the First World War (Pietras et al. 2016), and next it gradually spread to other European countries. After introduction to Europe it has been dispersed by zoochory (Réblová 2006). In Poland, the species was first recorded in 1973 near the village of Sieniawka in Łagiewniki Commune (Chlebicki 1997). Since then, basidiomata of *C. archeri* have been recorded in Poland in several dozen localities, but in the north of the country, only in several places (Miądlikowska 1995, Wojewoda 2003, Szczepkowski and Obidziński 2012, Pietras et al. 2016). Considering the countries that border Poland, it has been recorded in the Czech Republic, Slovakia, Germany, Ukraine (Wojewoda and Karasiński 2010, Pasaylyuk et al. 2018), and recently in Lithuania (Motiejūnaitė et al. 2016). It has also been reported from countries located north of Poland: Norway (Dring 1980), Sweden, and Denmark (Jeppson 2016).

The species so far has not been reported from the regions of Warmia and Masuria (Szczepkowski and Obidziński 2012, Pietras et al. 2016). That is why this study aimed to enrich our knowledge about the distribution of *C. archeri* in north-eastern Poland. We conducted field research and verified numerous data from naturalists and foresters about occurrence of this species in forests and at their edges. Our study provides also new information about its biology and habitat preferences. The collected information aims to draw attention to colonization of new habitats by alien fungal species in forests and its implications.

Materials and methods

The survey of forest complexes, in the search for basidiomata of *C. archeri* in north-eastern Poland, was conducted from May till November in 2019–2020. Additionally, from 12 October till 2 November 2020 the locality near the village of Gładysze, where the largest number of basidiomata was found, was monitored every day. We measured the height and width of young basidiomata at the egg phase (n = 15), the height of mature ones (n = 25), and length of their longest arms. Additionally, arms of individual basidiomata were counted. Photographs were taken with a NIKON D40 camera.

The confirmed localities of *C. archeri* in Poland were described according to the forest division of the State Forests National Forest Holding (BDL 2021) and the administrative division of the country. For each locality, we provided information on forest district, forest range, forest subcompartment, county (powiat), commune (gmina), the nearest village or town, and geographic coordinates. The systematic classification and species names follow for fungi the Index Fungorum (IF 2021), for plants the "Flowering plants and pteridophytes of Poland. A checklist" (Mirek et al. 2002), and for beetles the "Catalogue of Palaearctic Coleoptera" (Löbl and Löbl 2016).

Results

In this study, we have documented 7 localities of *C. archeri* in Warmian-Masurian Voivodeship in north-eastern Poland (Figure 1). Five of them were situated in wooded habitats, one in a meadow at a forest edge, and the last one outside forest (near a forester's lodge). In total, we found 63 basidiomata of this species (from 1 to 33 in individual localities).

