The Genus *Ganoderma* in Iran: A Comprehensive Survey of Taxonomic Studies and Its Impact on Forest Trees

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Abstract

Ganoderma Karst. is widely acknowledged within the Ganodermataceae for its exceptional healing properties for humans, but it also can cause diseases in plants. This study aims to compile all original articles and texts published on the morphological identification, phylogeny, host relationships, and dispersal of the *Ganoderma* species in Iran until 2024. The species predominantly inhabit Angiosperm trees, with occasional occurrences on gymnosperms. Recent studies showed that more trees have been infected with these species in Iran. According to the literature, nine *Ganoderma* species were reported in various provinces of Iran, including East Azerbaijan, Guilan, Mazandaran, Golestan, Khuzestan, and others. However, recent studies have revealed discrepancies in the previously reported species. One species (*G. australe* (Fr.) Pat.) was misidentified, while two other species (*G. manoutchehrii* Steyaert and *G. kosteri* Steyaert) have not been encountered during recent field studies conducted by recent Iranian mycologists. Although a herbarium sample of *G. kosteri* was found in the Meise Herbarium, no recent field collections have mentioned the existence of this species in Iran. Furthermore, this article discusses the presence of another reported species in Iran, *Ganoderma vanheurnii* Steyaert. Recent morphological and molecular studies in Iran have confirmed the existence of five species in recent years, which have had significant implications for trees and the ecosystem. This review assists environmental researchers in comprehending the forest destruction caused by the *Ganoderma* species. Additionally, it can assist taxonomists in precisely distinguishing similar species and properly introducing them to scientists engaged in pharmaceutical research on *Ganoderma*.

Keywords: *Ganoderma*, Taxonomy, Host relationship, Pharmaceutical aspects, Iran

Introduction

The genus *Ganoderma* is categorized under Polyporales, Ganodermataceae (Upadhyay, 2014). Over time, the species of *Ganoderma* have gained recognition for their valuable therapeutic properties.

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The earliest documentation of their healing abilities can be traced back to the "Classic of Materia Medica" authored by Shen Nong (Bodeker, 2012). Among these species, *G. lingzhi* previously known as *G. lucidum*, has been extensively utilized in medicine (Cao et al., 2012). Apart from their medicinal value, the species within this genus are known to act as parasitic or saprophytic agents on various trees (Tchoumi et al., 2018). Given the significance of these species, research on their taxonomy, healing properties, and plant pathogenicity has been conducted since the late twentieth century (Steyaert, 1972; Ryvarden, 1991; El-Mekkawy et al., 1998; Moncalvo et al., 2000; Ooi et al., 2002; Lee et al., 2006; Wasser et al., 2006; Saltarelli et al., 2009; Cao et al., 2012; Simone & Annesi, 2012; Bishop et al., 2015; Zeng et al., 2017; Huang et al., 2019).

It is estimated that there are approximately 250-400 *Ganoderma* species worldwide (Moncalvo et al., 1995; Richter et al., 2015), while only a maximum of nine species have been reported in different provinces of Iran, inhabiting both angiosperm and gymnosperm trees (Moradali et al., 2007; Ghobad-Nejhad & Hallenberg, 2012; Keypour et al., 2014a; Keypour et al., 2014b; Keypour & Asef, 2020). Considering the significance of the genus and the uncertainty of the species' presence in Iran, this paper aims to discuss the taxonomic status, accuracy of species availability reports, host relationships, and diversities of species of the genus *Ganoderma* in the country.

Methods

The present study aimed to compile a comprehensive collection of published articles and texts pertaining to the genus *Ganoderma* in Iran. To achieve this, a thorough search was conducted across multiple scholarly databases including Google Scholar, PubMed, ScienceDirect, Civilica, and SID. Additionally, original texts from libraries, materials provided by previous researchers, and conference papers were meticulously examined, without imposing any restrictions on the publication dates, up until 2024. Furthermore, the "Herbarium IRAN" was chosen as the main source for investigating *Ganoderma* samples that had been collected by eminent scientists. Communication with other Herbaria was also established to obtain information regarding samples from Iran that were deposited in their respective collections. Through a rigorous evaluation process, only authentic and reliable articles and texts were selected for analysis, thereby ensuring the accuracy and robustness of the collected references used in the preparation of this article.

