Description and Identification of Some Wild *Agaricus* Species Grown in Western Homs Governorate, Syria

B. Hola[1*], R. Murshed[1] and M. Jbour[2]
(1) Department of Horticulture, Faculty of Agriculture, Damascus University, Damascus, Syria;
(2) General Commission for Scientific Agricultural Research (GCSAR), Damascus, Syria.
[*]Email address of the corresponding author: boushra2.hola@damascusuniversity.edu.sy

Abstract

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Field collection missions of wild mushrooms were conducted in the western part of Homs governorate in Syria from early October to late December 2021, and from early November to late December 2022. During the survey, six specimens of wild mushrooms were collected. Morphological characterization of collected specimens, such as pileus, scales, lamellae and stipe measurements, color, odor and the presence of annulus were immediately made. Molecular identification of these mushroom specimens, using ribosomal DNA internal transcribed spacers (rDNA-ITS) sequencing showed that the collected isolates belong to three different species of the *Agaricus* genus. These are: *A. bisporus* (OP648153 and OP648159), *A. sinodeliciosus* (OP648154 and OP648156) and *A. qilianensis* (OP648155 and OP648157). This is the first record of the occurrence of these three species in the Syrian environment, and information on these species were deposited in the GenBank database which hopefully will facilitate their domestication and commercialization.

Keywords: Wild mushroom, identification, Syria, *Agaricus qilianensis, Agaricus sinodeliciosus, Agaricus bisporus*, rDNA.

Introduction

There are at least five million fungal species in nature, but only 2% are described (Lücking & Hawksworth, 2018). Part of it produces large fruiting bodies that can be seen with the naked eye (Chang & Miles, 1992; Chukunda & Simbi-Wellington, 2019). These macromycetes have been popular in human societies for thousands of years due to their high medical and nutritional values (Hall *et al.,* 2003; Peintner *et al.,* 2013). Wild *Agaricus* species have several nutritional and medical benefits, and some of them are collected for consumption (Grigson, 2008). However, these species are still poorly documented in some countries (Chang, 1999; Savoie *et al.,* 2013), particularly countries with a relatively dry and hot climate (including Mediterranean climate) because their fruiting period is often short and unpredictable (Callac & Chen, 2018).

The *Agaricus* genus (Agaricales, Basidiomycota) is distributed on all continents except Antarctica (Parra, 2008; Zhao *et al.,* 2011). Most of its species are known for their high commercial value, such as *A. bisporus* (He *et al.,* 2017). The number of *Agaricus* species increased rapidly from 200 species in 2008 (Kirk *et al.,* 2008) up to more than 500 species (Chen *et al.,* 2017; Karunarathna *et al.,* 2016; Kerrigan, 2016). The knowledge of the biogeographic patterns of fungal diversity remains fragmented (Loizides *et al.,* 2016; 2019; Paz *et al.,* 2017; Taşkın *et al.,* 2016), particularly in the eastern part of the Mediterranean, where macromycetes reference lists have not been completed yet.
In recent years, there has been a resurgence to document the fungal diversity of this neglected ecosystem (Kaya, 2009; Polemis *et al.,* 2012; Torrejón, 2014; Loizides *et al.,* 2016; 2018; 2019). Fungal diversity is closely linked to plant diversity (Hawksworth, 2004; Bruns *et al.,* 2002) and the Mediterranean is a significant site of diversity; therefore, Syria is likely to have a large and unique diversity of macromycetes which have not received due attention. The first mycoflora study was conducted in 1967 on Syrian soil fungi and their anti-biological characters. It included the soil of two governorates, Damascus and Sweida. The first publication on this group was in 1972, in which 40 different species of fungi were identified (Baghdadi, 1972). There are few studies on diversity of wild fungi in Syria (Baghdadi *et al.,* 2001) such as the systematic contributions to the classification of some species of Saprophytic and parasitic fungi in different areas of the country. These contributions have confirmed that Syrian flora is rich in wild fungi (Ahmad, 2020; Alabi & Ahmad,1996; Baghdadi *et al.,* 2001; Bawadikji & Ahmad, 2003; Ez, 2007; Hussein, 2001). The current study aims to contribute to the checklist of macromycetes in Syria using morphological and molecular methods.

Materials and Methods

Field collections

Three monthly field collection missions were conducted in the western part of Homs governorate (central Syria) (Figure 1), from early October to late December 2021. Low temperatures and snowfalls hindered collection later during winter and early spring. Another round of field collections was conducted from early November to late December 2022. Collected samples were initially studied for macro morphological features and then kept separately in paper bags within a box until laboratory examination.

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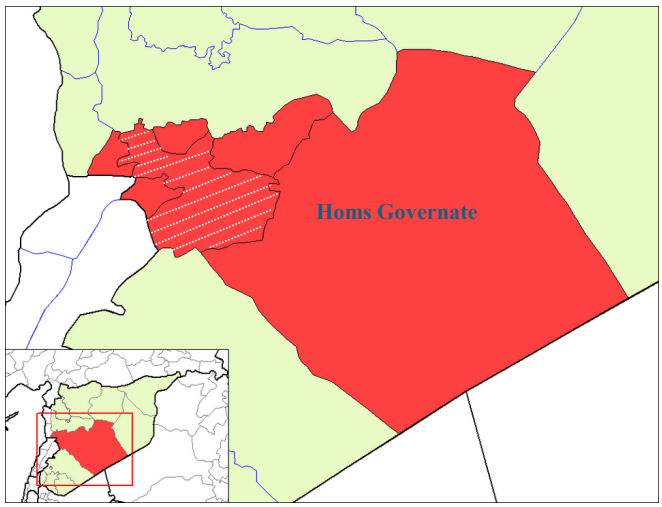

Figure 1. Map of Syria showing sampling site in Homs governorate. The dashed district represents the area of study.

