Mycologia Iranica 6(1): 33 – 39, 2019 Original Article DOI: 10.22043/mi.2020.121099

# An outlook on the diversity of polypores shared between Iran and the Mediterranean area

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**Abstract**: Polypore fungi are an important group of wood-inhabiting basidiomycetes that have significant roles in biomass recycling in forests and woodland ecosystems. Figures on the polypore diversity in Iran have been partly made available through few checklists, but there have been no comparative studies on the pattern of geographic distribution of the species. The prevalence of the Mediterranean bioclimate in Iran, and scattered Mediterranean vegetation in the country have been well-documented. Here, intensive analyses were made for the first time to compare the composition of the polypore species in Iran and the Mediterranean area, based on field records and well-curated explicit checklists. Our analyses reveal a high resemblance of the polypore composition of Iran to the Mediterranean area. It is shown that the majority of the polypore species in Iran (87%) are shared with the Mediterranean region. Noteworthily, there are several rare to very rare, as well as extra European taxa among the shared species in Iran. Moreover, it is shown that about 5% of the Iranian polypore species seem to be 'true Mediterranean', with their major world distribution being in the Mediterranean region. Remarkable shared species are discussed and illustrated. The results of this study would be important in conservation management of the vulnerable forests ecosystems in Iran, especially in the Hyrcanian forests where most of the rare to very rare species arise.

**Key words:** Bracket fungi, Mediterranean flora, poroid fungi, wood-inhabiting basidiomycetes

## INTRODUCTION

Poroid fungi (polypores) are an important group of wood-inhabiting macrobasidiomycetes that have significant roles in biomass recycling in forests and woodland ecosystems. Several species are bio-indicator of areas with high conservation value, and a considerable number of species possess bioactive compounds with diverse biotechnological and pharmaceutical applications (Grienke et al. 2014).

Among territories in southwestern Asia, Iran retains the richest flora and fauna and the highest level of plant endemism (Zohary 1973, Akhani 2006, Noroozi et al. 2018). Comparative figures on the mycota in southwestern Asia are less available. At least for polypores and corticioids, species diversity in Iran seems to be higher than most of the territories in the region (Ghobad-Nejhad et al. 2009, Ghobad-Nejhad & Hallenberg 2012). The forest coverage in Iran is very low, comprising less than 10% of the total area of the country, and is confined to the southern Caspian Sea forests (Hyrcan) as well as Zagros forests in western Iran (Sagheb-Talebi et al. 2014). Hyrcanian forests are the southernmost part of one of the northern Hemisphere biodiversity hotspots 'the Caucasus region', harboring glacial refugia with several relict plants (Röhrig 1991). In a survey on the composition of corticioid fungi in the Caucasus region, it has been shown that this region has possibly contributed as a source of fungal colonization in Europe after Pleistocene glaciations (Ghobad-Nejhad et al. 2012). Recently, Ordynets et al. (2018) concluded that the mean species richness of aphyllophoroids (mostly polypores and corticioids) in Hyrcan almost equals to that of Mediterranean Europe.

Accounts on diversity of polypores in Iran have been documented in studies on wood fungi by Hallenberg (1981), later updated by Ghobad-Nejhad & Hallenberg (2012). Amoopour et al. (2016) provided a checklist for polypores in Gilan province. However, comparative studies on the pattern of geographical distribution of the polypore species in Iran are lacking. In the present study, we made comparisons between the polypore composition in Iran and the

Submitted 6 Dec. 2018, accepted for publication 29 Feb. 2019
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Mediterranean area, also taking adjacent territories in the Caucasus region into account. The Caucasus region comprises southwestern Russia, Georgia, Azerbaijan, Armenia, eastern Turkey, and northern Iran (Ghobad-Nejhad et al. 2009). The Mediterranean area and Iran both embrace some of the remaining north temperate glacial refugia which have been crucial for revival of the north hemispheric biota after the last glacial maxima (Taberlet et al. 1998, Tarasov et al. 2000).

