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Some Basidiomycota Macrofungal Species from Salahadin Governorate (North Central Iraq), with the Addition of Four New Species to Iraq

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Abstract

Between the years 2016 – 2017, a survey on macrofungi was carried out in Al - Alam and Tikrit provinces from Tikrit district in Salahadin governorate / north central Iraq. It has been found that the two provinces comprise high diversity of macrofungi. In this paper 7 basidiomycetous macrofungal species belonging to 7 genera, 6 families and 3 orders were identified. These species are *Coprinellus disseminatus, Ganoderma lucidum, Lichenomphalia umbellifera, Montagnea arenaria, Phellinus pomaceus, Podaxis pistillaris* and *Trametes trogii*. All these fungi are described for the first time from Salahadin Governorate. Out of the seven species, *G. lucidum, L. umbellifera, M. arenaria* and *P. pomaceus* are new addition for the macromycota of Iraq. *C. disseminatus* and *L. umbellifera* are reported rare in the study area.

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Introduction

Macrofungi can be defined as fungi that form fruiting bodies greater than 1 cm in height and / or width (Redhead, 1997; Bates, 2006) and can be further defined as those fungi that produce fruiting bodies visible to naked eye which may be either epigenous or hypogenous (Mueller et al., 2007; Devi and Shrivastava, 2016). Most macrofungi belong to Basidiomycota and Ascomycota (Mueller et al., 2007). Of the 1.5 million estimated fungal species in the world, only 7.3% (about 110,000 species) are macrofungi, of which only 21,679 species of Ascomycota and Basidiomycota have been described (about 20% of the estimated macrofungal species) (Mueller et al., 2007). Macrofungi are saprotrophic or mutualistic (mycorrhizal symbionts) but few are plant pathogens (Mueller et al., 2007; Devi and Shrivastava, 2016). Beside of this, macrofungi serve as food, medicine and producers of pharmaceutical active compounds (Redhead, 1997; De Silva et al., 2013; Suliaman et al., 2017).

Salahadin governorate is situated in north central Iraq, north of Baghdad, the capital of Iraq with 24.363 Km^2 geographical area ($34^0 27'$ N$43^0 35'$ E). This governorate consists of eight districts (Al-Shirkat, Baiji, Tikrit, Al- Daur, Samaraa, Tooz, Balad and Dujail) and its topography varies from foothills in the north eastern parts to desert and steppe in the south west. Salahadin governorate is one of the most rural governorates of Iraq and its arable land comprises 14.715 Km^2. This governorate is characterized by low levels of

precipitation with most parts receiving an average annual rainfall of 175 – 225 mm while more rain (250 – 350 mm per year) occurs in the north eastern hilly areas. For this, agriculture in this governorate depends heavily on irrigation from Tigris River.

All the eight districts of the governorate are rich in vegetation, comprising tree species (Ex: *Populus* spp., *Salix* sp., *Pinus* sp., and several fruit tree species) with different species of shrubs and herbs. These plants providediverse habitats that sustain different macrofungal species in the governorate. Despite its biogeographic significance, information on macrofungi from thegovernorateis very limited. However, recent surveys on these fungi were reported fromSalahadin governorate (Al-Qaissi, 2014) and other parts of Iraq (Muhsin et al., 2012; Toma et al., 2013; Owaid et al., 2014; Muslat and Owaid, 2015; Al-Khesraji, 2016; Suliaman et al., 2017). This paper reports for the first timeseven Basidiomycota macrofungal species from Salahadin Governorate, four of which new to Iraq.

Materials and methods

This study was conducted in Tikrit ($34^0 36' 36'' N 43^0 40' 48'' E$ / elevation 137 m) and Al-Alam ($34^0 38' 41'' N 43^0 42' 0'' E$ / elevation 96 m) provinces between November 2016 to September 2017. The two provinces as part of Tikrit district are located on the Tigris River, about 140 Km northwest of Baghdad (Fig. 1).