Sampling and morphological study

A form of guiding check list was adopted (Imes, 1990) for mushroom sampling and on-the-spot assessment and morphological description based on pileus shape, color, edges, scales shape and color, context and color of flesh; lamellae shape, color and connection with the stipe; stipe length, diameter, shape, color, context, position and presence of annulus; and mushroom odor. In addition, images and samples of the fresh mushrooms were used to identify to which genus and species each sample belong (Desjardin *et al.,* 2015; Jordan, 1995; Lincoff, 2011; Vrinda & Pradeep, 2014). The microscopic study (OPTIKA Microscope, Italy) was performed on fresh fruiting bodies, to determine a number of important factors in the classification such as: basidia shape, transparency, number of spores per basidium, length, width, presence of cheilocystidia cell and oil droplets abundance (Largent, 1986; Largent *et al.,* 1978).

The KOH (potassium hydroxide) test (Petrini, 2009) was used to recognize many kinds of fungi, including boletes, polypores and gilled mushrooms. For gill mushroom, we placed a drop of KOH 3-10% aqueous solution on the surface of the pileus to test color change. Negative reaction (no change in color) meant that the fungus belonged to *A. bisporus*.

Molecular identification

Mushroom DNA isolation- The fungal genomic DNA was isolated from fruiting bodies using Favor Prep Fungi/Yeast Genomic DNA Extraction Mini Kit (Cat. No.: FAFYG 001) following manufacturer's instructions. DNA was quantified spectrophotometrically measuring the UV absorbance at 260 and 280 nm. DNA integrity was verified on 1% agarose (Carl Roth, Germany) gel prepared in TBE buffer (1x) to which 3 µl of Red safe staining solution (Intron, Korea) was added.

PCR reactions- The polymerase chain reaction (PCR) was performed using the GoTaq® Green Master Mix (Promega, USA) in Applied Biosystems™ Pro Flex™ PCR Systip (Fisher Scientific, USA). ITS primers (Macrogen, Korea) were designed based on sequences deposited in the GenBank database (White *et al.,* 1990). The forward ITS primer was: 5′-TCCGTAGGTGAACCTGCGG-3′ and the reverse primer was: 5′-TCCTCCGCTTATTGATATGC-3′ designed to amplify a 550 bp fragment. The PCR profile is: 95°C for 5 min the 30 cycles of 95°C for 45 sec, 58°C for 40 sec and 72°C for 1 min, then final cycle 72°C for 5 min. PCR products were stored at – 20°C and subsequently run in 1.5 % agarose gel for 1.5 hour and the amplified products were visualized in Gel Doc systip (Bio-Rad, USA). The PCR products were sequenced using Macrogen Sequencing Service (Korea). Sequences of the amplified fragments were deposited with the GenBank database.

Results and Discussion

The collection missions resulted in identifying 6 mushroom specimens belonging to the *Agaricus* genus (Table 1).

Morphological characterization of collected specimens

B.R.5 isolate

Pileus: 3-6 cm in diameter at maturity, and has a white color, edges were complete and wrapped inside with clear traces of veil's remnant. The scales were reddish brown to very dark brown with a reddish gloss, square shaped turns to thin filiform at the edges. The context is thick, with fleshy white tissue, convex to planate, and flattened with aging (Figure 2).

Lamellae: Free, unconnected to stipe, closed, narrow and short (unequal length). Little mushroom bodies had grey color lamellae, that turns pink with young fruit bodies then chocolate brown with age.

Stipe: 5 cm length and 1-2 cm in diameter, short, cylindrical, symmetrical with a pointed end. Crisp white color, dirty at stipe's bottom, the context is white, fleshy, coherent, centralized, easy to separate from cap. The surface is smooth or slightly fibrous.

Annulus: Traces were found on the stipe and bottom cap's edges of young fruiting bodies. Reddish brown discoloration observed on the edge tissues after cutting.

Odor: unmarked

Microchemical reactions: KOH reaction was negative.

Basidia: dimensions were 17.50-22.50 × 5.00-6.25 µm, number of studied basidia n=6, clavate, 2–spored.

Basidiospores: Length (L)= 8.75 to 10.00-11.25 × Width (W)=7.50-10.00 µm, Quotient Q= L/W =1.13-1.33 (Callac *et al.,* 2003). Estimated volume (V) =W^2 ×L×π/6 =257.41-294.19 to 330.96-588.38 µm^3 (Callac *et al.,* 2003), number of studied basidiospores n=15], transparent broadly ellipsoid (oval) with papilla, the color was rusty reddish brown, with the presence of clear oily droplets and abundant cheilocystidia cells.

Habitat: Scattered in grasslands.

Table 1. Date and location of collected mushroom specimens of the *Agaricus* genus in Homs Governorate.

Code of collected specimen	Collection site	Site coordinates	Collection date
B.R.5	Shin village	34 46'54.3" North, 36 25'33" East, 533 m above sea level	30/11/2021
B.R.9	Bahhur village	34 50'54.3" North, 36 21'40.4" East, 757 m above sea level	09/12/2021
B.R.17	Um Aledam village	34 42'18" North, 36 30' 59" East, 582 m above sea level	21/12/2021
B.R.22	Marj al-Qata village	34 45'34.4" North, 36 33'04.5" East, 542 m above sea level	20/12/2021
B.R.42	Al-Qabo village	34 51′ 34.0″ N, 36 31′13.2″ E, 542 m above sea level	01/12/2021
B.R.47	Al-Qabo village	34 51′ 12.2″ N, 36 30′ 44.6″ E, 542 m above sea level	01/12/2021