Results

Taxonomy

Ganoderma is classified taxonomically within Basidiomycota, Agaricomycetes, Polyporales, Ganodermataceae, as documented by Keypour et al. (2019). This cosmopolitan genus has been the subject of multiple studies conducted by various scientists in Iran, including Steyaert (1972), Moradali et al. (2007), Ghobad-Nejhad & Hallenberg (2012), and Amoopour et al. (2016) (Table 1). Among the nine species reported in Iran, *Ganoderma colossus* has been reclassified under the scientific name *Tomophagus colossus*. Additionally, it has been verified that *Ganoderma adspersum* is the accurate name for the species previously identified as *Ganoderma australe* in Iran. The morphological resemblance between *G. adspersum* and *G. australe* often leads to misidentification of the former in Iran. Furthermore, field studies conducted by mycologists in recent years have not yielded any evidence of *Ganoderma manoutchehri* and *Ganoderma kosteri*, two other species previously reported from Iran.

History of morphological identifications and numerical taxonomy

Various researchers, including Steyaert (1972), Adaskaveg and Gilbertson (1988), and Ryvarden (2000), have employed morphological characteristics to discriminate between different *Ganoderma* species. It should be noted that taxonomic confusion can arise due to the extensive morphological variability exhibited by these species (Ryvarden, 2000; Hapuarachchi et al., 2015). Despite this challenge, morphological studies serve as an initial step in species identification. Notably, *G. lucidum* Karst. was first documented in northern Iran by Buhse (1860), and subsequent reports on this species were provided by Khabiri (1968) and Saber (1987) (Table 2). Similarly, *G. applanatum* (Pers.) Pat. was first reported by Khabiri (1968) and Steyaert (1975) in Iran, followed by Saber and Minassian (2000). Saber and Minassian (2000) and Saber and Esmaeili Taheri (2004) documented the first occurrence of *G. australe* (Fr.) Pat. in Iran. The specimens of *G. kosteri* Steyaert. was collected by Ershad and Izadyar, while the sole sample of *G. manoutchehrii* Steyaert. was reported by Steyaert from Iran (Steyaert, 1972; Moradali et al., 2007; Ghobad Nejhad & Hallenberg, 2012). *G. resinaceum* Boud. was reported by Steyaert (1980), Saber (1987), and Saber and Minassian (2000), followed by the report of *G. tsugae* Murrill. from Iran by Saber & Minassian (2000). Steyaert (1972) briefly mentioned *G. vanheurnii* Steyaert. in Iran as a new taxon in the abstract of an article; however, in the description, the examined species was attributed to Indonesia, and no further information regarding its habitat in Iran was provided. In 2007, Moradali et al. conducted a morphological study on *Ganoderma* species in Iran, presenting an identification key with seven species categorized into two subgenera: *Elfivingia* subgenus (non-laccate species), including *G. applanatum, G. adspersum, G. colossus,* and *Ganoderma* subgenus (laccate species), comprising *G. lucidum, G. resinaceum, G. tsugae, and G. manoutchehrii*. Micro- and macro-morphological characteristics, as well as host associations, were the primary criteria employed to differentiate these species in their investigation. They presented a species identification key for *Ganoderma* in Iran, comprising seven species. However, their fieldwork efforts resulted in the collection of only four species, namely *G. applanatum, G. adspersum, G. lucidum,* and *G. resinaceum* from the northern regions of Iran (Fig 1.). The remaining three samples were either previously reported by other researchers or obtained from specimens deposited in the IRAN Herbarium (Steyaert, 1972; Saber and Minassian, 2000; Saber,