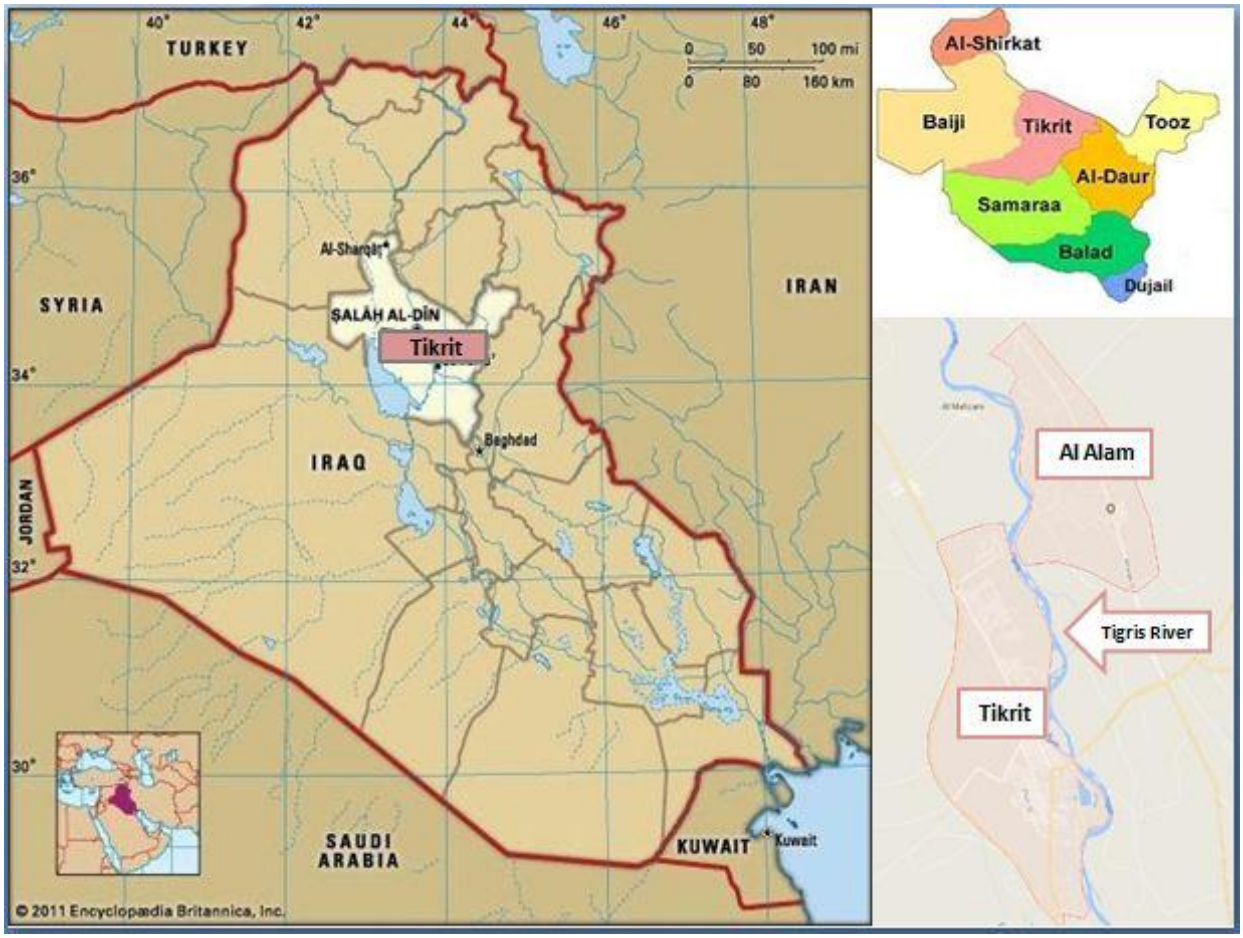

Fig. 1: Maps of the study area.

According to Koppen –Geiger climate classification system, the climate of Tikrit district is classified as hot desert with 22.1°C average annual temperature and 182 mm average rainfall. The least rainfall occurs in June (0 mm) and the most precipitation falls in December (averages 37 mm).

The macrofungi specimens were collected from different sites in Tikrit and Al-Alam provinces, including, orchards, grassland, gardens and desert and wasted areas. Fungal samples were photographed in their natural habitats and in laboratory. Locality, habitat (host/substrate) and habit (solitary, gregarious or other

growth forms) of the samples with season of fruiting body appearance were recorded. Macroscopic features (including: cap size, shape, color and surface texture, gills color and attachment to stipe (if present), number of pores / mm, stipe size, color, surface texture and presence or absence of annulus and volva) and microscopic features (including: basidium size and its spore number, spore size, shape and color and presence or absence of cystidia with their size, shape and type) were reported. Cotton blue in lactophenol and 3% KOH were used for light microscopy. Identification of the samples was performed according to relevant literatures, keys and monographs (May et al., 2003; Kuo, 2004; 2008 and 2017; Gonthier and Nicolotti, 2007; Bhosle et al., 2010; Laursen and Seppelt, 2010; Justo and Hibbett, 2011; Thakur, 2013; Yousaf et al., 2013; Desjardin et al., 2016; Svetlova and Zmitrovich, 2017). All identified samples are deposited in the Department of Biology, College of Education for Pure Sciences /Tikrit University, Iraq.

Results and discussion

Seven basidiomycetous macrofungal species belonging to 7 genera, 6 families and 3 orders (*Coprinellus disseminatus, Ganoderma lucidum, Lichenomphalia umbellifera, Montagnea arenaria, Phellinus pomaceus, Podaxis pistillaris* and *Trametes trogii*) were reported for the first time from Salahadin governorate. *G.lucidum, L.umbellifera, M. arenaria* and *P. pomaceus* are new records for the macromycotaof Iraq. Ecologically, the recorded fungal species are either saprobic or parasitic inhabitats.*C. disseminatus* and *L. umbellifera* are considered rare in study area.Description and distribution of identified macrofungi are given below.