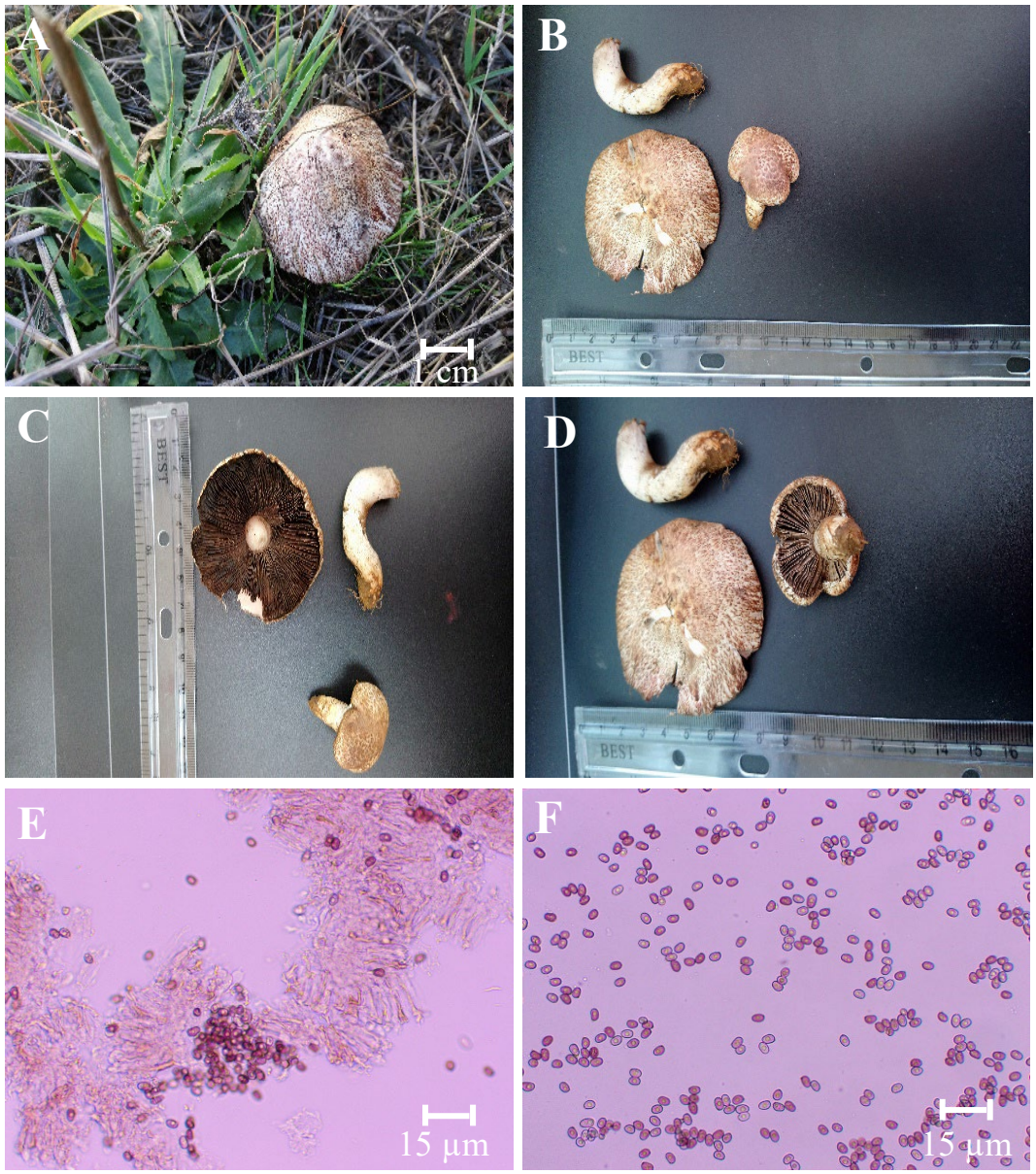

Figure 2. Morphological characteristics of B.R.5 mushroom specimen. (A-D) fresh fruiting body, (E) basidia, (F) basidiospores.

B.R.9 isolate

Pileus: 3.9-5.6 cm in diameter at maturity, white colored, edges are complete, wrapped inside and had clear traces of partial veil's remnant. Scales are reddish brown to very dark brown with a reddish gloss, square-shaped and distributed in regular circles at the center and become thin filiform at the edges. The context is thick, fleshy, with white tissues, convex to planate, and flatten with aging. Several cracks were observed at the center (Figure 3).

Lamellae: Free, unconnected to stipe, closed, closely distributed and short (unequal in length), crowded, pink in young fruit bodies then they get chocolate brown with age.

Stipe: 3-3.5 cm length × 1-1.1 cm in diameter, long thin cylindrical, and symmetrical with a regular end, crisp white dirty at the stipe's bottom, the context is fleshy, thick with white tissues. It is centrally situated and easy to separate from the pileus, the surface is smooth, slightly fibrous.

Annulus: traces are found on the stipe and bottom cap's edges of young fruit bodies.

Reddish brown discoloration observed on the edge tissues after cutting.

Odor: unmarked

Microchemical reactions: KOH reaction is negative.

Basidia: dimensions are (20-) 25 (-37.50) × (3.75-) 5 (-7.50) µm, n=5, Mono, 2-spores, 4-spores, most of which are 2-spore, not wide at the bottom, clavate.

Basidiospores: L (8.75-)10-12.50 × W (5-) 6.25-7.50 µm [Q= (1.17-) 1.33-2, V=130.75-294.19 × 367.73 μm^3, n=15], transparent elongated ellipsoid with papilla, brown rusty reddish, with clear oily droplets and. abundant Cheilocystidia cells.

Habitat: scattered in grasslands.

B.R.17 isolate

Fruiting bodies: medium to large, growing underground (in sandy soil), buried when small, and then go outside (Figure 4).

