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Research Article

New Records with an Updated Checklist of Aphyllophoroid Fungi (Basidiomycota) in Iraq

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ABSTRACT: Based on earlier research and field sample collections, a checklist of the species composition of aphyllophoroid basidiomycetes in Iraq is presented. A total of 26 species belonging to 20 genera, 13 families, and 8 orders are reported. Among them, *Fuscoporia torulosa* (Pers.) T. Wagner & M. Fisch., *Phellinus hartigii* (Allesch. & Schnabl) Pat., and *Stereum hirsutum* (Willd.) Pers. are newly recorded for the Iraqi mycobiota. The orders Russulales, Polyporales, and Hymenochaetales displayed the greatest species diversity. The families with the highest number of taxa were Stereaceae and Hymenochaetaceae (5 species each), followed by Phanerochaetaceae (4 species) and Atheliaceae (2 species). The other reported families—Corticaceae, Fomitopsidaceae, Hydnaceae, Hydnodontaceae, Oliveoniaceae, Peniophoraceae, Plerulaceae, Rickenellaceae, and Schizoporaceae—were represented by a single species each. The distribution and habitat of each species in Iraq are also summarized. This checklist will be useful for future studies on fungal diversity in the country.

KEYWORDS: Aphyllophoroid fungi, Basidiomycota, Checklist, Iraq.

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1. INTRODUCTION

Aphyllophoroid fungi are characterized by developing basidiomata with one-celled basidia and smooth, toothed, irregularly folded to poroid hymenophores instead of gills or a closed reproductive structure. Following that, a molecular phylogenetic analysis revealed that aphyllophoroid fungi belong to the orders Agaricales, Atheliales, Cantharellales, Corticiales, Gloeophyllales, Hymenochaetales, Polyporales, Russulales, and Trechisporales, and are extremely phylogenetically varied groupings of Basidiomycota (Larsson, 2007; Jang et al., 2016; He et al., 2019; Wijayawardene et al., 2020; Maekawa, 2021; He and Zhao, 2022). They are the primary wood decomposers responsible for brown and white rot, as well as playing essential roles in nutrient cycling and soil formation in forest ecosystems (Hakala et al., 2004; Lonsdale et al., 2008). Although some aphyllophoroid species are mycorrhizal and do not contribute to wood deterioration, they play a crucial role in maintaining forest health (Rosenthal et al., 2017).

Natural products are abundant in aphyllophoroid fungi. They produce a variety of physiologically active chemicals, some of which have been utilized in medicine for a long time (Wasser and Weis, 1999; Sevindik et al., 2021). Furthermore, white rot fungi can produce a variety of ligninolytic enzymes with broad substrate specificities, allowing them to be used in a variety of biotechnological applications such as bio-pulping, wastewater treatment, and bioremediation of polycyclic aromatic hydrocarbons and other chemicals (Hakala et al.2004; Gao et al. 2010; Pozdnyakova, 2012).

Some aphylophoroid basidiomycetes associated with pine bark beetles serve as important nutritional sources for beetles (Harington, 2005; Harrington et al., 2021). Numerous plant diseases are known to be caused by aphylophoroid fungi, including Athelia rolfsii (Curzi) Tu & Kimbrough, the causal agent of southern Sclerotium rot (Tu and Kimbrough, 1978), and esca-related wood rots on grapevines caused by species in Hymenochaetales (Fischer and Binder, 2004; Cloete et al., 2015).

Iraq is a Middle East country with a total area of 438.317 square kilometer and is located between latitudes 33 00 ° N and longitudes 44 00 ° E. From the north, Iraq is bordered by Turkey, on the east Iran, on the northwest, Syria, from the west, Jordan and on the south, Saudi Arabia and Kuwait (Al-Ansari, 2021). According to Guest and Townsend (1966), Iraq may be classified into four regions based on the type of the physical landscape (Mountain Region, Plateau and Hills Regions, the Mesopotamian plain and Jazeera and Western Plateau). The climate is mostly arid, with mild to cool winters and dry, hot summers. The average temperature ranges from below zero in January to above 48◦C in July and August. The northern mountainous parts bordering the Iranian and Turkish borders experience cold winters with sporadic heavy snowfall that melts in early spring. The majority of the yearly rainfall, which averages between 10 and 18 cm from December through April. In comparison to the central or southern arid regions, the northern mountainous region of Iraq experiences noticeably more precipitation (Al-Ansari, 2021).