Kingdom : Mycetae
Phylum : Basidiomycota
Class : Agaricomycetes
Order : Agaricales
Family : Psathyrellaceae
Species : *Coprinellus disseminatus (*Pers.) J.E.Lange

Macroscopic and microscopic features (Fig. 2) : Cap 0.5 – 1 cm broad, 2 – 8 mm tall, conical to bell – shaped, white to pale yellow - brown with brownish disc when young, gray ash in age with brownish disc, minutely granular, lined from the margin to near the disc ; gills free from stipe, white turn blackish in age but not deliquescent in maturity; stipe 1.0 – 2.5 cm tall, 1 – 2 mm thick, white, cylindrical, hairy, hallow, often bent from the base. Basidia 18 – 25 x 5 -6 µm, 4 – spored ; spores 7 – 10 x 4 – 5 µm, elliptic, smooth, with apical pore, deep brown. Habit and habitat : gregarious or in large groups with hundreds of tiny specimens on tree stumps (*Populus* sp. and *Salix* sp.) or on decaying wood. Locality : Al - Alam province (Al-Efri village). Season : March – July. This fungus is very rare in study area. On the basis of general morphology, this fungal species was previously reported from Al – Anbar governorate under the name *Coprinus disseminatus (*Owaid et al., 2014), so the present study provides for the first time from Iraq a detailed description of this fungus. *C. disseminatus* was also reported from Iran (Karim and Kavosi, 2013), Turkey (Sesli and Denchev, 2014), Tanzania (Tibuhwa et al., 2011) and India (Ao et al., 2016).

Family : Hygrophoraceae
Species : *Lichenomphalia umbellifera (*L.)Redhead, Lutzoni, Moncalvo & Vilgalys

Macroscopic and microscopic features (Fig. 3) : Cap : 8 – 12 mm diam., flat when young, becoming shallowly depressed in the centre, minutely pubescent, slightly striate, cinnamon to brownish, margin, sulcate, crenulate or fluted ; gills broad, decurrent, distant, concolourous with cap ; stipe 10 -12 x 1- 2 mm, cylindrical, slightly enlarged at base, concolourous with cap, solid, minutely pubescent. Basidia 4 – spored, 30 – 35 x 8 – 10 µm, sterigmata varied in length; spores 8 – 12 x 5 -7 µm, elliptical, smooth, hyaline ; clamp – connections and cystidia absent. Habit and habitat : solitary or gregarious, on soil and in association with bryophytes under *Thuja* sp.. Locality : Tikrit province (Tikrit University campus). Season : December – March. This fungusis very rarely observed in study area. *L. umbellifera* was reported from India (Ao et al., 2016), Czech Republic (Liska et al., 2008), Germany (Stordeur et al., 2015), Poland (Lubek and Jaroszewicz, 2012), Russia (Chesnokova and Konoreva, 2015), Turkey (Sesli and Denchev, 2014) and UK (Graham, 2013).

Family : Agaricaceae
Species : *Montagnea arenaria* (DC.) Zeller

Macroscopic and microscopic features (Fig.4) : Cap disc shaped 1-3 cm across, convex becoming plane to depressed, disc yellowish brown ; gills free, black, not deliquescent at maturity; stipe 3 -7 cm long, 0.5- 0.8 cm thick, cylindrical, often tapering downward, whitish, hallow when young, hard, furrowed and scaly in age ;

volva thick, 1 cm high,white, fused with base of stipe but free on top, buried in sand. Basidia 4 – spored ; spores6 – 7 x 3 – 5 µm, dark brown, oblong, ovoid, elliptical, thick walled, smooth, with an apical germ pore, black in mass.Habit and habitat : solitary to scattered in sandy and calcareous soils and in wasted places. Locality :Tikrit province (desert and wasted areas near by the university). Season : March – August. This fungus was reported from Turkey (Sesli and Denchev, 2014), Iran (Ershad, 2009), Qater (Al- Thani, 2010)and Poland (Stasinska and Prajs, 2002).Itwas listed as endangered species in some European countries like Poland (Wojewoda and Lawrynowicz, 1992), Armenia (Nanagulian, 2002), Slovakia (Kautmanova, 2004) and Czech Republic (Holec and Beran, 2006).