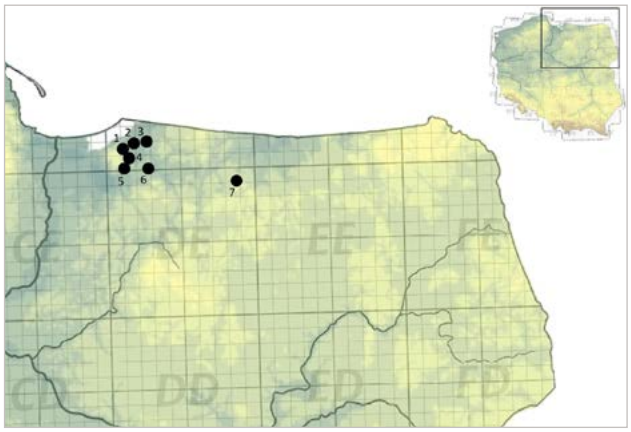

Figure 1. Localities of *Clathrus archeri* (Berk.) Dring in north-eastern Poland

Locality 1. Zaporowo Forest District, Blizin Forest Range, forest subcompartment 674w, 54°14'13.2"N, 19°38'58.1"E (within Elbląg County, Młynary Commune, near the village of Karszewo). About 90-year-old beech stand, with scattered trees of other species: silver birch *Betula pendula* Roth., oak *Quercus*, hornbeam *Carpinus betulus* L., linden *Tilia*, Scots pine *Pinus sylvestris* L., and Norway spruce *Picea abies* (L.) H. Karst. The forest stand includes some over 100-year-old specimens (oak, beech *Fagus sylvatica* L., and spruce). Beech dominates in the underbrush, underwood and is self-sown abundantly. In the underbrush it is accompanied by hornbeam, alder buckthorn *Frangula alnus* Mill., and spruce. Forest stand with moderate crown closure and small area (1.36 ha), growing on rusty brown soils, at a site of fresh broadleaved forest. On 30 July 2019, in total 5 basidiomata were observed there.

Locality 2. Zaporowo Forest District, Blizin Forest Range, forest subcompartment 646ax, 54°16'09.1"N, 19°39'52.8"E (within Elbląg County, Młynary Commune, in a village of Włóczyska), near farm buildings beside Blizin Forester's Lodge, at a site where firewood was stored. Soil covered with sawdust, bark pieces, and wood. On 20 July 2019, in total 5 basidiomata were observed there.

Locality 3. Zaporowo Forest District, Chruściel Forest Range, forest subcompartment 437a, 54°17'11.6"N, 19°47'13.6"E (within Braniewo County, Płoskinia Commune, near the village of Chruściel). Broadleaved forest stand aged about 65 years, dominated by oaks, with considerable proportions of elm *Ulmus* and birch, with solitary pine and spruce trees. The forest stand includes some scattered, over 80-year-old elm trees. In the underbrush, oak is accompanied by alder buckthorn and spruce. The forest stand, covering 2.15 ha, grows on leached brown soils, at a site of fresh broadleaved forest. As a result of damage caused by insects, crown closure is broken. On 22 July 2019, only 1 basidioma was observed there.

Locality 4. Zaporowo Forest District, Blizin Forest Range, forest subcompartment 684a, 54°13'30.5"N, 19°39'53.1"E (within Elbląg County, Młynary Commune, near the village of Stare Monasterzysko). Mixed forest stand aged about 20 years, dominated by oak, beech, and larch *Larix decidua* Mill., with considerable contributions of birch, alder *Alnus glutinosa* (L.) Gaertn., and pine. Some hold-over alder trees are more than 60-year-old. Also, scattered trees of other species present: ash *Fraxinus excelsior* L., linden, and spruce. The underbrush is composed of many species: birch, linden, blackthorn *Prunus spinosa* L. and willow *Salix.* Forest stand with moderate crown closure, covering 2.59 ha, growing on acidic brown soils at a site of fresh broadleaved forest. On 3 August 2019, only 2 basidiomata were observed there.

Figure 2. Basidiomata of *Clathrus archeri* (Berk.) Dring at various phases of development near the village of Gładysze, Wilczęta Commune

Locality 5. Młynary Forest District, Klasztorne Forest Range, forest subcompartment 104b, 54°13'05.5"N, 19°38'42.0"E (within Elbląg County, Młynary Commune, near the village of Nowe Monasterzysko). About 25-year-old stand, dominated by beech, oak, and alder, with considerable contributions of birch, linden, and pine. Also scattered trees of other species present hornbeam, larch and spruce. Some hornbeam trees are more than 40-year-old, while birch trees, about 50-year-old. The underbrush is composed of beech, black elder *Sambucus nigra* L. and aspen *Populus tremula* L. Forest stand with full crown closure, covering 6.49 ha, growing on leached brown soils, at a site of fresh broadleaved forest. On 11 August 2020, in total 12 basidiomata were observed there.