Only very limited published data is available on the diversity of aphylloporoid species from Iraq, comparable to adjacent countries, particularly Iran and Turkey. However, few authors have made notable contributions to the exploration of the aphyllophoroid fungi in Iraq. Rattan and Abdullah (1976) earlier reported seven species, including a novel species *Galzinia cystidiata* Rattan and Abdullah. Subsequently, Rattan et al. (1978) added 9 species, including a novel species, *Gloeocystidiellum zawitense* Rattan, Abdullah and Ismail. All the reported species were collected from a coniferous forest in Duhok province, North Iraq. Rattan and Al-Dboon (1980) investigated the fungi associated with date palm trees (Phoenix dactylifera L.) from Basrah Province, Southern Iraq. They reported seven aphyllophoroid fungal species. Aziz and Toma (2012) reported *Phellinus igniarius* (L.) Quél and *Stereum rugosum* Pers. and *Bjerkandera adusta* P.Karst ., on trunks of Oak trees from Qandil Mountains, Erbil province, North Iraq. Al-Khesraji et al. (2017) reported *Phellinus pomaceus* (Pers.) Maire on branches and trunk of poplar and willow plants from Salahaddin province, the middle of Iraq.

The goal of this study is to provide an updated list of aphyllophoroid fungi from Iraq, while also contributing to our understanding of the region's fungal diversity.

2. MATERIALS AND METHODS

The majority of the included species in this checklist were collected between 1976 and 2017. Recent collections, including new reported taxa, were made from forest regions dominated by Aleppo oak (*Quercus aegilops* L.) in Duhok Province, northern Iraq, between April and November 2015. Identifications of the newly recorded taxa were based on Rattan (1977), Ryvardin and Gilberston (1994), and Bernicchia and Gorjón (2020). The names of fungi are given in accordance with the Index Fungorum database (www.indexfungorum.org).

3. RESULTS AND DISCUSSION

The reported species were grouped at the order level, in accordance with the recent classification of Basidiomycota (He et al., 2019; Gorjon, 2020; Wijayawardene et al., 2020; Maekawa, 2021), and arranged as shown in Table 1.

The present paper is the first updated checklist on aphyllophoroid fungi in this country. Of these 26 species listed, 8 species belong to the order Hymenochaetales, accounting for 30.7% of the total species, 6 species to the order Russulales (23.1%), 5 species to Polyporales (19.2%), 2 species to each of Cantharellales and Atheliales(7.7%) and 1 species belongs to Agaricales, Corticales and Trechisporales (3.8%) (Table 2.). The reported taxa of aphyllophoroid fungi are much lower than those in neighboring countries (Ghobad-Nejhad et al., 2009; Doğan, 2011; Amoopour et al., 2016; Doğan et al., 2021). This may be partially ascribed to the limited number of expert mycologists doing field surveys and the comparatively small areas that have been explored. Additionally, the small mountainous region in the north and north-east of Iraq, which borders Turkey and Iran, is the only place where forest woody plants that serve as a good host for aphyllophoroid fungi may be found.

Table 1. List of reported fungal species.

Fungal name	Order	Family	Substrate	Location	References
Radulomyces submolaris Parm. 1968	Agaricales	Pterulaceae corner 1970	Burnt log of *Pinus brutia*,31 January 1976	Zawita, Duhok 36.9047° N, 43.1359° E	Rattan & Abdullah (1976)