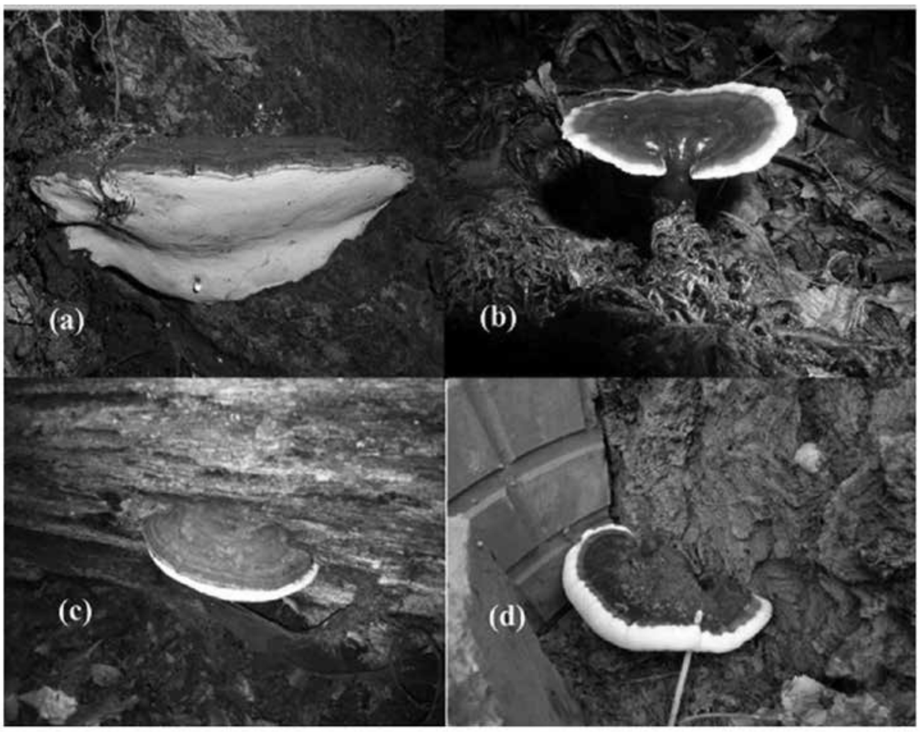

Fig 1. Four *Ganoderma* species collected from Iran; a) *G. applanatum*, b) *G. lucidum*, c) *G. adspersum*, d) *G. resinaceum*

2000). Recent investigations conducted by other scientists in the Hyrcanian forests of northern Iran led to report of five out of the nine previously documented *Ganoderma* species in Iran (Keypour et al., 2014a; Badalyan and Borhani, 2019). Figure one illustrates the macromorphological features of four species collected from the Hyrcanian forests. Among these species, *G. adspersum* which often misidentified as *G. australe* and *G. lucidum* have been frequently reported in all parts of Hyrcanian forests and mostly in Guilan Province respectively (Keypour et al., 2014; Badalyan & Borhani, 2019). According to Moncalvo and Buchanan (2008), *G. australe* is exclusively found in the Southern hemisphere, while *G. adspersum* is distributed in the northern hemisphere. Although there is a report of *G. australe* in the Kew Botanical Garden which this occurrence can be attributed to horticultural activities involving the introduction of the fungus's host from the Southern hemisphere. Thus, the appropriate scientific name for the species in Iran is *G. adspersum*. In contrast to the previous findings, *G. applanatum, G. tsugae*, and *G. resinaceum* were either absent or rarely encountered in Guilan Province (Keypour et al., 2014a; Amoopour et al., 2016). Subsequent investigations employing numerical taxonomy and other morphological studies on *Ganoderma* species in Iran revealed that these species could be classified into two distinct clades: non-laccate and laccate *Ganoderma*, based on their morphological characteristics (Keypour et al., 2014b). However, these studies demonstrated that host relationships and morphological traits were inadequate for reliable species identification (Keypour et al., 2014a; Keypour et al., 2014b). Notably, a novel host, *Pinus taeda* L., was reported for a collected sample in Iran, which exhibited distinct morphological and cultural features. Subsequent investigations confirmed the identification of this sample as *G. lucidum* but the species has been separated from other collected *G. lucidum* specimens in the UPGMA dendrogram (Keypour et al., 2014b; Keypour et al., 2020).