Locality 6. (Figure 2) Młynary Forest District, Godkowo Forest Range, near forest subcompartment 288c, 54°09'41.0"N, 19°55'20.4"E (within Braniewo County, Wilczęta Commune, near the village of Gładysze). Hay meadow near an apiary, bordering on a 150-year-old forest stand dominated by oak, linden, and hornbeam. For a few years in the past, firewood was stored there. On 12 October 2020, in total 33 basidiomata were found: 15 at the

Table 1. Characteristics of mature basidiomata of *Clathrus archeri* (Berk.) Dring in the locality near the village of Gładysze, Młynary Forest District (no. 6)

Basidioma number	Height of mature basidioma [cm]	Number of arms	Length of the longest arm of basidioma [cm]
1	11.1	5	8.1
2	12.0	5	8.8
3	10.5	6	7.3
4	10.2	5	7.0
5	11.8	5	8.9
6	10.0	6	7.2
7	11.3	6	8.0
8	16.7	5	13.8
9	10.2	7	7.3
10	13.7	6	11.5
11	11.8	6	8.4
12	10.4	6	7.2
13	9.0	6	5.1
14	9.6	7	7.8
15	10.9	6	7.7
16	12.8	9	9.1
17	13.0	10	10.2
18	9.7	4	7.7
19	12.2	6	8.0
20	9.0	5	6.2
21	12.0	6	9.0
22	11.3	6	8.6
23	9.6	5	6.8
24	11.0	6	8.0
25	12.9	6	9.5
Mean	11.3	6.0	8.3

egg phase, 10 mature ones, and 8 decaying ones. The eggs were up to 4.8 cm high and 4.2 cm wide. Mature specimens were 9.0–16.7 cm high (mean 11.3 cm), while their longest arms were 5.1–13.8 cm long (mean 8.3 cm). The basidiomata had 4–10 arms (mean 6) (Table 1). The observations were finished on 2 November 2020, when the last basidioma was completely decomposed. Thus, since its discovery, this local population was observed for 21 days. The largest number of mature specimens (14) was recorded on 18 October 2020. During measurements, we noticed flies (Diptera) and rove beetles (Staphylinidae).

Locality 7. Bartoszyce Forest District, Czarny Las Forest Range, forest subcompartment 207a, 54°03'51.8"N, 20°43'38.3"E (Olsztyn County, Jeziorany Commune, near the village of Wólka Szlachecka). More than 30-year-old oak stand with considerable proportions of spruce and birch. Also scattered trees of other species present: hornbeam, alder, aspen, and larch. Underbrush is composed of black elder, alder buckthorn, and spruce. Forest stand with moderate crown closure, covering 4.05 ha, growing on typical brown soils, at a site of fresh broadleaved forest. On 13 August 2019, in total 5 basidiomata were observed there.

So far, *Clathrus archeri* was recorded mainly in the southern part of and from single localities in the central and north-western parts of Poland. Currently, the range of *C. archeri* has expanded to the areas of north-eastern Poland (Figure 3).

Figure 3. Distribution of *Clathrus archeri* (Berk.) Dring in Poland and Lithuania

Discussion and conclusions

Frequency of occurrence of various fungal species in individual habitats can change in response to climate change. Observations from Great Britain indicate that in the last few decades, the fruiting season of macrofungi was gradually extended, and many species started to produce basidiomata both in spring and in autumn (Gange et al. 2007). Such changes result in more effective dispersal of many alien and invasive species (Desprez-Loustau et al. 2007, Desprez-Loustau 2009). According to Kreisel (2006), valleys of large rivers in Europe (Rhine, Inn, Elbe, Oder, and perhaps Vistula) with floodplain forests and dunes have greatly facilitated the northward expansion of southern fungi, e.g. *Auricularia mesenterica* (Dicks.) Pers., *Trametes trogii* Berk., *Pluteus aurantiorugosus* (Trog) Sacc., and *Agaricus bohusii* Bon. In contrast, Perry et al. (1990) suggested that migration of many fungal species, especially mycorrhizal ones, is dependent on the presence of specific plant species. In Poland, during the last 50 years, researchers observed the spread of many fungal species, including *C. archeri* (Wojewoda and Karasiński 2010).