Pileus: 3.85–6 cm at maturing, slightly convex, with full edge wrapped inside; asymmetric at the center. The surface has a white to creamy background, which is covered by square-shaped and dark brown scales at the center, which become thin filiform and dirty light brown to creamy at the edges. The context is thick, fleshy, with white tissues, reddish brown colored when bruised and after cutting.

Lamellae: Free, crowded, very narrow, with series of short, closed, repeated lamellulae, first pink, then brown, and finally dark brown.

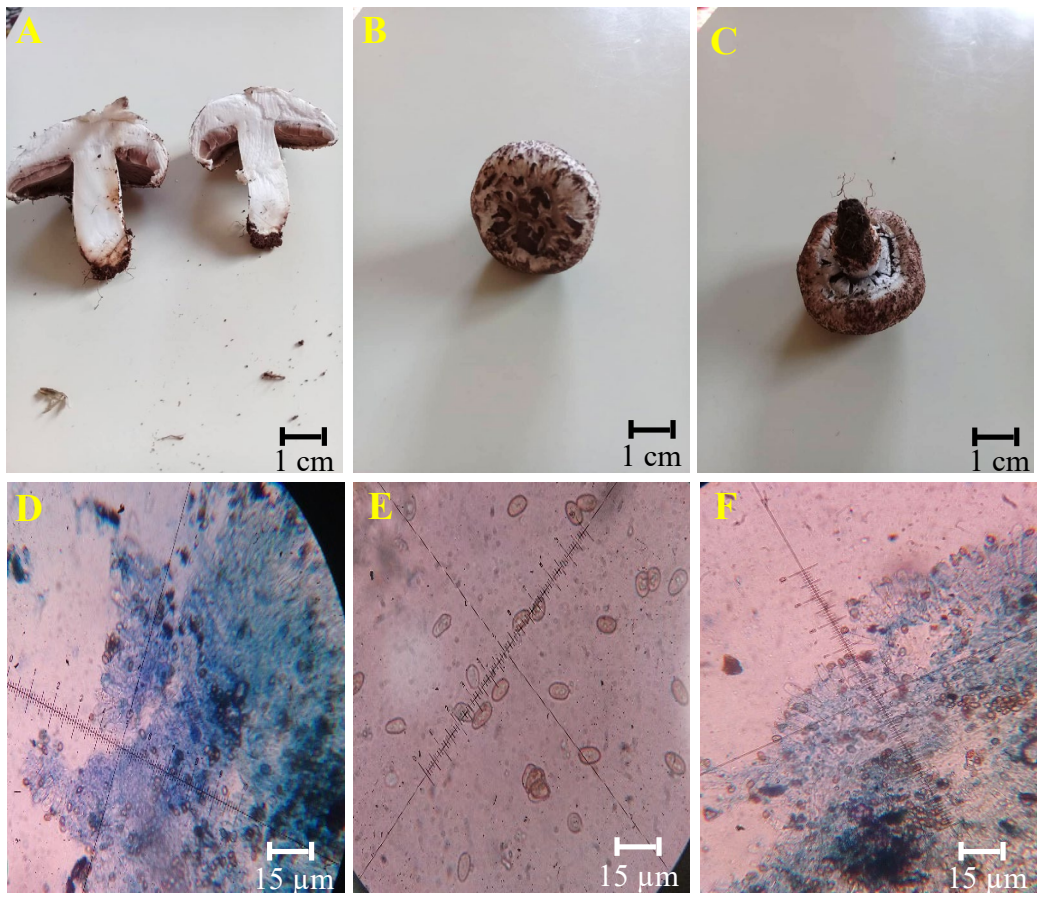

Figure 3. Morphological characteristics of B.R.9 mushroom specimen. (A-C) fresh fruiting body, (D) basidia, (E) basidiospores, (F) cheilocystidia.

