**Distribution and conservation status of *Grifola frondosa* (Polyporales, Basidiomycota) in Ukraine**

Mariya V. SHEVCHENKO, Vasyl P. HELUTA, Vera P. HAYOVA

M.G. Kholodny Institute of Botany, National Academy of Sciences of Ukraine
2 Tereschenkivska Str., Kyiv 01004, Ukraine
Shevchenko_Mariya@ex.ua

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**Abstract.** *Grifola frondosa* is a nationally red-listed species in Ukraine. In the third edition of the *Red Data Book of Ukraine* it is assigned to a category Vulnerable (VU). Previously, the fungus was known from 17 localities in nine regions of Ukraine: Cherkasy, Dnipropetrovsk, Donetsk, Kharkiv, Kherson, Kyiv, Sumy, Ternopil, Transcarpathian, and the Autonomous Republic of Crimea. Over the recent decade, *G. frondosa* has been also recorded in the following eight regions: Chernihiv, Chernivtsi, Ivano-Frankivsk, Khmelnytskyi, Lviv, Rivne, Volyn, Zhytomyr, and Kyiv city. Thus, a number of known up to now localities of *G. frondosa* increased from 17 to more than 40. However, the expanded number of records is due to additional data recently provided from field observations by amateur mycologists, rather than a result of the increasing population trend of the fungus.

Based on the current distribution pattern of *G. frondosa* in Ukraine, its contemporary conservation status on the national level was evaluated using the IUCN categories and criteria. The species was assessed as Endangered, EN under criteria С2а(i). This is the higher threat category as compared to Vulnerable (VU) in the current edition of the *Red Data Book of Ukraine*. For conservation purposes, it is necessary to protect the already known sites, to search for new localities of the fungus, and to explore possibilities of its re-introduction into natural habitats. Global distribution and the Red List status of *G. frondosa* in Europe are briefly discussed. A list of currently known localities of the species in Ukraine and a distribution map of the reported sites are provided.

**Keywords:** assessment, fungal conservation, IUCN categories and criteria, *Red Data Book of Ukraine*.

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Інститут ботаніки ім. М.Г. Холодного НАН України
вл. Терещенківська 2, Київ 01004, Україна

Реферат. *Grifola frondosa* в Україні підлягає охороні на національному рівні. У третьому виданні "Червоної книги України" вид віднесений до категорії "уразливий" (VU). Раніше гриб був відомий з 17 локалітетів у дев'яти областях України — Дніпропетровській, Донецькій, Київській, Закарпатській, Сумській, Тернопільській, Харківській, Херсонській і Черкаській, а також в Автономній Республіці Крим. Упродовж останнього десятиліття *G. frondosa* була зареєстрована ще у восьми областях — Волинській, Житомирській, Івано-Франківській, Львівській, Рівненській, Чернівецькій, Чернігівській і Хмельницькій та в місті Києві. Таким чином, кількість відомих локалітетів виду зросла з 17 до понад 40. Однак це збільшення пов’язане насамперед з великим залученням до пошуку *G. frondosa* мікологів-аматорів, а не є наслідком тенденції до збільшення чисельності гриба. На основі уточнених даних про поширення *G. frondosa* в Україні проведено оцінку природоохоронного статусу цього виду на національному рівні та використанням категорій та критеріїв МСОП. Вид оцінено як "зникаючий", EN за критеріями С2а(i). Ця категорія відповідає вищому ступеню загрози порівняно із категорією "уразливий" (VU) у третьому виданні "Червоної книги України". Надалі для збереження виду потрібно охороняти відомі його локалітети, проводити пошук нових місцезростань гриба та досліджувати можливість його реінтродукції до природних місць існування. У статті стисло обговорюються загальні засоби охорони та природоохоронний статус *G. frondosa* в Європі. Наведено список відомих на сьогодні локалітетів та карта поширення цього виду в Україні.

**Ключові слова:** категорії та критерії МСОП, охорона грибів, оцінка виду, Червона книга України
**Introduction**

*Grifola frondosa* (Dicks.) Gray (*Polyporales, Basidiomycota*) is a rarely recorded fungus in Ukraine and worldwide. It is a wood-inhabiting fungus forming its large annual fruit bodies on the ground near or at the base of old living or dead tree trunks or stumps. As a facultative parasitic or saprotrophic fungus, *G. frondosa* is capable of degrading lignin components of woody substrates, thus causing white rot or butt rot of tree stems or roots.