In Europe, *C. archeri* is reported primarily from areas with temperate oceanic climate. Most of its Polish localities are in the south, and only several in the central and northern parts of the country (Figure 3). Such a distribution pattern suggests that *C. archeri* spreads northwards. Simultaneously, the occurrence and further spread of this species in Poland seem to be strongly associated with climatic conditions, especially annual precipitation. About 80% of localities of *C. archeri* are concentrated in uplands and in mountains, where precipitation is higher than 600 mm (Pietras et al. 2016). The area, where records of *C. archeri* in north-eastern Poland where confirmed, was characterized by annual precipitation of 700–800 mm in 2019, higher than the mean for 1971–2000 (Pawelec and Wereski 2019). According to Pietras et al. (2016), the major factors determining basidiomata production are annual precipitation and mean temperature during the driest months. Réblová (2006) reported that in the Czech Republic, the most suitable sites for octopus stinkhorn are located mostly in foothills, in valleys of rivers and streams or near ponds, i.e. in places where groundwater level is high.

The closest published records of *C. archeri*, situated north of the new localities, are: (1) near the village of Dymnica in Poland (ca. 160 km to the north-west), currently within Lębork County, in Pomeranian Voivodeship (Miądlikowska 1995); and (2) near the town of Kartena in Lithuania (ca. 260 km away), in Kretinga District, Klaipeda County (Figure 3). The Lithuanian population was found on a partly wooded slope, covered with shrubs and herbaceous vegetation between young trees: *Picea abies* and *Pinus sylvestris* (Motiejūnaitė et al. 2016). In those localities, *C. archeri* occurred in areas with a milder climate, under the influence of the Baltic Sea.

In the village of Włóczyska (no. 2) and near the village of Gładysze (no. 6) (Figure 1), basidiomata of *C. archeri* appeared in places where firewood was stored earlier for many years and the soil was covered with sawdust and pieces of bark. Among the measured 25 basidioma-

ta of *C. archeri* two had more than eight arms, i.e. 9 and 10 arms. In the case of three basidiomata, that the length of the longest arm exceeded 10 cm (10.2, 11.5, and 13.8 cm) was noted. These values are higher than those reported by: Dring (1980), Rudnicka-Jezierska (1991), Réblová (2006), Wojewoda and Wojewoda (2007), Szczepkowski and Obidziński (2012), Bîrsan et al. (2014), Motiejūnaitė et al. (2016). It is probably the result of the accumulation of large amounts of decomposed wood in the place of occurrence of basidiomata. Pasaylyuk et al. (2018) reported that beech sawdust proved to be suitable for mycelium growth of *C. archeri* in laboratory conditions. Additionally, Pegler et al. (1995) reported on occurrence of *C. archeri* on forest chips.

Near the village of Gładysze, on basidiomata of *C. archeri*, we observed rove beetles (Staphylinidae) and flies (Diptera). Similarly, Johnson and Jürgens (2010) on mature basidiomata of this species observed dipterans of the families Calliphoridae, Muscidae, and Sarcophagidae. During extensive research, Tuno (1998) found on basidiomata of the genus *Dictyophora* (Phallaceae) beetles of 5 families (Nitidulidae, Scaphidiidae, Scarabaeidae, Staphylinidae, Lucanidae), dipterans of 12 families (Calliphoridae, Cecidomyiidae, Chloropidae, Drosophilidae, Dryomyzidae, Heleomyzidae, Lauxaniidae, Muscidae, Phoridae, Psychodidae, Sciaridae, Sphaeroceridae), and hymenopterans of 2 families (Formicidae, Ichneumonidae). Also Nouhra and de Toledo (1994) as well as Tan (2008) informed about the presence of dipterans and sap beetles (Nitidulidae) on basidiomata of fungi of the order Phallales. Whereas Román (2008) reported that on basidiomata of the closely related *Clathrus ruber*, near Seville in Spain, 3 specimens of sacred scarab *Scarabaeus sacer* L. were found: 2 of them outside and the last one inside a basidioma. It is noteworthy that scarab beetles feed on fresh dung along routes of movement and grazing of farm animals: sheep, cattle, and horses (Byk and Piętka 2018, Byk et al. 2020). Johnson and Jürgens (2010) investigated the smell released by *C. archeri* in respect of chemical composition and found that it contained compounds typical of faeces (phenols, indole, *p*-cresol) and carrion (oligosulphides). Thus various insect species contribute to the dispersal of spores of this fungus (Nouhra and de Toledo 1994, Tuno 1998).