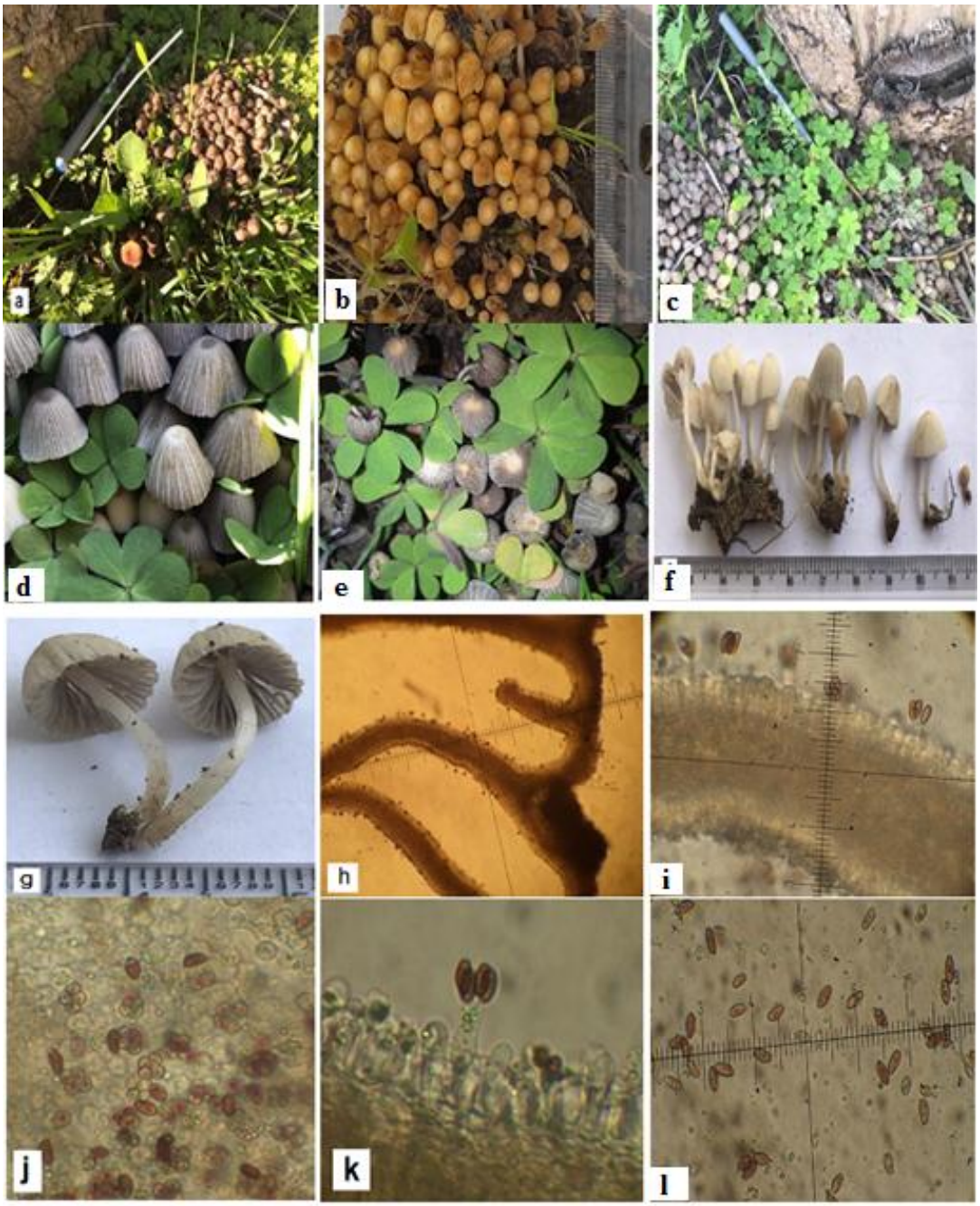

Fig. 2: *C. disseminatus.* a – e, in natural habitat; a, b, young fruit body; c – e, mature fruit body; f, g, general morphology (in lab); h, I, gills in section; j, k, 4 spored basidia in surface view and in section. l, spores; h (100x)/ i – l (400x).

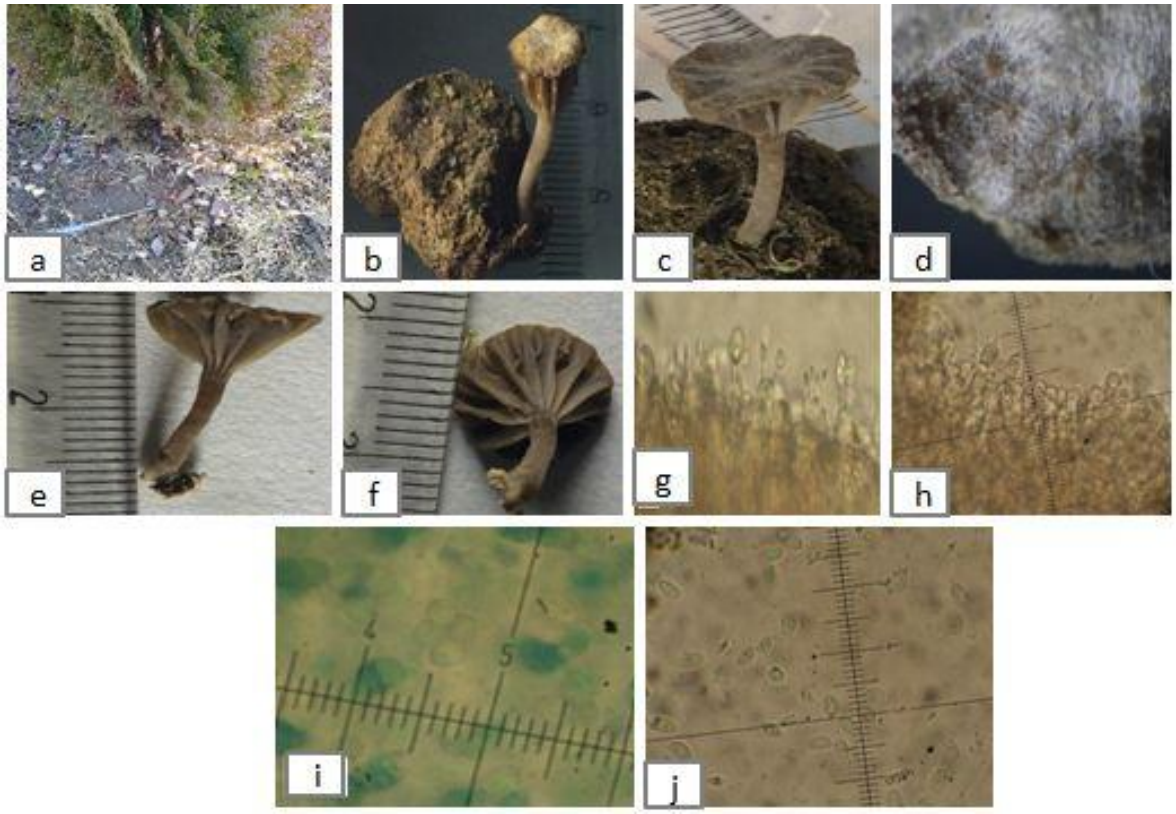

Fig. 3: *L. umbellifera*. a, in natural habitat (under *Thuja* plant); b, c, general morphology; d, hairy surface; e, f, stipe, cap and gills; g – i, basidia in section (g & h) and surface view (i); j, spores.