Most frequently *G. frondosa* is associated with old trees of *Quercus* spp. However, it may occur on other old-growth deciduous hardwoods, e.g. *Acer* L., *Betula* L., *Carpinus* L., *Castanea* Mill., *Eucalyptus* L’Hér., *Fagus* L., *Juglans* L., *Populus* L., and *Ulmus* L. (Ryvarden, Melo, 2014), with only a few known records on large conifers. Occurrence on conifers has been reported outside of Europe: on *Pinus* L., *Pseudotsuga* Carrière and *Larix* Mill. in North America (Gilbertson, Ryvarden, 1986), on *Abies* Mill. in China (https://nt.ars-grin.gov/fungaldatabases/).

In Ukraine, the fungus has been so far recorded mostly on *Quercus robur* L., occasionally on *Fagus sylvestria* L. and, according to literature data (Gutsevich, 1940; Sarkina et al., 2003), once on *Carpinus betulus* L. In the current edition of the *Red Data Book of Ukraine* this species is listed as Vulnerable (Prydiuk, 2009). Prior to 2009, it was reported from 17 localities in nine regions of Ukraine: Cherkasy, Dnipropetrovsk, Donetsk, Kharkiv, Kherson, Kyiv, Sumy, Ternopil, Transcarpathian Regions, and the Autonomous Republic of Crimea. Recently, the fungus was found to occur in new localities in the western, central and northern parts of Ukraine.

This article presents an update on the current distribution of *G. frondosa* in Ukraine and results of the re-evaluation of its conservation status on the national level.

**Taxonomic notes**

*Grifola frondosa* (Dicks.) Gray, *Nat. Arr. Brit. Pl. (London)* 1: 643. 1821

The fungus was described as *Boletus frondosus* Dicks. in 1785 from Britain. In 1821, E. Fries changed the name to *Polyporus frondosus* (Dicks.) Fr. In the same year, S.F. Gray transferred the species to a new genus, *Grifola* Gray. Having made that combination, he established for this fungus its currently accepted name, *Grifola frondosa*. At present the species has over 20 homotypic and heterotypic synonyms. Although this fungus has a nearly worldwide distribution, molecular phylogenetic analysis revealed a strong support for species partition separating eastern North American and Asian isolates, as well as a distinct European lineage of *G. frondosa* (Shen et al., 2002). Thus, future taxonomic revision may split the species; in that case, the name *G. frondosa* is to be applied to the European lineage, with other two different names for the North American and Asian populations.

The genus *Grifola* is placed in the family *Meripilaceae* (*Polyporales*) (www.indexfungorum.org/), or in *Fomitopsidaceae* of the same order (www.mycobank.org/). Recently, based on molecular data (Justo et al., 2017), *Grifolaceae* Jülich, which appears as sister to *Polyporaceae*, was restored as an accepted family name to accommodate the genus *Grifola*.

**Global distribution and evaluation**

*Grifola frondosa* is traditionally regarded as a circum-polar species in the Northern Hemisphere where it has its major distribution. In this case, the fungus is considered as native to temperate hardwood regions of Europe, North America, and Asia (Bondartseva, 1998; Ryvarden, Melo, 2014). In North America it can be found in Eastern Canada, northeastern and mid-Atlantic states of the USA, and more rarely in northwestern or southeastern states (Chen et al., 2000). In Asia, it is known to occur in southwestern and northeastern China and northeastern Japan (Yamanaka, 1997; Chen et al., 2000). In the Southern Hemisphere, few records have been reported in Australasia (Australia, New Zealand) (Bondartseva, 1998). Although the fungus has a rather wide geographic distribution, it is a rarely occurring species throughout most of its range.

Since the eastern North American and Asian material may not be conspecific with the European records (see above), the recently proposed assessment of *G. frondosa* on the global level under the *Global Fungal Red-List Initiative* (http://iucn.ekoo.se/iucn/species_view/362177) is based on the European populations.