Molecular identification, phylogeny and genetic diversity

The genus *Ganoderma* is known for its complex nature, with many species exhibiting similar morphological characteristics. Relying solely on morphological traits and host relationships for species identification can lead to erroneous conclusions in studies (Ryvarden, 2000). To resolve taxonomic discrepancies, Pires and Marinoni (2010) emphasized the utilization of molecular characteristics for accurate identification. Molecular markers such as the internal transcribed spacer (ITS) and mitochondrial small subunit (mtSSU rDNA) have proven valuable in elucidating phylogenetic relationships among *Ganoderma* taxa (Cao et al., 2012; Kinge et al., 2012). In a survey conducted by Badalyan et al. (2015) on genetic resources and mycelial characteristics of various Polypores from different countries using ITS sequencing, it was revealed that the Iranian strain (Gl-1093), previously identified as *G. lucidum* based on morphological features, is *G. resinaceum*.

Furthermore, investigations focusing on the ITS of a single *Ganoderma* sample confirmed the effective confirmation of the previous morphological identification of a collected sample from North Iran as *G. lucidum* (Heydarian and Hatamian-zarmi, 2017). Phylogenetic studies conducted on *Ganoderma* species in Iran utilizing ITS and mtSSU rDNA markers indicated that, despite Iran's geographical location in the Middle East (Southwest Asia), Iranian *Ganoderma* species are sister taxa to European *Ganoderma* species (Keypour et al., 2020). Additionally, molecular sequence analysis of *G. lucidum, G. resinaceum, G. adspersum*, and *G. applanatum* from European, trans-Caucasian, and Iranian regions demonstrated their close relationship while being distinct from East Asian strains (Badalyan et al., 2015; Keypour et al., 2020). In 2021, another experiment conducted using ITS sequencing of some polypores collected from Alamdardeh Forest in Mazandaran, Iran, showed that the *G. adspersum* (STF113) in their study is similar to the sample (HSBU200894) that was collected by Keypour et al. (2020), from Guilan, Iran (Keypour et al., 2020; Bari et al., 2021).

Genetic diversity plays a crucial role in shaping species morphology and their ability to endure various environmental changes and diseases. Consequently, the investigation of genetic diversity holds significant potential for comprehending species adaptation within a specific geographic region. Notably, a study conducted in 2019 by Keypour et al. revealed a substantial level of genetic diversity among laccate *Ganoderma* species in Iran (Keypour et al., 2019). Further investigations focusing on the *G. lucidum* complex collected from the Hyrcanian forests in northern Iran, utilizing the RAPD-PCR technique, unveiled a wide

Table 1. *Ganoderma* species reported from Iran since 1968 and their descriptions. *Tomophagus colossus* previously known as *Ganoderma colossus*, has been mentioned in the table due to its report as a genus of *Ganoderma* by some authors and not as a confirmed scientific name by the authors of this article