Fig.4: *M. arenaria.* a, in early stages; b – d, in natural habitat; e, volva; f, scaly stipe; g, general morphology; h, spores.

Species : *Podaxis pistillaris* (L.) Fries

Macroscopic and microscopic features (Fig. 5) : Cap 6 - 8 cm tall, 3 - 4 cm broad, white when young, yellowish brown at maturity, oval to ellipsoidal at maturity, with rounded apex, shaggy to scaly, margin fused to stipe, shredded when mature to release its spore dust; gleba reddish brown in age, capillitial threads non septate, 2.5 – 5 µm broad, interspersed between spores; stipe 9 - 12 cm long, up to 1 cm thick, cylindrical with bulbous base buried in soil, scaly, solid, white to rusty or yellowish brown, ring absent.

Spores 10.0 – 16.0x 9.0 – 12.5µm oval, globose to subglobose, smooth, with thick double wall and apical germ pore, when mature reddish in water and ochre - colored in KOH, mature spore powder blackish or darck brown. Habit and habitat : solitary or scattered in arid places including desert, semidesert, dunes, roadsides, wastelands and old fields. Locality : Tikrit provinces (Tikrit university campus).Season : April - September. This species was reported for the first time from Iraq by Muhsin et al. (2012), to southern Iraq. Here is the first report of *P. pistillaris* from Salahadin governorate /central Iraq.*P. pistillaris* was reported from some countries bordering Iraqlike Iran (Eckblad, 1976)and Saudia Arabia (Gaafar and El- Wakil, 2015) and from other part in the world like Australia (Lenz and Priest, 1999), India (Rajput et al., 2015) and Brazil (Baseia and Galvao, 2002). It was recorded for the first time from Europe by Friebes and Wendelin (2014).

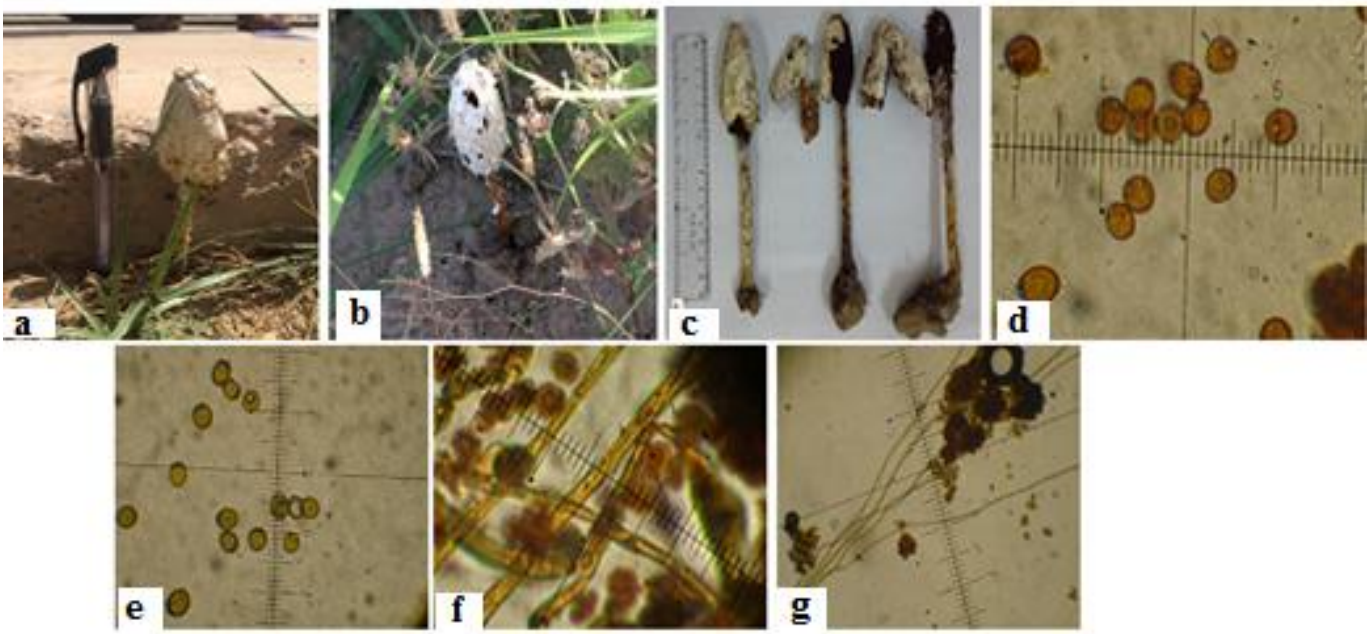

Fig. 5: *P. pistillaris*. a, b, in natural habitat; e, general morphology; d, e, spores in water and KOH respectively; f, spores and skeletal hyphae; g, binding hyphae.

Order : Polyporales
Family : Ganodermataceae
Species : *Ganoderma lucidum (*Curtis)Karst.