## MATERIALS AND METHODS

The core analysis in this study is based on the most recent account of polypores of the Mediterranean region by Bernicchia & Gorjón (2020), list of Iranian wood-inhabiting basidiomycetes (Ghobad-Nejhad & Hallenberg 2012) and intensive field records by the authors. Moreover, the general distribution pattern for each species (categorized as widespread or common, northern European, southern-central Europe, Mediterr anean, tropical/subtropical, and extra European species) was extracted from various published works including Ryvarden & Melo (2014), Dai (2012), and Ghobad-Nejhad (2011). Rare refers to species which are known by small number of records and their distribution pattern in Europe is not clear. Nomenclature mostly follows Mycobank (www.mycobank.org, accessed August 2019).

## RESULTS

### Polypore shared species between two areas

The most recent account of polypores of the Mediterranean region (Bernicchia & Gorjón 2020) enumerates ca. 372 species for this area. In Iran, a total number of 132 polypore species are present (updated list unpublished) from which, 115 polypore species (87%) are shared with the list of polypores for the Mediterranean region (Fig. 1). In other words, 31% of polypores in the Mediterranean region are also present in Iran.

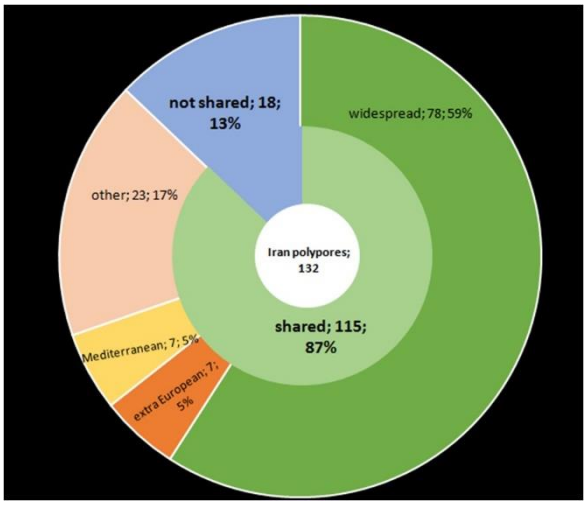


**Fig. 1.** Sunburst chart presenting the absolute numbers and proportion of polypore species shared between Iran and the Mediterranean region. Out of total number of polypores in Iran (132 species), 87% are shared with the Mediterranean region from which, 59% are widespread species, 5% are extra European, 5% are 'true' Mediterranean species, and 18% are central to southern-central European, north European, and rare (marked as 'other' in this chart). Only 13% of Iranian polypores are not shared with the Mediterranean region.

As shown in fig. 1, more than half of the shared species (59%) are widespread or are very-to fairly common in Europe. Twenty-three species (18%) are central to southern-central European, north European, or rare. Seven species (5%) are extra European, and 5% are 'true' Mediterranean species. Widespread species are not discussed here, but selected species from other distribution categories are mentioned in the following paragraphs.

*Cinereomyces lindbladii* (Berk.) Jülich and *Inonotus obliquus* (Ach. ex Pers.) Pilát are mostly distributed in northern Europe, while *Ceriporiopsis gilvescens* (Bres.) Domanski is generally distributed in central Europe. Species belonging to southern to south--central in Europe include: *Ceriporia excelsa* (S. Lundell) Parmasto, *Fuscoporia torulosa* (Pers.) T. Wagner & M. Fisch., *Ganoderma australe* (Fr.) Pat., *Ganoderma resinaceum* Boud., *Gloeophyllum trabeum* (Pers.) Murrill, *Inonotus nidus-pici* Pilát ex Pilát, *Inocutis tamaricis* (Pat.) Fiasson & Niemelä, and *Oligoporus simanii* (Pilát ex Pilát) Bernicchia.

Rare but scattered species in Europe are *Datronia stereoides* (Fr.) Ryvarden, *Gloeoporus pannocinctus* (Romell) J. Erikss., *Steccherinum lacerum* (P. Karst.) Kotir. & Saaren., and *Rhodonia placenta* (Fr.) Niemelä, K.H. Larss. & Schigel. Rare species include: *Daedaleopsis tricolor* (Bull.) Bondartsev & Singer, *Inonotus krawtzewii* (Pilát) Pilát, *Metuloidea fragrans* (A. David & Tortic) Miettinen, *Odoria alborubescens* (Bourdot & Galzin) V. Papp & Dima, *Oligoporus simanii* (Pilát ex Pilát) Bernicchia, *Perenniporia narymica* (Pilát) Pouzar, *Trametes warnieri* (Durieu & Mont.) Zmitr., *Tyromyces kmetii* (Bres.) Bondartsev & Singer, and *Tyromyces fissilis* (Berk. & M.A. Curtis) Donk.