Species name	Morphological description
Ganoderma lucidum (Curtis) P. Karst.	Basidiomata sessile or centrally to laterally stipitate, laccate, 15 × 12.2 × 3.2 Cm. margin acute, yellow, or white in the active growing specimens turning to orange-red to dark reddish-brown. Stipe lateral, vertical, and cylindrical up to 3.5 Cm thick and 9.3 Cm long. Cutis is thin, shiny, and hymenodermis type. Context 1 Cm thick; creamy white becoming dark orange. The tube layer is dark brown up to 1.3 Cm thick. Pores circular to angular; 3–6 per millimeter. Basidiospores Ovid, double-walled, echinulate, ellipsoid, and truncate at the apex, 7–14 × 5–10 µm. Hyphal system trimitic; generative hyphae thin-walled, skeletal hyphae aseptate and binding hyphae.
Ganoderma resinaceum Boud.	Basidiomata stipitate, reddish-brown, laccate, 21.9 × 14.3 × 4.6 Cm. pileus irregularly rugose; margin rounded, light ochraceous; stipe absent or short, lateral, 3–5 × 2–3 Cm. Hymenial surface creamy white, later brown white, pores circular to angular, 4-6 per mm. context pale brown, up to 15 Cm thick at the base. Basidiospores truncated ellipsoid, light yellowish, 5–12 × 5–9 µm. The hyphal system was trimitic; generative hyphae thin-walled, skeletal hyphae aseptate, and binding hyphae.
Ganoderma adspersum (Schulzer) Donk.	Basidiomata sessile, non-laccate dark brown, up to 15.7 × 13.4 × 5.6 Cm. Context dark brown and 4 Cm thick. The tube layer is whitish, without distinct separating context zones between each tube layer and tubes, up to 1.9 Cm. 4 or 5 pores per millimeter. Basidiospores ovoid, with a rounded or truncate apex, spinulose, 6–12 × 4–9 µm in size. The cutis is 0.9 mm thick and characodermis type. The hyphal system is trimitic; the skeletal hyphae are thick-walled, binding hyphae branched, and generative hyphae.
Ganoderma applanatum (Pers.) Pat.	Basidiomata perennial, non-laccate, light brown to dark brown, sessile, fan-shaped to slightly convex, 27.5 × 20 × 9 Cm. The margin is rounded and white in the early stage. The context cinnamon brown to dark brown 5–20 mm thick. 4 or 5 pores per millimeter. Tube layer up to 2.4 mm thick. Basidiospores 5–12 × 4–8 µm. The crust of the characodermis type. The hyphal system; trimitic, and skeletal hyphae are thick-walled, binding hyphae branched, and thin-walled generative hyphae.
Ganoderma australe (Fr.) Pat.	in Iran, *Ganoderma adspersum* is mistaken with this species.
Ganoderma tsugae Murrill.	Basidiomata sessile, stipitate, laccate brown to orange, up to 20 ×30 ×5 Cm. Context white to brown and up to 3.5 Cm thick. The tube layer, ochraceous buff, multi-layered, up to 0.8 Cm. 4-6 pores per millimeter. Basidiospores ovoid, with a rounded apex, 9–11 × 6–8 µm in size. The hymenodermis type. The hyphal system is trimitic; the skeletal hyphae are thick-walled, binding hyphae branched, and generative hyphae.
Ganoderma colossus (Fr.) C.F. Baker.	Basidiomata sessile, laccate turning non-laccate when older, up to 35 x 9 Cm. Context cream to pale buff, up to 10 Cm thick. Chlamydospores are scattered through context and rare in the trama. The tube layer is pale brown, up to 3 Cm thick. 2-4 pores per millimeter. Basidiospores ellipsoid, 13-19.5 x 8-12.5 µm in size. Cutis hymenodermis. Hyphal system dimitic, generative hyphae thin-walled, skeletal hyphae thick-walled.
Ganoderma manoutchehrii Steyaert.	Basidiomata flat, subungulate, laccate, blackish brown. Context dark Kaiser brown and 4-5 Cm thick. The tube layer Cacao brown, without intervening layers of context tissue, up to 1.6-2 Cm. Pores round. Basidiospores ovoid, truncate at maturity, dark brown, 9.5–12 × 6.5-7 µm in size. The cutis is 0.24 mm thick and mummy brown with a central zone, close to the characodermis type. The hyphal system is trimitic; the skeletal hyphae are thick-walled, binding hyphae branched, and generative hyphae.
Ganoderma kosteri Steyaert.	Basidiomata sessile, non-laccate, blackish brown, up to 1.8 × 5 Cm. Context bay and 0.3-0.5 Cm thick. The tube layer up to 0.5 Cm, bay, generally striated by white lines. Pores are round and often irregular. Basidiospores are ovoid or subspherical, slightly fuliginous, 9-10.5 × 6.5-8 µm in size. The cutis is 0.15 mm thick and anamixoderm type.