Macroscopic and microscopic features (Fig. 6) : Cap 8 – 32 cm across, 0.5 – 2.0 cm thick, knobby when young, fan – shaped or kidney – shaped and very tough in age, shiny red to reddish brown zonate surface, pore surface white but later becoming brownish with 4 – 5 rounded pores / mm; stipe : rudimentary but when present, up to 10 cm tall, broad near the cap and narrow towards the base, concolourous with cap. Spores 7.5 – 12.5 x 5.0 – 7.5 µm elliptical to ovoid with one end truncated, double walled, appearing rough under oil immersion. Spore print : reddish brown. Habit and habitat : solitary or gregarious, parasitic on living trees of *Prunus domistica* and *Morus* sp. and saprobic on their stumps, usually at or near the base of the tree. Locality : Al- Alam province (villages of AL-Efri, Defsha and Al-Jabara). Season : collected between March – September. This medicinal white rot, wood decaying fungus is cosmopolitan in distribution, particularly in the Far East countries like China, Japan and Korea (Wasser, 2005; Upton et al., 2006). It was also found in India (Thakur, 2013), Turkey (Sesli and Denchev, 2014), Iran (Keypour et al., 2014), USA (Bates, 2006), Colombia (Vasco – Palacios and Franco – Molano, 2013), Qater (Al-Thani, 2010), Italy (Bernicchia, 2001) Cyprus (Torrejon, 2014), Finland (Kunttu et al., 2015).

Family : Polyporaceae
Species : *Trametes trogii* Berk.

Macroscopic and microscopic features (Fig. 7) : Cap 4 – 15 cm across, semi-rounded, flat with concentric zones, frequently overlap in layers to form large fruiting mass, upper surface covered with ocher to brown hairs, lower surface white to creamy ocher, comprises layer of thick

tubes ended in rounded, angular or irregular pores, 2 – 3 pores/ mm, hyphal system trimitic, skeletal hyphae (5 µm wide, cylindrical, thick walled, non – septate, unbranched), second type similar but finner (2.5 µm wide, irregular in contour) and generative hyphae (the thinnest hyphal type, septate), it attaches directly to the wood of dead or living trees. Basidia 4 – spored; spores cylindrical, curved cylindrical or banana –shaped, somewhat granular, 7.5 – 13.0 x 2.5 – 5.0 µm.Habit and habitat : solitary or gregarious on trunks of poplar and willow. Locality : Al – Alam province (Defsha village). Season : any season (collected between February – September).*T. trogii* was described for the first time from Northern Iraq (Iraqi Kurdistan) by Suliaman et al. (2017) and this is the first report from central Iraq (Salahadin governorate).This species was reported from other countries like Turkey (Sesli and Denchev, 2014), Iran (Ershad, 2009), Croatia (Zupanic et al., 2009), Spain (Garcia – Bona, 2017), and Russia (Svetlov and Zmitrovich, 2017). *T. trogii* is rare in western Europe and is listed in Red Book (Svetlov and Zmitrovich, 2017).