In north-eastern Poland, 5 out of 7 confirmed localities of *C. archeri* were in broadleaved forests with a small proportion of conifers. Also in Czechia, this fungal species prefers warm broadleaved and mixed forests with slightly acidic soil and substrate rich in decaying plant remnants (Réblová 2006). Szczepkowski and Obidziński (2012) report that in Poland about 65% of localities of this species were found in forests, at their edges or on forest roads.

The major factors enabling good growth of *C. archeri* include continuously high soil moisture content and partial shading, which create a favourable microclimate (Réblová 2006). According to Pietras et al. (2016), basidiomata appear after longer periods of moist weather. It seems that when temperature, humidity and soil moisture are suitable, *C. archeri* has favourable conditions for development in fertile broadleaved forests of north-eastern Poland. From wooded habitats, it is sometimes accidentally introduced (e.g. with wood) into open and urban areas. Szczepkowski and Obidziński (2012) report that so far there is no unambiguous evidence indicating any negative influence of *C. archeri* on native fungal species or other components of the occupied habitats. Observations made during this study seem to confirm this neutral opinion. Considering the observed climate change (Ozolinčius 2012, Bolle et al. 2015), we can expect a further spread of *C. archeri* to the north-eastern part of Poland, and an increase in the number of its localities in the countries of the Baltic Sea region.

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References

Arora, D. and Burk, W.R. 1982. *Clathrus archeri*, a stinkhorn new to North America. *Mycologia* 74(3): 501–504. https://doi.org/10.2307/3792972.

BDL. 2021. Bank Danych o Lasach [Forest Data Bank]. Available online at: www.bdl.lasy.gov.pl. Last accessed on 25 January 2021 (in Polish and in English).

Bîrsan, C., Cojocariu, A. and Cenuşă, E. 2014. Distribution and ecology of *Clathrus archeri* in Romania. *Notulae Scientia Biologicae* 6(3): 288–291. https://doi.org/10.15835/nsb.6.3.9389.

Bolle, H.-J., Menenti, M. and Rasool, S.I. (Eds). 2015. Second assessment of climate change for the Baltic Sea Basin. Cham-Heidelberg-New York-Dordrecht-London: Springer, 501 pp.

Byk, A., Matusiak, A., Taszakowski, A., Szczepański, W.T., Walczak, M., Bunalski, M. and Karpiński, L. 2020. New and interesting findings of scarab beetles (Coleoptera: Scarabaeoidea) from Tajikistan. *ZooKeys* 1003: 57–82. https://doi.org/10.3897/zookeys.1003.55457.

Byk, A. and Piętka, J. 2018. Dung beetles and their role in the nature. *Edukacja Biologiczna i Środowiskowa* 66(1): 17–26, https://doi.org/10.24131/3247.180103.

Chlebicki, A. 1997. Nowe stanowiska smardzówki czeskiej *Verpa bohemica*, okratka australijskiego *Clathrus archeri* i czasznicy olbrzymiej *Calvatia gigantea* na Dolnym Śląsku [New localities of *Verpa bohemica*, *Clathrus archeri* and *Calvatia gigantea* in Lower Silesia]. *Chrońmy Przyrodę Ojczystą* 53(1): 104–110 (in Polish).