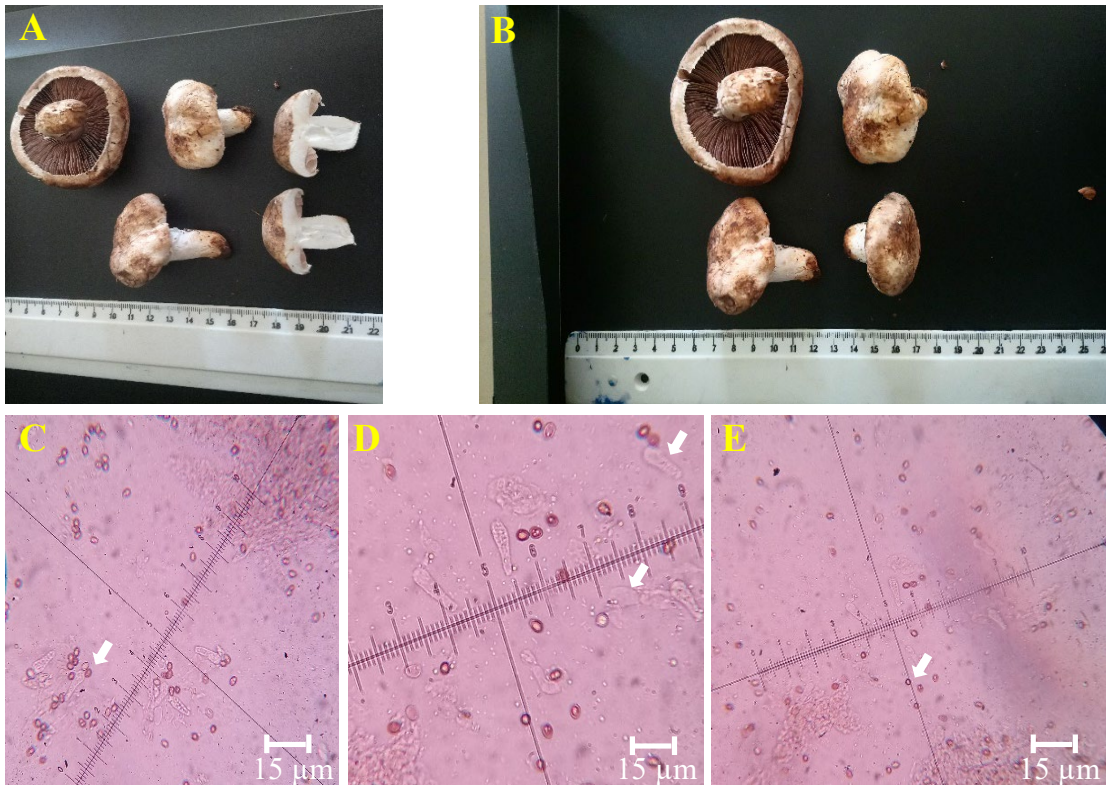

Figure 4. Morphological characteristics of B.R.17 mushroom specimen. (A-B) fresh fruiting body, (C) basidia, (D) basidiospores, (E) cheilocystidia.

Stipe: 2.5–4 × 1.5-1.9 cm, centralized, easy to separate from the pileus, firm, first broadly fusiform with a rounded base, then it becomes cylindrical with a tapering base with age, the surface is fibrous, a small hole in the middle of the stipe, the stipe surface is white, and the lower part is dirty brown. The tissue color is white that was not changed after cutting.

Annulus: derived from partial veil's remnant, its traces often remain on stipe's surface and pileus, but sometimes fall completely.

Odor: unmarked

Microchemical reaction: KOH reaction is negative.

Basidia: are rare or even absent on the lamellae, 22.50 (-27.50) × (5-)7.50 µm, n=6, clavate, transparent with 2-spores and 3-spores.

Basidiospores: (7.50-)8.75–10 × 5.08(-625) µm [Q= (1.50-1.75–2, V= 98.06-114.041 × 204.30 µm^3, n=15], Very variable in size and shape, elongated, soft, thick-walled, rusty brown, and have papilla without apical pore and oily droplets.

Cheilocystidia: globose, clavate or broadly clavate, often with a long pedunculi, hyaline or with yellowish-brown vacuolar pigment, pleurocystidia similar to the cheilocystidia, some with primitive sterigmata at apex.

Habitat: singular or collective, in the sandy soil of grasslands. This type features by medium to large semihypogeous basidia, light-colored cap, large spores, and the presence of pleurocystidia.

B.R.22 isolate

Pileus: 3.5-5.7 cm at maturity, white, light brown-to-creamy scales are irregularly distributed at the center and transformed into thin Fili format at the edges, the cap's edges are complete, wrapped inside, with clear traces of partial veil's remnant, the context is thick, fleshy with white tissues, convex to planate and flatten with age and asymmetric at the center with large fruit bodies (Figure 5).

Lamellae: Free, unconnected to stipe, closed, closely distributed with short lamellulae (unequal in length), crowded, little mushrooms bodies have white to grey color, turned pink with young fruitbodies and became chocolate brown to dark black with age.

Stipe: 2.4 × 3.5 cm, Long, thin, cylindrical, symmetrical with a bulging end, white, firm, fleshy, central, easy to separate from a cap, there are scales on the stipe.

Annulus: there are traces on the stipe and the bottom edges of the pileus of small bodies.

Odor: unmarked

Microchemical reaction: KOH reaction is negative.

Basidia: 22.50–25 × 5-7.50 µm, n= 8, they are mono but most of them 2-spore, clavate, and transparent.

Basidiospores: (5-)7.50-8.75(-10) × 5-6.25 µm [Q= (0.91-)1.50(-2), V=79.10-98.06 × 178.76 µm^3, n= 15], ellipsoid, reddish rusty brown color, with clear oily droplets and papilla.

Cheilocystidia: abundant Cheilocystidia cells with the absence of pleurocystidia.

Habitat: scattered in grasslands.

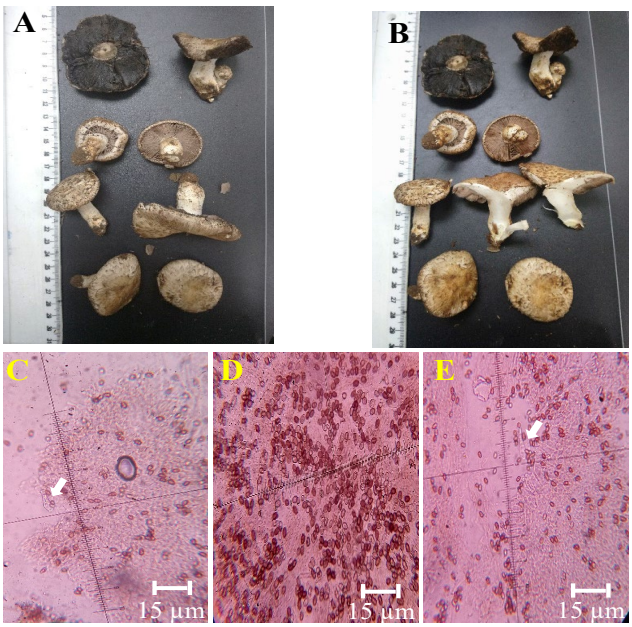

Figure 5. Morphological characters of B.R.22 mushroom specimen. (a-b) fresh fruiting body, (c) basidia, (d) basidiospores (e), cheilocystidia.

B.R.42 isolate

Pileus: diameter 2.5-4.5 cm at maturity, slightly convex to planate, full edge, and wrapped inside; asymmetric at the center, the surface is covered by thin filiform scales distributed irregularly from the center to the edges. The fibers have a creamy to light brown color, on creamy background, the context is thick, fleshy with white, tissues that become reddish brown when bruised and cut (Figure 6).