Amphinema byssoides (Pers.) J. Erikss.1958	Atheliales	Atheliaceae Jülich 1982	Slash of *Pinus brutia*,31 January 1976	Zawita, Duhok 36.9047° N, 43.1359° E	Rattan & Abdullah (1976)
Athelia acrospora Jülich 1972			Slash of *P.brutia*,29 January 1976	Zawita, Duhok (36.9047° N, 43.1359° E)	Rattan & Abdullah (1976)
Sistotrema brinkmanii (Bres.) Erikss.1948	Cantharellales	Hydnaceae Chevall. 1826	Leaf bases of date palm *Phoenix dactylifera* L, April 1977	Basrah province 30.5258° N, 47.7738° E	Rattan & Al-Dboon (1980)
Oliveonia pauxilla (Jackson) Donk 1958		Oliveoniaceae P.Roberts 1998	decaying leaf bases of date palm, January 1978	Basrah province (30.5258° N, 47.7738° E),	Rattan & Al-Dboon (1980)
Galzinia cystidiata S.S.Rattan &Abdullah 1976	Corticales	Corticaceae Corticaceae Herter 1910	logs of *Pinus brutia* Ten.,29 January 1976	Zawita,Duhok(36.9047° N, 43.1359° E).	Rattan & Abdullah (1976)
**Fuscoporia torulosa* (Pers.) T.Wagner & M.Fisch.2001	Hymenochaetales	Hymenochaetaceae Donk 1948	Aleppo Oak wood *(Quercus aegilops* L), April 2015	Gara Mountain, Duhok (37°2'37" N 43°9'25" E),	Yasin (2016)
**Phellinus hartigii* (Allesch. &Schnabl) Pat., 1903			Aleppo Oak wood *(Quercus aegilops* L), Nov. 2015	Ghlbish village, Duhok 37°5'23" N 43°11'40" E	Yasin (2016).
Phellinus igniarius (L.) Quél.1886			Deciduous trees April, 2010	Qandil mountains, Erbil 36°32′28″N 44°59′46″E	Aziz & Toma (2012)
Phellinus pini (Thore ex Fr.) Pilat.1974			Living tree of *P.brutia*, 31 January,1976	Suara Tuka,Duhok 37°0'43N 43°13'32" E	Rattan et al. (1978)
Phellinus pomaceus (Pers.) Maire 1933			Branches and trunk of poplar, July 2017	Al-Alam, salahaddin 34.5338° N, 43.4837° E	Al-Khesraji et al. (2017)
Peniophorella pubera (Fr.) P. Karst.1889		Rickenellaceae Vizzini 2010	Leaf bases of date palm *Phoenix dactylifera*.Throughout the year 1977	Basrah province 305258° N, 47.7738° E	Rattan & Al-Dboon (1980)
Xylodon sambuci (Pers.) Tura, Zmitr, Wasser &Spirin		Schizoporaceae Jülich 1982	Decaying leaf base of date palm, throughout the year	Basrah province 305258° N, 47.7738° E	Rattan & Al-Dboon (1980)
Trichaptum abietinum (Pers.ex J.F.Gmel.)Ryvarden 1972	Hymenochaetales genera incertae sedis		On fallen branches of *Pinus brutia*,31 January 1976	Suara Tukah, Duhok 37°0'43" N 43°13'32" E	Rattan et al. (1978)

Antrodia albida (Fries) Donk 1966	Polyporales	Fomitopsidaceae Jülich 1982	On the dead trunk of a date palm. July 1977	Basrah province 30.5258° N, 47.7738° E	Rattan&Al-Dboon (1980)
Bjerkandera adusta (wild.) P. Karst.1879		Phanerochaetaceae Jülich 1982	On decaying conifer wood, April 1976	Mosul forest, Nineva 36° 20' 24.0'' N, 43° 7' 48.0036'' E	Rattan et al. (1978)
			On deciduous trees, April 2010	Rusti village, Qandil mountain. 36°32′28″N 44°59′46″E	Azziz & Toma (2012)
Phaeophlebiopsis ravenelii (Cooke) Zmitr. 2018			On bark of *P.brutia*, 30 January 1976	Suara Tukah, Duhok 37°0'43'' N 43°13'32'' E	Rattan et al. (1978)
			On log of *P.brutia*, January 1976	Zawita forest,Duhok 36.9047° N, 43.1359° E	
Phanerochaete sordida (P.Karst.)J.Eriksss.&Ryvarden 1977			On a fallen trunk of date palm *(Phoenix dactylifera* l.), October 1977	Basrah province 30.5258° N, 47.7738° E	Rattan & Al-Dboon (1980)
Phlebiopsis gigantea (Fr.) Jülich, 1978			on stump of *Pinus brutia* Ten.,31 January 1976	Zawita forest, Duhok. 36.9047° N, 43.1359° E	Rattan et al. (1978)
Asterostroma medium Bres. 1920	Russulales	Peniophoraceae Losty 1907	On a slash of *Pinus brutia* Ten.,29 January 1976	Zawita forest, Duhok. 36.9047° N, 43.1359° E	Rattan & Abdullah (1976)
Gloeocystidiellum luridum (Bres.) Boidin 1951		Stereaceae Pilat 1930	On decaying wood of *Pinus brutia* Ten., 29 January 1976	Zawita forest, Duhok. 36.9047° N, 43.1359° E	Rattan & Abdullah (1976)
Gloeocystidiellum zawitense S.S.Rattan, Abdullah & Ismail 1978			On wood of *Pinus brutia* Ten., 29 January 1976,	Zawita forest, Duhok. 36.9047° N, 43.1359° E	Rattan et al. (1978)
**Stereum hirsutum* (Willd.) Pers. 1800			On *Quercus aegilops*, April 2015	Gara Mountain, Duhok. 43°11'19.96"E 37° 4'52.63"N	Yasin (2016)
Stereum rugosum Pers. 1794			On the rotten stump of *Pinus brutia* Ten., 31 January 1976	Zawita forest, Duhok. 36.9047° N, 43.1359° E.	Rattan et al. (1978)
			On the stump and trunks of	Qandil Mountains, Erbil.	Azziz & Toma (2012)