Desprez-Loustau, M.-L. 2009. Alien fungi of Europe. In: Drake, J.A. (Ed.): Handbook of alien species in Europe. Dordrecht: Springer, p. 15–28.

Desprez-Loustau, M.-L., Robin, C., Buée, M., Courtecuisse, R., Garbaye, J., Suffert, F., Sache, I. and Rizzo, D.M. 2007. The fungal dimension of biological invasions. *Trends in Ecology and Evolution* 22(9): 472–480. https://doi.org/10.1016/j.tree.2007.04.005.

Dring, D.M. 1980. Contributions towards a rational arrangement of the *Clathraceae*. *Kew Bulletin* 35(1): 1–96.

Gange, A.C., Gange, E.G., Sparks, T.H. and Boddy, L. 2007. Rapid and recent changes in fungal fruiting patterns. *Science* 316(5821): 71. https://doi.org/10.1126/science.1137489.

IF. 2021. Index Fungorum. Available online at: www.indexfungorum.org. Last accessed on 25 January 2021.

Jeppson, M. 2016. Stinksvampar – vackra och oblyga [Stinkhorns – beautiful and unashamed]. *Svensk Mykologisk Tidskrift* 37(3): 32–46 (in Swedish with English abstract).

Johnson, S.D. and Jürgens, A. 2010. Convergent evolution of carrion and faecal scent mimicry in fly-pollinated angiosperm flowers and a stinkhorn fungus. *South African Journal of Botany* 76(4): 796–807. https://doi.org/10.1016/j.sajb.2010.07.012.

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

Læssøe, T. and Petersen, J.H. 2019. Fungi of Temperate Europe. Princeton-Oxford: Princeton University Press, 1715 pp.

Löbl, I. and Löbl, D. (Eds.). 2016. Catalogue of Palaearctic Coleoptera. Vol. 3. Revised and Updated Edition. Scarabaeoidea, Scirtoidea, Dascilloidea, Buprestoidea and Byrrhoidea. Leiden-Boston: Brill, 983 pp.

Miądlikowska, J. 1995. New locality of *Clathrus archeri* in Poland. *Acta Mycologica* 30(1): 51–52. https://doi.org/10.5586/am.1995.013.

Mirek, Z., Piękoś-Mirkowa, H., Zając, A. and Zając, M. (Eds.). 2002. Flowering plants and pteridophytes of Poland. A checklist. Kraków: W. Szafer Institute of Botany, Polish Academy of Sciences, 442 pp.

Motiejūnaitė, J., Kutorga, E., Kasparavičius, J., Lygis, V. and Norkutė, G. 2016. New records from Lithuania of fungi alien to Europe. *Mycotaxon* 131: 49–60. https://doi.org/10.5248/131.49.

Nouhra, E.R. and de Toledo, L.D. 1994. Interaccion entre Phallales (Basidiomycotina) e insectos (Coleopteros y Dipteros) [Interaction between Phallales (Basidiomycotina) and insects (Coleoptera and Diptera)]. *Boletín de la Sociedad Argentina de Botánica* 30(1-2): 21–24 (in Spanish with English summary).

Ozolinčius, R. 2012. Possible effects of climate change on forest biodiversity, tree growth and condition: review of research in Lithuania. *Baltic Forestry* 18(1): 156–167.

Pasaylyuk, M., Petrichuk, Y., Tsvyd, N. and Sukhomlyn, M. 2018. The aspects of reproduction of *Clathrus archeri* (Berk.) Dring by re-situ method in the National Nature Park Hutsulshchyna. *Forest Research Papers* 79(3): 281–287. https://doi.org/10.2478/frp-2018-0028.

Pawelec, W. and Wereski, S. (Eds.). 2019. Biuletyn Państwowej Służby Hydrologiczno-Meteorologicznej [Bulletin of the National Hydrological and Meteorological Service]. Warszawa: Instytut Meteorologii i Gospodarki Wodnej, Państwowy Instytut Badawczy, 61 pp. (in Polish).