Table 2. Biodiversity and host relationships of reported species

Species	Locality (province)	Hosts	References
G. lucidum	Mazandaran, Guilan, Golestan (northern Iran)	*Carpinus betulus, Pterocarya fraxinifolia, Populus caspica, Gleditschia caspica, Pinus taede, Fagus sp., Quercus castaneifolia*	(Buhse, 1960; Khabiri 1968; Saber, 1987; Saber & Minassian, 2000; Moradali et al., 2007; Keypour et al.,2008; Borhani et al.,2010; Borhani, Mousazadeh & Badalyan, 2013; Keypour et al., 2014a; Keypour et al., 2014b; Amoopour, Ghobad-Nejhad & Khodaparast, 2016)
G. applanatum	Mazandaran, Guilan, Golestan (northern Iran), Khuzestan (south of Iran)	*Citrus* spp., *Parrotia persica, Quercus* spp., *Pinus pinea, Fagus orientalis, Carpinus betulus, Quercus castaneifolia, Pinus* sp., *Acer* Sp.	(Khabiri 1968; Steyaert, 1975; Saber & Minassian, 2000; Moradali et al., 2007; Borhani et al., 2010; Borhani, Mousazadeh & Badalyan, 2013; Keypour et al., 2014a; Sefidi & Etemad, 2015; Amoopour, Ghobad-Nejhad & Khodaparast, 2016)
G. adspersum / G. australe	Mazandaran, Guilan, Golestan (northern Iran), Tehran	*Zelkova carpinifolia, Pterocarya fraxinifolia, Gleditschia caspica, Pinus taede, Albizzia julibrissin, Laurus* sp., *Carpinus betulus, Quercus* sp., hardwood trunk	(Saber & Minassian, 2000; Saber & Esmaeili, 2004; Moradali et al., 2007; Keypour et al., 2014a; Keypour et al., 2014b; Sefidi & Etemad, 2015; Amoopour, Ghobad-Nejhad & Khodaparast, 2016)
G. resinaceum	Mazandaran, Guilan, Golestan (northern Iran), Khuzestan (south of Iran)	*Prunus persica, Acer velatinum, Carpinus betulus, Gleditschia caspica, Populus deltoids, Morus alba, Manilkara zapota*	(Steyaert, 1980; Saber, 1987; Saber & Minassian, 2000; Moradali et al., 2007; Keypour et al., 2014a; Keypour et al., 2014b; Amoopour, Ghobad-Nejhad & Khodaparast, 2016; Keypour & Asef 2020)
G. manoutchehrii	Mazandaran (northern Iran)	*Acacia* sp.	(Steyaert, 1972)
G. tsugae	Guilan (northern - Iran)	Conifer	(Moradali et al., 2007; Amoopour, Ghobad-Nejhad & Khodaparast, 2016; Saber & Minassian, 2000)
G. colossus	South of Iran	*Ziziphus spina-christi, Ficus benghalensis*	(Saber, 2000)
G. kosteri	Mazandaran (northern Iran)	*Carpinus betulus, Parrotia persica*	(Ghobad-Nejhad & Hallenberg, 2012)

Fig. 2. *Ganoderma* species dispersal in Iran

spectrum of diversity, with inter-specific diversities of 61.48 and 40.16 observed for the laccate species *G. lucidum* and *G. resinaceum*, respectively (Keypour et al., 2019). Ariffin et al. (2000) suggested that the heightened genetic diversity observed in *Ganoderma* species may be attributed to their adaptation to a broad range of host organisms, a characteristic that is also evident in *Ganoderma* species collected from Iran (Table 1 and 2). The extensive genetic diversity observed in laccate *Ganoderma* species collected from Iran, as reported by Keypour et al. (2019), confirms the finding that a diverse array of tree species across various regions of Iran are susceptible to laccate *Ganoderma* infections. This underscores the significance of early-stage disease management in promoting forest survival and preservation.

Biodiversity and host relationship

Numerous studies have been conducted to explore the taxonomy, biodiversity, and host relationships of *Ganoderma* species in Iran. Noteworthy contributions include the works of Khabiri (1968), Saber (1972), Soleimani (1976), Hallenberg (1979), Moradali et al. (2007), Keypour et al. (2008), Ghobad-Nejad and Hallenberg (2012), Rostamian et al. (2013), Borhani et al. (2013), Keypour et al. (2014a, 2014b), and Keypour and Asef (2020) (Table 2). These investigations have significantly enhanced our understanding of *Ganoderma* species in Iran.

The initial comprehensive survey on the taxonomy and biodiversity of *Ganoderma* species in Iran was conducted by Moradali et al. (2007), which paved the way for subsequent studies focusing on various aspects of *Ganoderma* (Keypour et al., 2008; Ershad, 2009; Keypour et al., 2014a, 2014b; Sefidi and Etemad, 2015; Amoopour et al., 2016; Badalyan and Borhani, 2019). Recent research findings indicate a higher incidence of *Ganoderma* species infecting trees compared to earlier reports by Ershad in 2009 (Keypour et al., 2014a, 2014b). Further investigations have shed light on the influence of field slope on fungal sporocarp abundance. Bari et al. (2019) revealed that *G. adspersum* and *G. lucidum* were found on slopes of various orientations in the forests of northern Iran, while *G. tsugae* was observed exclusively on the northwest slope and in *Fagus* forests, contrary to previous beliefs associating it solely with coniferous trees. Additionally, *G. applanatum* was documented on both northern and southern slopes (Borhani et al., 2013; Badalyan and Borhani, 2019).