Few species can be regarded as extra European: *Inocutis levis* (P. Karst.) Y.C. Dai is a central Asian species, and *Amylosporus campbellii* (Berk.) Ryvarden is subtropical. Moreover, *Antrodia malicola* (Berk. & M.A. Curtis) Donk, *Ceriporia alachuana* (Murrill) Hallenb., *Loweomyces fractipes* (Berk. & M.A. Curtis) Jülich, *Dichomitus squalens* (P. Karst.) D.A. Reid, and *Pyrofomes demidoffii* (Lév.) Kotl. & Pouzar are almost absent in Europe but widespread in North America or East Asia.

Finally, *Antrodia serpens* (Fr.) P. Karst., *Ceriporia aurantiocarnescens* (Henn.) M. Pieri & B. Rivoire, *Fomitiporia rosmarini* (Bernicchia) Ghobad-Nejhad & Y.C. Dai, *Fomitopsis iberica* Melo & Ryvarden, *Fomitopsis spraguei* (Berk. & M.A. Curtis) Gilb. & Ryvarden, and *Trametes ljubarskyi* Pilát species seem to be predominantly distributed in the Mediterranean Europe or are 'true' Mediterranean. *Phellinus rimosus* (Berk.) Pilát also takes a Mediterranean distribution in

Europe, yet is widespread in Eurasia, Africa, and Australia (Hattori et al. 2014).

**Notes on remarkable shared species**

***Amylosporus campbellii*** (Berk.) Ryvarden

This is an extra European species mostly distributed in tropical-subtropical regions, and was only recently recorded in Sicily by Bernicchia et al. (2017). The species was recorded as associated with a graminaceous plant in southern Iran (Saber & Minassian 1998), a place located in Saharo-Sindian floristic region influenced by a tropical climate.

***Ceriporia alachuana*** (Murrill) Hallenb.

This is a temperate to subtropical species dominantly distributed in southern North America and eastern Asia (Dai 2012), and only seldom reported in Europe. Three collections were reported by Hallenberg (1979) from northern Iran who at that time, assigned them as the first record of the species outside North America.

***Ceriporia aurantiocarnescens*** (Henn.) M. Pieri & B. Rivoire

This is a rare species recorded only from few Mediterranean countries. In Asia, this species has been sporadically reported from Georgia, China, and was recently reported by Amoopour et al. (2016) from Iran. The salmon to later becoming vinaceous pore surface is striking in this species.

***Inocutis levis*** (P. Karst.) Y.C. Dai Fig. 2a

This is apparently a central Asian species growing on different hardwoods, and has not been recorded in Europe. In Iran, it grows successfully on planted *Platanus orientalis* L. and *Ulmus glabra* in urban areas in central Iran, and seems to be well-adapted to air-polluted metropolitans (Ghobad-Nejhad & Kotiranta 2008, Hashemi et al. 2017).

***Inonotus krawtzewii*** (Pilát) Pilát Fig. 2b

The distribution range of this species is not well-clarified. Collections in Europe referred to as *Inonotus andersonii* (Ellis & Everh.) Cerný are known from a few countries. Zhou et al. (2014) confined *I. andersonii* to North America, and verified *I. krawtzewii* from Slovakia and Czech Republic, suggesting that all reports of *I. andersonii* from Europe (as well as Asia) should be named *I. krawtzewii*. Interestingly, *I. krawtzewii* was recently reported on *Quercus brantii* from several localities in western Iran and unlike elsewhere, it acts as a destructive trunk-rot agent in Zagros forests (see full account and illustrations in Ghobad-Nejhad 2016).

***Fomitiporia rosmarini*** (Bernicchia) Ghobad-Nejhad & Y.C. Dai Fig. 2c

The species seems to be truly Mediterranean, reported externally only once from Iran (Ghobad-Nejhad & Dai 2007). Polemis et al. (2018) suggested *F. rosmarini* as a candidate bioindicator polypore to be used for habitat evaluation and conservation.