**Red-list status in Europe**

In Europe, the reported conservation status of *G. frondosa* varies across the continent. In many countries the species is nationally red-listed under the threatened categories: Estonia – CR (Lõhmus et al., 2018), Bulgaria, Lithuania, North Macedonia – EN (Gyosheva et al., 2006; Iršenaitė et al., 2007;
Fig. 1. *Grifola frondosa*. A: registration of parameters of two fruit bodies found at the base of an oak trunk; B, C: fruit bodies of the fungus
In vitro research in Ukraine and worldwide

A large number of in vitro studies in Ukraine and other countries has demonstrated that G. frondosa is rich in a variety of polysaccharides which possess antitumor and immunostimulating activity as well as have antibiotic, antiviral and antioxidant properties (Kodama et al., 2002; Zhou, Wasser, 2004; Bartuv-Tal et al., 2009; Masuda et al., 2010; Linovystska et al., 2011; Bisko et al., 2018). Pharmacologically active substances derived from G. frondosa are widely used in pharmacognosy, in food production and as a source of biologically active compounds for dietary supplements. Apart from the advantages of nutritional value and medicinal effect, this fungus is famous for its delicious taste and appealing mushroom aroma. It is widely used in commercial growing and mushroom industry, particularly in Asia and North America. The world leader in production and consumption of G. frondosa is Japan where its...
annual production is estimated to be about 41,000 tonnes (Mayuzumi, Mizuno, 1997; Yamanaka, 2011).

In Ukraine, 29 strains of *G. frondosa* of different origin are currently maintained in the IBK mushroom culture collection of the M.G. Kholodny Institute of Botany, National Academy of Sciences of Ukraine, and one strain — in the FCKU culture collection of fungi of the Educational and Scientific Centre "Institute of Biology and Medicine", Taras Shevchenko National University of Kyiv (Bisko et al., 2016, 2018).

### Distribution in Ukraine

*Grifola frondosa* forms large (up to 100 cm in diam.) multipileate grayish-brown basidiocarps (Fig. 1). They are easily recognizable and usually much looked after. Apart from literature data, herbarium materials, and our personal field observation results (Fig. 1, A), we have also analysed reports published by amateur mycologists in two social network groups (https://www.facebook.com/groups/Hryby.Ukrayiny/?ref=bookmarks,https://www.facebook.com/groups/119266158163241/), if and when these newly reported records were confirmed by photographs. Altogether, a number of known up to now localities *G. frondosa* was expanded from 17 indicated in the current edition of the *Red Data Book of Ukraine* to over 40. For the first time, the fungus was reported in the following eight regions: Chernivtsi, Chernihiv, Ivano-Frankivsk, Lviv, Khmelnytsky, Rivne, Volyn, Zhytomyr, and Kyiv city. However, the expanded number of the recently reported records is due to additional field observations in appropriate habitats undertaken by amateur mycologists, rather than a result of increasing population trend of the fungus.

Below we provide a list of all currently known localities of *G. frondosa* in Ukraine. Since the species is nationally red-listed, according to the Ukrainian legislation on the *Red Data Book of Ukraine* (Zakon..., 2017), its published distribution data do not include information on the exact localities. All reported sites are shown on the map (Fig. 2).

**Autonomous Republic of Crimea:** near Alushta, Crimean Nature Reserve, autumn 1936, S.A. Gutsevich (Gutsevich, 1940; Sarkina et al., 2003).

**Cherkasy Region:** Smila District, near Smila (Bondartsev, 1953).

**Chernihiv Region:** Ichnya District, Ichnyanskyi National Nature Park, 16.10.2016 (Shevchenko, 2018).

**Chernivtsi Region:** Hlyboka District, 27.09.2007, M.D. Nykyrsa (Volutsa, 2014).

**Dnipropetrovsk Region:** Novomoskovsk District (Taran et al., 1989).

**Donetsk Region:** Slovyansk District, October 2003 (Triskiba et al., 2005; Leshan, Pakhomov, 2009).

**Ivano-Frankivsk Region:** Galych District, Galytskyi National Nature Park (Malanyuk, 2012); Burshtyn, 27.09.2018, I. Zubrytsky; Kalush District, 03.10.2018, V. Petriv; Tismenytsia District, 31.08.2016, 21.09.2016, 29.09.2018, S. Labuz’ko.

**Kharkiv Region:** Kharkiv District, near Kharkiv (Bondartsev, 1953).

**Kherson Region:** Oleshky District (Prydiuk, 2009).

**Khmelnytsky Region:** Izyaslav District, Male Polissya National Nature Park, 09.10.2017, N. Kratasyuk; ibid., 17.09.2018, O. Mnyukh et al.; Slavuta District, Male Polissya National Nature Park, 09.16.2018, V.P. Heluta, M.P. Prydiuk, V.P. Hayova.