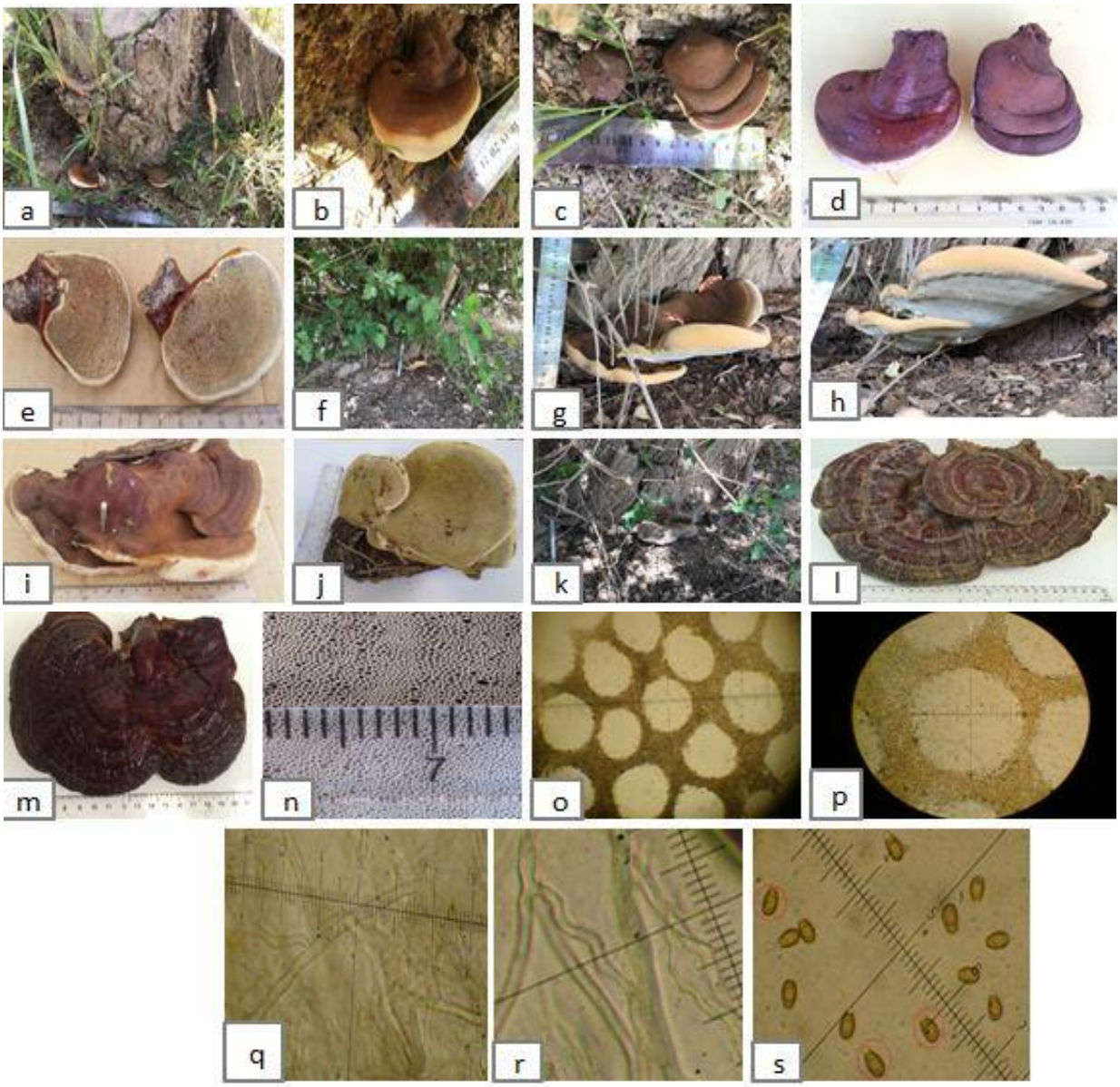

Fig. 6: *G. lucidum*. a, young stages in natural habitat (under poplar stump); b, c, magnified; d, e, cap upper and lower surface (in lab.); f – h, advanced stages in natural habitat; i, j, cap upper and lower surface (in lab.); k, mature stage in natural habitat (under *Morus* sp.); l, m, general morphology (in lab.); n, lower surface magnified; o, p, pores in section; q, branched skeletal hypha; r, branched binding hypha; s, spores. o – p, 400x.

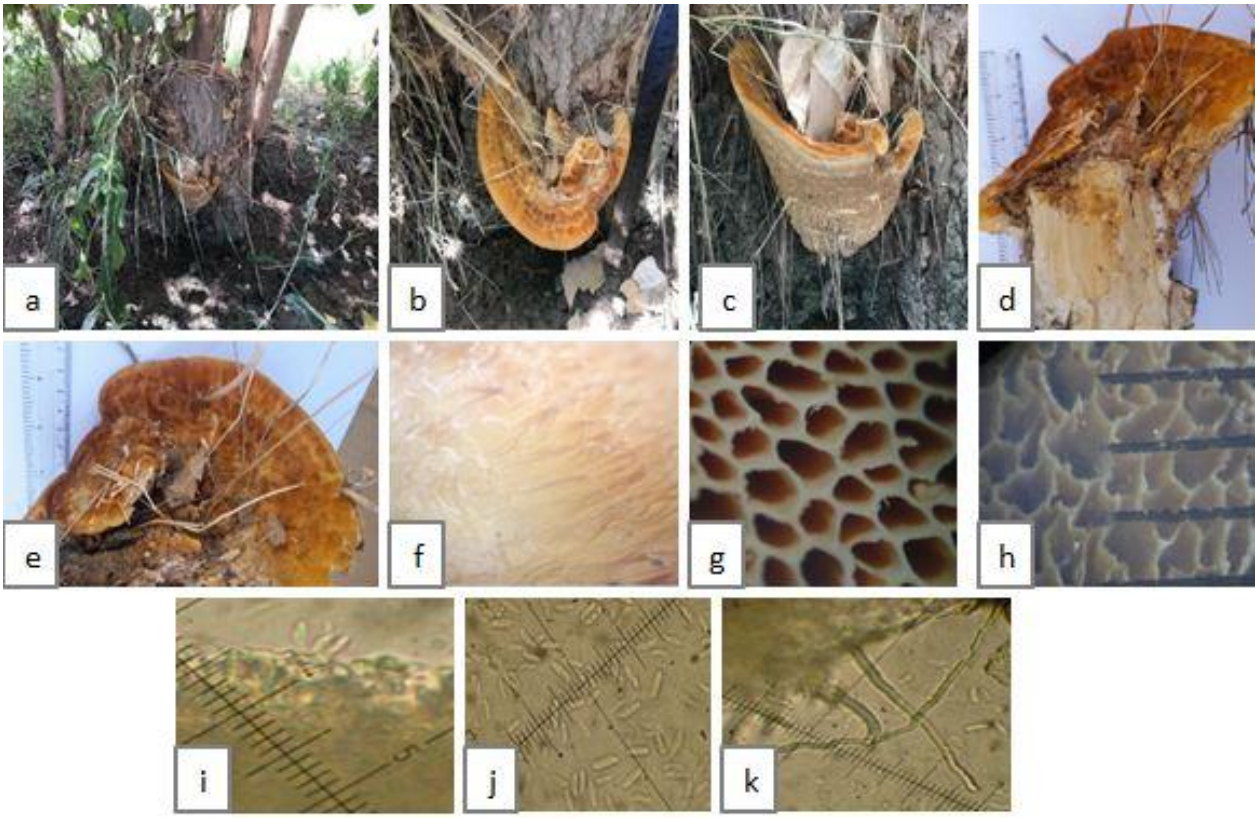

Fig. 7: *T. trogii*. a – c, in natural habitat; d, e, in lab; f, hairy upper surface; g, h, pores of lower surface; i, basidium; j, spores; k, skeletal and binding hyphae.