***Fomitopsis iberica*** Melo & Ryvarden Fig. 2d

This is a rare Mediterranean species known also from Armenia, Iran, Georgia, and the Russian Caucasus. Vouchers of Iranian specimens were examined by Vampola (1996) and Spirin et al. (2006).

***Metuloidea fragrans*** (A. David & Tortic) Miettinen

This is a rare species in southern-central Europe, and has been rarely recorded in China (Dai 2012). Amoopour et al. (2016) recently reported it from northern Iran, as *Antrodiella fragrans* (A. David & Tortic) A. David & Tortic, and is also known from a collection made by Nils Hallenberg in the Russian Caucasus (Ghobad-Nejhad et al. 2009).

***Odoria alborubescens*** (Bourdot & Galzin) V. Papp & Dima

This is an interesting, rare European species associated with old-growth *Fagus* forests, and its taxonomy, distribution and ecology has been fully discussed recently by Papp & Dima (2017). Its occurrence in the Caucasus region (Ghobad-Nejhad et al. 2009) is assumedly the southern- or easternmost known extension of its range.

## DISCUSSION

The influence of the Mediterranean climate and vegetation in Iran has been subject to different studies. According to recent analyses, there are three macrobioclimates in Iran *viz.*, Temperate, Mediterranean, and Tropical, corresponding to the three floristic regions Euro-Siberian (comprising Hyrcan), Irano-Turanian (interior Iran), and Saharo-Sindian (southern Iran) (Djamali et al. 2011). As shown *l.c.*, the Mediterranean is the most prevalent macrobiocliamte in Iran, also partly represented in the northern Temperate and southern Tropical floristic regions of the country.

Despite the prevalence of Mediterranean bioclimate in Iran, the Mediterranean vegetation is not much established because of high level of continentality in Iran (Raven 1971, Djamali et al. 2011). Mediterranean vegetation, comprises only 1.5% of the total flora in Iran, in the form of scattered vegetation of some species including *Cupressus sempervirens, Buxus sempervirens, Cercis siliquastram, Ficus carica, Jasminum fruticans, Myrtus communis, Rubus tomentosus*, as well as *Olea europea* (Zohary 1963). Vegetations under various Mediterranean bioclimates include isolated conifer communities of northern Iran, the Zagros Mountains in western Iran with *Quercus brantii*-dominated open woodlands, and xerophytic communities in eastern Zagros with *Pistacia* spp., *Amygdalus* spp., and *Jumiperus excelsa* (Djamali et al. 2011).

According to Zohary (1963), some current Mediterranean woody plant genera predominantly


**Fig. 2.** In situ basidiocarp photos of some polypore species discussed in the text. a. *Inocutis levis* (coll. Ghobad-Nejhad, in 2016); b. *Inonotus krawtzewii* (coll. Ghobad-Nejhad, in 2015); c. *Fomitiporia rosmarini* (Bernicchia 1464); d. *Fomitopsis iberica* (Cartabia 3142); e. *Fomitopsis spraguei* (Bigelow, June 2017); f. *Trametes ljubarskyi* (Botyakov 3627). Photos: Ghobad-Nejhad (a, b), Bernicchia (c–f).

distributed in Irano-Turanian region e.g., *Amygdalus*, *Pistacia*, and *Prunus*, have possibly been originated from the latter region. Besides, to better explain the flora relationships, it is possible to speculate some sort of 'species turnover' or replacement of species in plant communities, in a way that some Mediterranean species absent in Iran may have been replaced with other, functionally equivalent, species. This might also apply to wood-associated fungi such as polypores.

The majority of polypores of Iran (87%) are shown to be shared with the Mediterranean region. Many of the species are found throughout Europe, but there are

also several rare to very rare, and even extra European species. About 5% of the Iranian species seem to be 'true Mediterranean', mostly distributed in the Mediterranean region.

Despite their very small land coverage, forests in Iran hold several rare European polypore species, some of which come across their eastern or southernmost known range extensions in Iran. One reason might be that the Hyrcanian region exhibits highly diverse topography, climate, and flora over its quite small area, which might equal to the variation of those factors over far larger areas at least in temperate Europe (Noroozi et al. 2018). Unfortunately, these pristine forests undergo severe range reduction and their naturalness is rapidly decreasing due to overexploitation.