Lamellae: Free, crowded, very tight, with short, closely repeated lamellae, first pink, then brown, and finally dark brown.

Stipe: 2.9-4.5 × 0.7-1.5 cm, centralized, easy to separate from the cap, firm, without fibers on the stipe, first broadly fusiform with a rounded base, then cylindrical with a tapering base with age, the stipe surface is white tilted to diamond color, the bottom is dirty brown. The tissue is fleshy, coherent, and white, color did not change after cutting.

Annulus: Derived from partial veil's remnant, the scales often remain at the lower part of the stipe surface, but sometimes fall completely.

Odor: unmarked

Microchemical reaction: KOH reaction is negative.

Basidia: are very rare, transparent, 22.50–25(-37.50) × 6.25-7.50 µm, n=9, clavate, mono and most of them 2-spores and 3-spores.

Basidiospores: (3.75-)5-7.50 × 2.50-5 µm [Q= (1-)1.50-2, V=16.34 X 98.06 μm^3, n=15], Very variable in size and shape with papilla and without apical pore, ellipsoid, soft, thick-walled, rusty brown, oil droplets.

Cheilocystidia: globose, broadly clavate or clavate, often with a long pedunculi, hyaline or with green vacuolar pigment, Pleurocystidia similar to the cheilocystidia, some with primitive sterigmata at apex.

Habitat: singular or collective, in sandy soil of grasslands. This type features by medium to large semihypogeous basidia, light-colored cap, large spores, and the presence of pleurocystidia.

B.R.47 isolate

Pileus: 1.25-3 cm at maturity, white, the scales are reddish brown, a satin gloss covering the whole pileus, complete edges, wrapped inside, the context is thick, fleshy with white tissue, convex to planate and flatten with age, asymmetric at the center with older fruit bodies (Figure 7).

Lamellae: Free, unconnected, closed, closely connected with short lamellae (unequal in length), crowded, small mushrooms bodies have grey color, then pink in young fruit bodies, chocolate brown to dark black with age.

Stipe: length 1.5-3 × diameter 0.5-1cm, Long, thin, cylindrical, centralized easy to separate from pileus, symmetrical with a bulging end, white, the context is firm, fleshy, with white tissues, there are scales on stipe.

Annulus: traces on the lower part of the stipe and the bottom pileus edges of small mushroom bodies.

Odor: unmarked

Microchemical reaction: KOH reaction is negative.

Basidia: has the following dimensions (17.50-) 22.50-25 (-32.50) × 5-7.50 µm, n=7, mono, 2-spores, 3-spores, clavate, transparent.

Basidiospores: (5-)7.50 (-12.50) × 5 µm [Q=(1-)1.50(-2.50), V=(65.38-)98.06(-163.44), n=15], ellipsoid with papilla, rusty reddish-brown color, clear oily droplets.

Cheilocystidia: abundant Cheilocystidia cells with the absence of Pleurocystidia.

Habitat: scattered in grasslands.

Molecular identification

The fungal Genomic DNA amplified was isolated from the six mushroom specimens, and the DNA fragment size was verified on agarose gel. The PCR product size from the six mushroom isolates using ITS primers was found to be 550 bp as compared to 100 bp DNA molecular ladder (Figure 8). The PCR products were sequenced and the sequence data were deposited with the GenBank database under accession numbers as shown in Table 4. The morphological characterization and molecular identification of these mushroom specimens showed that they belonged to three species of the *Agaricus* genus: *A. bisporus*, *A. sinodeliciosus* and *A. qilianensis* (Table 2).

Evolutionary history was inferred using the UPGMA method (Sneath 1973). The analysis involved 22 nucleotide sequences (Figure 9). Evolutionary analyses were conducted by using MEGA 6 software (Tamura *et al.,* 2013).