			trees, of different April 2010,	36°32′28″N 44°59′46″E	
Stereum sanguinolentum (Alb. & Schw.ex Fr.) Fr.1838			On the stump of Pinus brutia Ten., 29 January 1976,	Zawita forest,Duhok. 36.9047° N, 43.1359° E	Rattan & Abdullah (1976)
Trechispora farinacea (Pers.) Liberta 1966	Trechisporales	Hydnodontaceae Jülich, 1982	On trunks of fallen date palms and decaying leaf bases, February to March 1977	Basrah province, 30.5258° N, 47.7738° E	Rattan & Al-Dboon (1980)

Legend: *New record for Iraq Mycodata.

It is interesting to include in this checklist seven aphyllophoroid species that were found on non-woody plants (Phoenix dactylifera L.), as revealed by the study of Rattan and Al-Dboon (1980) in Basrah Province, South Iraq. These include *Antrodia albida* (Fries) Donk, *Sistotrema brinkmanii* (Bres.)Erikss., *Oliveonia pauxilla* (Jackson) Donk, *Peniophorella pubera* (Fr.) P.Karst., *Xylodon sambuci* (Pers.) Tura, Zmitr, Wasser & Spirin, *Phanerochaete sordida* (P.Karst.)J.Erikss. & Ryvarden and *Trechispora farinacea* (Pers.) Liberta.

Table 2. Distribution of families, genera and species of aphyllophoroid fungi in their respective orders.

Order	Family	Genera	Species	% Of total species
Hymenochaetales	3	5	8	30.7
Russulales	2	3	6	23.1
Polyporales	2	5	5	19.2
Cantharellales	2	2	2	7.7
Atheliales	1	2	2	7.7
Agaricales	1	1	1	3.8
Corticales	1	1	1	3.8
Trechisporales	1	1	1	3.8
8	13	20	26	-

Hymenochaetales, Russulales and Polyporales showed the highest species diversity. Species diversity of these orders is also higher in other parts of the world (Ghobad-Nejhad et al.2009; Dai, 2012; Prasher and Deepali, 2013; Ryvarden and Melo, 2014; Zhou et al.2016). In a recent study on the diversity of this group of fungi, He et al. (2022) in R.P. China found that Polyporales had the highest species diversity (70.53%), followed by Russulales (12.63%) and Hymenochaetales (6.32%), while Gafforov et al. (2020) in Uzbekistan found a similar pattern, with Polyporales followed by Hymenochaetales and then Russulales.

4. CONCLUSION

This study provides the first comprehensive checklist of aphyllophoroid basidiomycetes in Iraq, documenting 26 species across diverse families and orders. The identification of Fuscoporia torulosa, Phellinus hartigii, and Stereum hirsutum as new records highlights the limited exploration of the country's fungal diversity and emphasizes the need for further surveys across different habitats. The dominance of taxa within Russulales, Polyporales, and Hymenochaetales reflects their ecological adaptability and widespread occurrence. This checklist establishes a baseline for future ecological, taxonomic, and conservation-oriented research on wood-inhabiting basidiomycetes in Iraq.

Ethical Statement

Not Applicable.

Conflicts of Interest

The authors declare no competing interests.

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