Bari et al. (2019) attributed the high diversity of macro-fungi in the forests of northern Iran to the increased moisture content, altitude, and management and logging practices. Among the *Ganoderma* species, *G. adspersum* and *G. lucidum* exhibited the highest frequency of occurrence, while *G. tsugae*, *G. resinaceum*, and *G. applanatum* were less commonly found in the forests of northern Iran (Amoopour et al., 2016). Notably, Keypour and Asef (2020) provided an updated account of the occurrence of *G. resinaceum* in Iran, confirming its presence in the Khuzestan province (southern Iran) and on two previously unreported host species. Figure two shows *Ganoderma* species biodiversity in Iran.

Discussion

In contrast to several other Middle Eastern countries, Iran exhibits a diverse array of vegetation due to its distinctive environmental characteristics, which have a significant impact on plant diversity and abundance (Heshmati, 2007). Although scattered trees, forests, and favorable climatic conditions in other parts of the country also facilitate the occurrence of *Ganoderma* species, the northern region of Iran stands out in terms of plant richness, (Keypour and Asef, 2020). Keypour and Asef (2020) published a report documenting the presence of *G. resinaceum* in southern Iran, representing the first record of this species in that region. It is worth noting that while the majority of *Ganoderma* species are commonly found in the Hyrcanian forests of the Caspian Sea region due to the favorable climatic conditions supporting their growth (Badalyan and Borhani, 2019), certain species can be encountered in other parts of Iran where the climate may not be as conducive to their development. This recent report indicates a higher incidence of *Ganoderma* species infection among trees within the country, surpassing initial expectations. As a result, there is an augmented risk of the development of *Ganoderma*-induced diseases, such as root rot or butt rot, in affected trees.

This article provides a comprehensive collection and analysis of various studies conducted since 1860 on the morphology, taxonomy, phylogeny, and biodiversity of *Ganoderma* species isolated from Iran.

In general, different *Ganoderma* species have been reported in Iran over the years (Steyaert, 1972; Saber & Minassian, 2000; Moradali et al., 2007). However, recent studies have confirmed the presence of only five species, namely *G. lucidum, G. resinaceum, G. tsugae, G. applanatum*, and *G. adspersum*, in forests of Iran (Keypour et al., 2014a; Keypour et al., 2014b; Badalyan and Borhani, 2019). Despite repeated visits to the type locality of *Ganoderma manoutchehri* in different years, Moradali and Keypour were unable to locate the species. Furthermore, an investigation of the IRAN Herbarium to examine the collected samples identified as *Ganoderma kosteri* and *Ganoderma manoutchehrii* yielded no results. As for the species *Ganoderma kosteri*, two samples collected from Iran were found to have been deposited in the Meise Herbarium, although information regarding the identifier(s) was incomplete.

This study contributes to the understanding of *Ganoderma* species, causing rot root in trees, in Iran by investigating their morphological taxonomy, phylogeny, host relationships, and biodiversity. It is important to note that the use of molecular tools for accurate species identification has gained prominence among scientists. By employing molecular techniques, it becomes possible to discern the susceptibility of different tree species to specific *Ganoderma* species. Molecular techniques enable the development of rapid and accurate diagnostic tools for detecting *Ganoderma* infections. These tools can detect the presence of the fungus in tree tissues or soil samples, allowing for early detection and timely implementation of control measures. Moreover, the morphological variations observed among species within the *Ganoderma lucidum* complex posed challenges for taxonomical identification and pharmaceutical companies. However, scientists have successfully overcome these challenges by employing molecular analysis techniques. In recent years, molecular markers have been utilized to assess the genetic diversity and authenticate the identification of *Ganoderma* species collected from Iran. It is worth mentioning that further studies incorporating specific molecular markers, in addition to ITS and mtSSUrDNA, hold the potential to yield new insights into the taxonomy of *Ganoderma* species in Iran in the future.

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