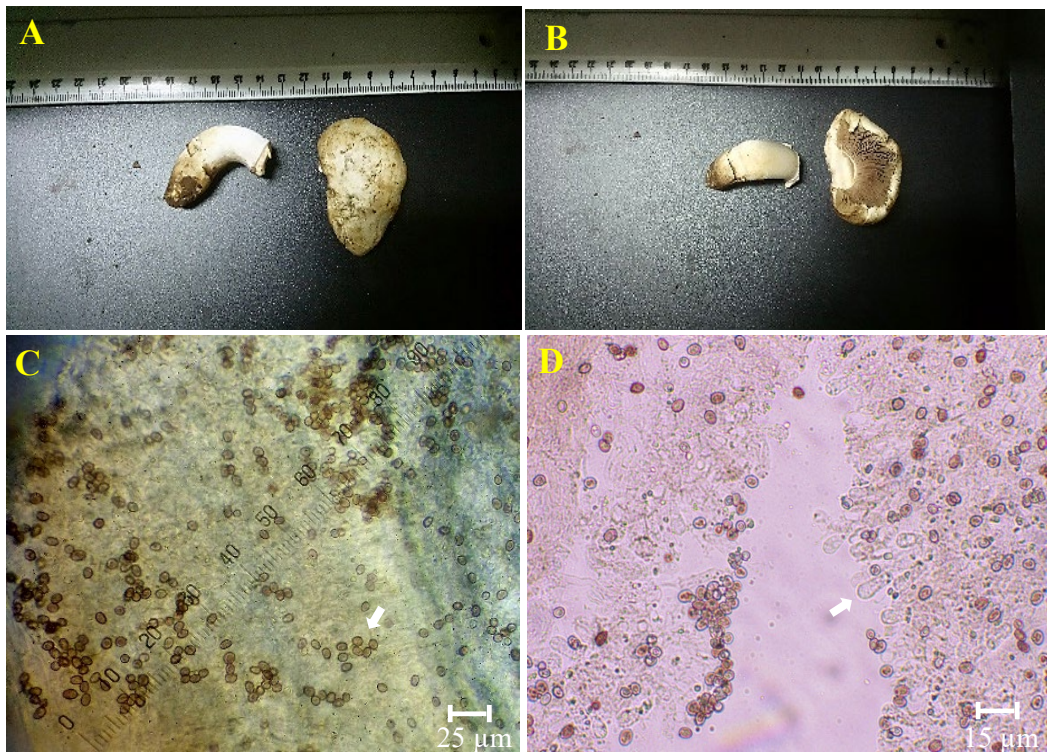

Figure 6. Morphological characters of B.R.42 mushroom specimen. (A and B) fresh fruiting body, (C) basidiospores, (D) cheilocystidia.

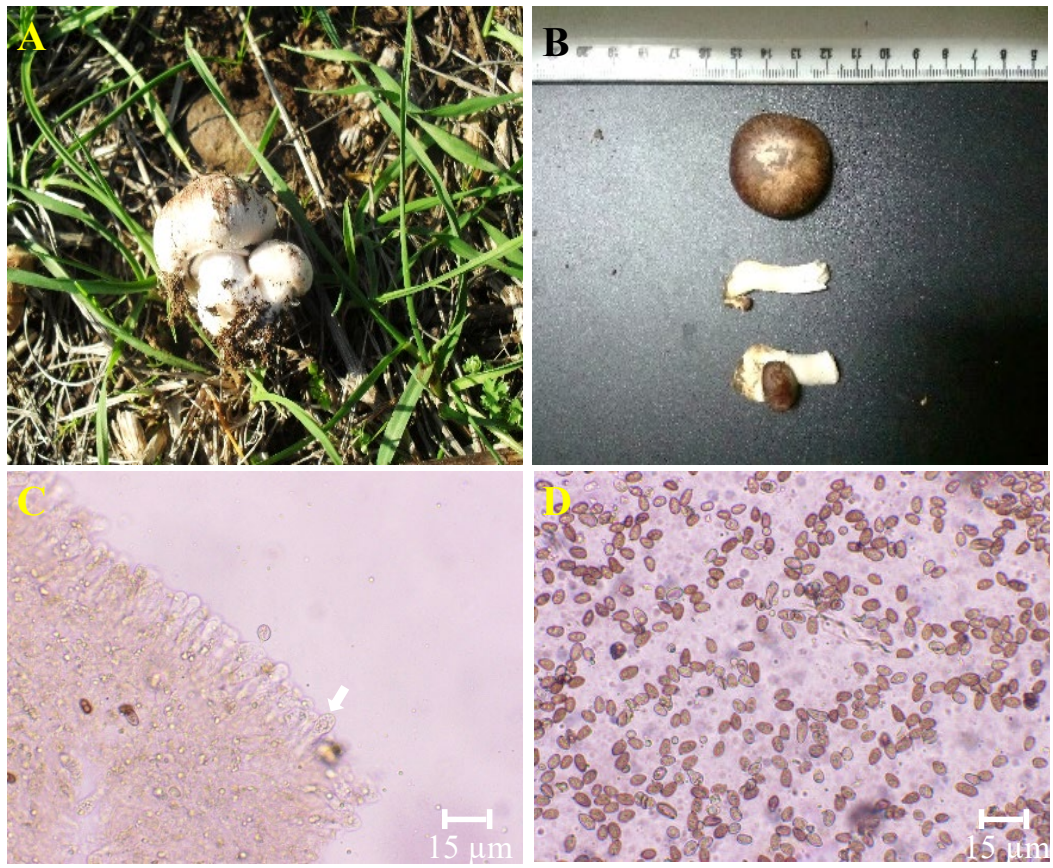

Figure 7. Morphological characteristics of BR47 mushroom. (A and B) fresh fruiting body, (C) basidia, (D) basidiospores.

Table 2. PCR ITS products accession numbers deposited in the GenBank.

Collection No.	Accession numbers	Taxon
B.R.5	OP648153.1	*Agaricus bisporus* (white)
B.R.9	OP648159.1	*Agaricus bisporus* (white)
B.R.17	OP648154.1	*Agaricus sinodeliciosus*
B.R.22	OP648155.1	*Agaricus qilianensis*
B.R.42	OP648156.1	*Agaricus sinodeliciosus*
B.R.47	OP648157.1	*Agaricus qilianensis*

Discussion

Studied mushroom samples were found to belong to three species of the *Bivelares* section. Some of the *Bivelares* mushrooms are edible with high nutritional value (Zhuo-Ren *et al.,* 2015) and others are widely cultivated (Zhang *et al.,* 2017). Most of its types are adapted to the dry (Zhuo-Ren *et al.,* 2015) and the moderate climate (Zhang *et al.,* 2017). Homs governorate, where collections were made, has a typical Mediterranean climate with hot and dry summer, moderate spring and autumn, cold and rainy winter with intermittent snowfall.

The six mushroom isolates identified in this study grew on sandy and dry soils and the plant types in those regions are mostly consisted of *Picea* species in addition to some species of dispersed lawn weeds and herbs.