**Kyiv city:** Holosiiv National Nature Park, 13.10.2009, M. Shevchenko; October 2009 (Ivanenko, 2014); Feofaniya park, September 2012–2013 (Ivanenko, 2014); 15.09.2018, A. Cherenkova.

**Kyiv Region:** Borodyanka District, 08.09.2018, A. Cherednichenko; Ivaniv District, 24.09.2017, K. Oleynik; Kyiv-Svyatoshinsky District, 20.09.1985, T.L. Horova (KW-M 2716); Makariv District, 23.10.2017, V. Hnatenko; Obukhiv District, 23.09.2018, L. Prokopova, Ye. Rudenko; 30.09.2018, V. Mykolaenko.

**Lviv Region:** Zhovkva District, 27.09.2018, O. Star-nilnyk.

**Rivne Region:** Volodymyrets District, 23.09.2017, O. Shatkov’ska; Sarnty District, 30.09.2018, M. Mel’nyk.

**Sumy Region:** Krasnopillya District, 13.10.2002 (Karpenko, 2004); Nedrigailiv District, 12.10.2002 (Karpenko, 2004); Romny District (Chala, Karpenko, 2012); Sumy District, 20.10.2000 (Karpenko, 2004); Trosytanets District, 06.10.1996 (Karpenko, 2004).

**Ternopil Region:** Berezhany District (Namysłowski, 1914); Husyatyn District, Medobory Nature Reserve, 17.07.2008, M.P. Pridyuk (Dzhagan et al., 2010); Chortkiv District, August 1935 (Pilát, 1940).

**Transcarpathian Region:** Perechyn District, 13.08.1982, N.Yu. Mytropolska (KW-M 19583); Rakhiiv District, August 1934 (Pilát, 1940; Bondartsev, 1953); Carpathian Biosphere Reserve (Lovas, Küffer, 2006).

**Volyn Region:** Lutsk District, 14.07.2017, V.V. Rev-nyuk.

**Zhytomyr Region:** Zhytomyr District, 08.09.2018, V. Yakymchuk; 28.10.2018, O. Volychnuk; Malyn District, 29.09.2018, S. Stepanyuk; Khoroshiv District, 23.09.2017, Z. Kosyns’ka.
Assessment and conservation status in Ukraine

After having updated its current distribution in Ukraine, we evaluated *G. frondosa* on the national level using the IUCN Red List Categories and Criteria (IUCN Red List Categories and Criteria, 2012).

The species is assessed under criterion C (Small population size and decline) based on the number of mature individuals. The calculation was made according to the concept of functional individual (Dahlberg, Mueller, 2011), now generally accepted in fungal red-listing. Thus, the currently known number of localities of the fungus is about 40. Since *G. frondosa* is associated exclusively with old-growth oak trees (or rarely beech trees), maximum actual number of the localities can be increased tenfold, apparently not exceeding 400. For *G. frondosa* as a lignicolous fungus, sporocarps inhabiting individual tree may represent one functional individual. Since each functional individual should be counted at minimum as two mature individuals, in our case total number of mature individuals is equal to 800. As *G. frondosa* may not fruit every year under the same tree, if to suggest that one or two fruit bodies under individual tree correspond to four mycelia, the total number of mature individuals would not exceed 1600. In addition, large old-growth oak and beech trees are under long-term ongoing decline. Hence, number of mature individuals is < 2,500; there is an observed, estimated, projected or inferred continuing decline (C2); number of mature individuals in each subpopulation is < 250. Therefore, the species is assessed as Endangered (EN) under criteria C2a(i).

Conclusion

Based on our update on distribution of *G. frondosa* in the country, the species was assessed nationally as Endangered (EN) which is the higher threat category as compared to Vulnerable (VU) in the current edition of the Red Data Book of Ukraine. It is therefore necessary for conservation purposes to protect the already known sites, to search for new localities of the fungus in appropriate habitats, and to explore potential re-introduction of the strains of local origin into natural habitats. Thus, in the next edition of the Red Data Book of Ukraine, the conservation status of *G. frondosa* should be indicated as EN C2a(i).

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