Pegler, D.N., Læssøe, T. and Spooner, B.M. 1995. British puffballs, earthstars and stinkhorns. An account of the British gasteroid fungi. Kew, UK: Royal Botanic Gardens, 255 pp.

Perry, D.A., Borchers, J.G., Borchers, S.L. and Amaranthus, M.P. 1990. Species migrations and ecosystem stability during climate change: the belowground connection. *Conservation Biology* 4(3): 266–274.

Pietras, M., Rudawska, M., Iszkuło, G., Kujawa, A. and Leski, T. 2016. Distribution and molecular characterization of an alien fungus, *Clathrus archeri*, in Poland. *Polish Journal of Environmental Studies* 25(3): 1197–1204. https://doi.org/10.15244/pjoes/61230.

Réblová, M. 2006. Fungi – houby. In: Mlíkovský, J. and Stýblo, P. (Eds.) Nepůvodní druhy fauny a flóry České republiky [Alien species of fauna and flora of the Czech Republic]. Praha: ČSOP, p. 19–21 (in Czech).

Román, J. 2008. *Scarabaeus sacer* Linnaeus, 1758 (Coleoptera: Scarabaeidae) visitando un hongo de la especie *Clathrus ruber* Micheli: Persoon (Clathraceae) [*Clathrus ruber* (Clathraceae) visited by *Scarabaeus sacer* (Scarabaeidae)]. *Boletín Sociedad Entomológica Aragonesa* 42: 348 (in Spanish with English abstract).

Rudnicka-Jezierska, W. 1991. Grzyby (Mycota). Podstawczaki (Basidiomycetes): purchawkowe (Lycoperdales), tęgoskórowate (Sclerodermatales), pałeczkowate (Tulostomatales), gniazdnicowe (Nidulariales), sromotnikowe (Phallales), osiakowe (Podaxales) [Fungi (Mycota). Basidiomycetes: Lycoperdales, Sclerodermatales, Tulostomatales, Nidulariales, Phallales, Podaxales]. Kraków: Instytut Botaniki PAN, 208 pp. (in Polish).

Stengl-Rejthar, A. and Wojewoda, W. 1985. Expansion of the fungus *Clathrus archeri* (Berk.) Dring (Gasteromycetes) in Europe and Poland. *Zeszyty Naukowe Uniwersytetu Jagiellońskiego. Prace Botaniczne* 13: 105–110.

Szczepkowski, A. and Obidziński, A. 2012. Obce gatunki sromotnikowatych Phallaceae w lasach Polski [Alien species of stinkhorns Phallaceae in forests of Poland]. *Studia i Materiały CEPL w Rogowie* 33(4): 279–295 (in Polish with English abstract).

Tan, H.H. 2008. A sighting of a stinkhorn fungus, *Dictyophora* species. *Nature in Singapore* 1: 165–169.

Tuno, N. 1998. Spore dispersal of *Dictyophora* fungi (Phallaceae) by flies. *Ecological Research* 13: 7–15.

Wojewoda, W. 2003. Checklist of Polish larger Basidiomycetes. Kraków: W. Szafer Institute of Botany, Polish Academy of Sciences, 812 pp.

Wojewoda, W. and Karasiński, D. 2010. Invasive macrofungi (*Ascomycota* and *Basidiomycota*) in Poland. *Biological Invasions in Poland* 1: 7–21.

Wojewoda, W. and Wojewoda, M. 2007. Grzyby inwazyjne: okratek australijski *Clathrus archeri* i pierścieniak uprawny *Stropharia rugosoannulata* w Beskidzie Wyspowym [Invasive fungi: *Clathrus archeri* and *Stropharia rugosoannulata* in the Beskid Wyspowy]. *Wszechświat* 108(10-12): 300–303.