Some 13% of polypores species in Iran are not shared with the Mediterranean region. Among these are: *Antrodiella semisupina* (Berk. & M.A. Curtis) Ryvarden, *Cyanotrama rimosa* (Murrill) Ghobad-Nejhad, *Fuscoporia senex* (Nees & Mont.) Ghobad-Nejhad, *Ganoderma kosteri* Steyaert, *Ganoderma manoutchehrii* Steyaert, *Ganoderma tsugae* Murrill, *Inonotus plorans* (Pat.) Bondartsev & Singer, *Melanoporia nigra* (Berk.) Murrill (North America), *Phellinus allardii* (Bres.) S. Ahmad, *Phellinus inermis* (Ellis & Everh.) G. Cunn., *Phylloporia spathulata* (Hook.) Ryvarden (possibly neotropical), *Polyporus udus* Jungh., *Sanghuangporus ligneus* Ghobad-Nejhad, *Sanghuangporus lonicerinus* (Bondartsev) Sheng H.Wu, L.W. Zhou & Y.C. Dai, and *Tomophagus colossus* (Fr.) Murrill. Interestingly, the majority of the Iranian polypores absent from the Mediterranean region seem to be extra European (taxonomically ambiguous *Ganoderma kosteri*, *G. manoutchehrii*, and *G. tsugae* not considered), are mostly of tropical origin, and are also absent from mainland Europe.

Evidently, fine molecular studies are required to verify conspecificity of geographically different isolates of widespread species, or different isolates of biogeographically disjunctive species. Phylogeographical studies are essential to elaborate on complex distribution patterns. Moreover, combining fruiting body-guided inventories with community metagenomics will help to achieve a more precise understanding of the distribution pattern of polypores in Mediterranean areas and Iran.

## ACKNOWLEDGEMENTS

The authors thank the helpful comments made by the reviewers which helped to improve the work.

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# نگاهی بر تنوع قارچ‌های پلی‌پور مشترک بین ایران و ناحیه مدیترانه‌ای

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**چکیده:** پلی‌پورها گروه مهمی از قارچ‌های چوبزی هستند و نقش بارزی در بازیافت زیتوده در اکوسیستم‌های جنگلی دارند. در مورد تنوع قارچ‌های پلی‌پور در ایران تعداد اندکی فهرست منتشر شده است، لیکن بررسی‌های مقایسه‌ای در خصوص الگوی پراکنش جغرافیایی گونه‌ها در دست نیست. در ایران نوع غالب بیواقلیم مدیترانه‌ای و حضور پوشش‌های مدیترانه‌ای پراکنده به خوبی نشان داده شده است. در این پژوهش، برای اولین بار ترکیب گونه‌ای قارچ‌های پلی‌پور ایران با ناحیه مدیترانه‌ای بر اساس داده‌های میدانی و فهرست های تخصصی و به-روز مورد مقایسه و بررسی قرار گرفت. نتایج واکاوی، شباهت بالایی بین ترکیب گونه‌ای پلی‌پورهای ایران با ناحیه مدیترانه‌ای را نشان می‌دهد. بر این اساس، ۸۷٪ پلی‌پورهای ایران با پلی‌پورهای ناحیه مدیترانه مشترک هستند. قابل توجه آنکه در میان گونه‌های مشترک، تعدادی گونه نادر، بسیار نادر و غیر اروپایی نیز در ایران حضور دارند. به نظر می رسد حدود ۵٪ پلی‌پورهای ایران 'مدیترانه‌ای واقعی' هستند، و پراکنش عمده آنها در ناحیه مدیترانه‌ای متمرکز است. تصاویر و توضیحات تکمیلی برای برخی گونه‌های قابل توجه ارائه شده است. نتایج این پژوهش می‌تواند در مدیریت حفاظت از اکوسیستم‌های جنگلی در معرض خطر موثر باشد، به ویژه جنگل‌های هیرکانی که خواستگاه اغلب گونه‌های نادر و بسیار نادر مشخص شده در این پژوهش است.

**کلمات کلیدی:** قارچ‌های طاقچه‌ای، فلور مدیترانه‌ای، ماکرومیست‌های پلی‌پور، قارچ‌های چوبزی، بازیدیومیست

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تاریخ دریافت: ۱۳۹۷/۰۹/۱۵ تاریخ پذیرش: ۱۳۹۷/۱۲/۱۰