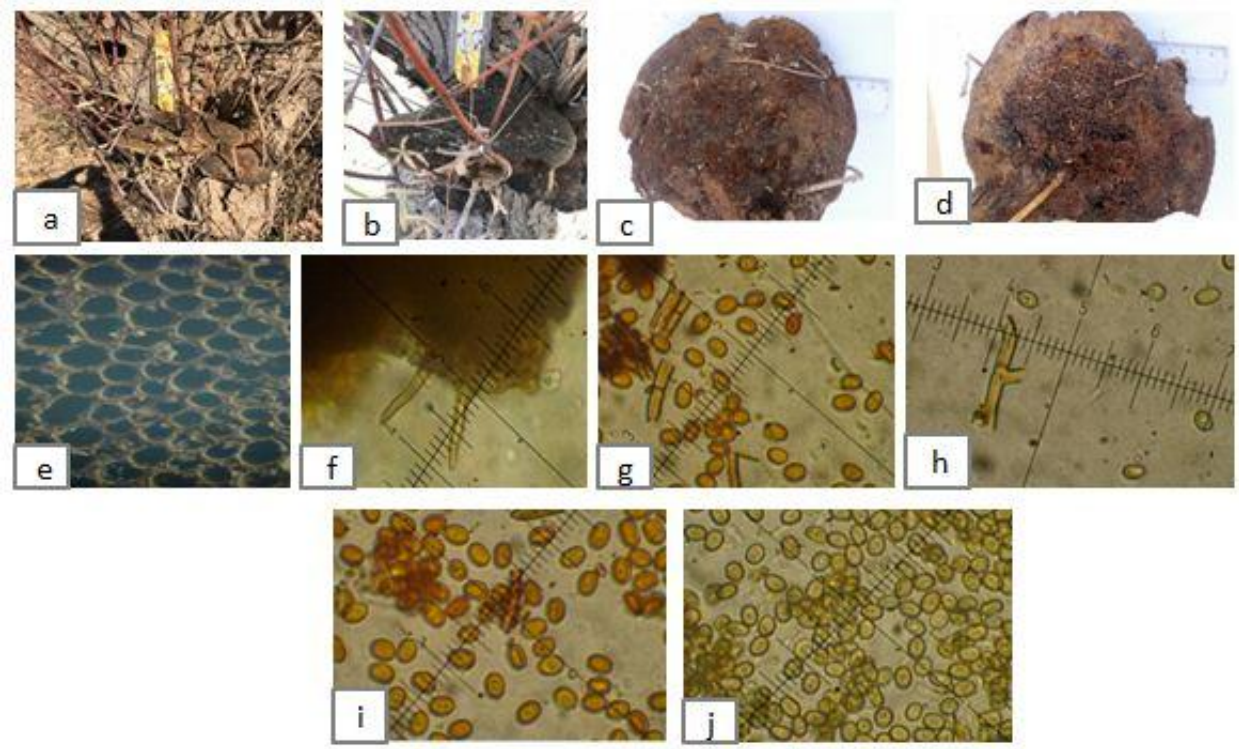

Fig. 8: *P. pomaceus*. a, b, in natural habitat; c, cap upper surface; d, cap lower surface; e, pores of lower surface; f, setae; g, septate skeletal hyphae and spores; h, branched skeletal hypha; i, spores in water; j, spores in KOH.

Order : Hymenochaetales
Family : Hymenochaetaceae
Species : *Phellinus pomaceus* (Pers.) Maire

Macroscopic and microscopic features (Fig. 8): Cap 10 – 20 cm across, 5 – 12 cm tall, 5 – 10 cm height, resupinate, hoof – like, with concentric layers, upper surface grey when young, turning to black brown at maturity, often cracked in age ; tubes yellowish brown or brown, up to 15 mm deep ; pores very small, rounded, 4 – 6 / mm ; trimitic, both generative and sterile hyphae are rarely septate and rarely branched ; spores 7.5 – 10.0 x 5.0 – 6.0 µm, elliptical to spherical, smooth, hyaline to yellowish, red to reddish brown in KOH, commonly with one oil droplet, flesh brown. Habit and habitat : solitary parasitic or saprobic on trunks and branches of poplar and willow. Locality : Al – Alam province (villages of Defsha, AL-Jabara and Sekhel) . Season : any season (collected between February – July). Information on *P. pomaceus* in countries bordering Iraq are only available from Turkey (Sesli and Denchev , 2014). However, the fungus was reported in other parts of the world such as Italy (Bernicchia, 2001), Arizona (Bates, 2006), Bulgaria (Denchev and Assyov, 2010) and Cyprus (Torrejon, 2014).

Conclusion

This paper reports seven basidiomycetous macrofungal species from Salahadin governorate (Tikrit district), north central Iraq and a contribution was made to Iraqi macromycota by the addition of four new records. The data presented in this study is an important step towards generating a checklist of macrofungi in this governorate in particular and Iraq in general.

Conflict of interest statement

Authors declare that they have no conflict of interest.

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