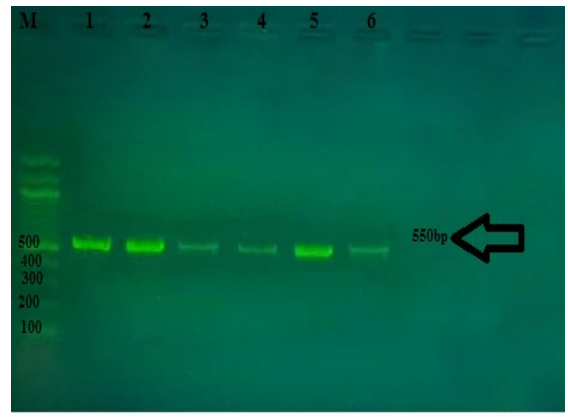

Figure 8. PCR product with size of 550 bp was separated from the six mushroom isolates electrophoresed on 1.5% agarose at 5 volt/cm^2 in 1x TBE buffer for 1:30 hours. M= DNA 100 bp molecular ladder.

There is a wide diversity of *Agaricus* within the *Bivelares* section, of which two new types of this section were first found in China in 2016, *A. sinodeliciosus*, the prefix "Sino" reflect Chinese origin; The nickname "deliciosus" means this type is edible and delicious (Zhuo-Ren *et al.,* 2015) and *A. qilianensis*, the prefix "qilian" refers to Mount Qilian where the first sample was found (Zhang *et al.,* 2017). It is the second time these two species are registered globally and the first time at the regional level. Two commercially known wild *A. bisporus* types were also found and registered.

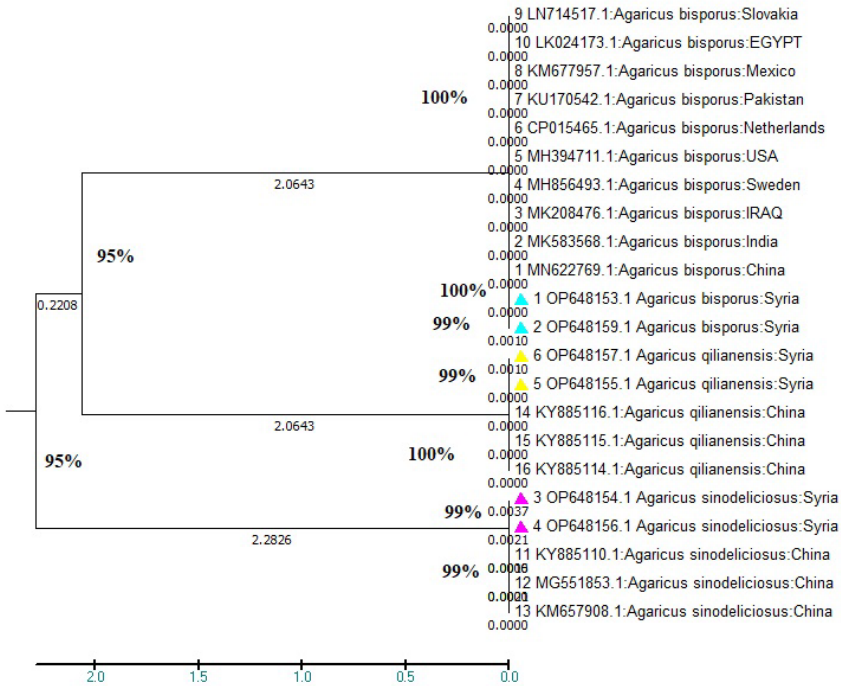

Figure 9. Phylogenetic tree by using ITS sequence data drawn by using Mega 6 software and NCBI data.

The isolates of *A. sinodeliciosus* and *A. qilianensis* mentioned in this study are characterized by a medium to large pilea with a delicious taste that makes them attractive and desirable by the local people. The results revealed some differences in terms of basidia dimensions and basidiospores size compared to the measurements reported by previous studies (Zhang *et al.,* 2017; Zhuo-Ren *et al.,* 2015). This might be attributed to the impact of environmental and growing conditions, such as temperature, pH, moisture, degree of aeration, amount and kind of nutrients (Alsohaili & Bani-Hasan, 2018; Gaddeyya *et al.,* 2012). Attempts to cultivate these types gave promising and encouraging results for *A. sinodeliciosus* and *A. qilianensis*. These findings constitute solid evidence that there is a need for further studies on mushroom diversity in the region.

It can be concluded from this study that some macro fungal species were recorded in Syria for the first time (*Agaricus sinodeliciosus, Agaricus qilianensis*), which encourage scientists to study further the diversity of mushroom within the Syrian environment especially in the un-surveyed locations.

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الملخص

هولا، بشرى، رمزي مرشد وموفق جبور. 2025. وصف وتحديد بعض أنوع الفطور البرية التابعة للجنس *Agaricus* في المنطقة الغربية من محافظة حمص، سورية. مجلة وقاية النبات العربية، 43(3):414−424. https://doi.org/10.22268/AJPP-001335

تمّ إجراء جولات ميدانية لجمع الفطر البري من الجزء الغربي لمحافظة حمص في سورية خلال أوائل تشرين الأول/أكتوبر وحتى أواخر كانون الأول/ديسمبر 2021، وكذلك من أوائل تشرين الثاني/نوفمبر إلى أواخر كانون الأول/ديسمبر 2022. نتج عن تحديد الفطور التي جمعت وجود ستّ عزلات من الفطر البري التابعة للجنس *Agaricus*. تمّ على الفور أخذ قراءات التوصيف الشكلي للعينات المجموعة، مثل قياسات، اللون، رائحة القبعة، الساق ووجود الحلقة −. أظهر التعريف الجزيئي لعينات الفطر المدروسة، باستخدام سلسلة نسخ الفواصل البينية للـ DNA الريبوزومي (rDNA-ITS)، أنها تنتمي إلى ثلاثة أنواع مختلفة على الشكل التالي: *A. bisporus* (OP648153 و OP648159)، *A. sinodeliciosus* (OP648154 و OP648156) و *A. qilianensis* (OP648155 و OP648157). تعدّ هذه المرة الأولى التي يتمّ فيها تحديد هذه الأنواع الثلاثة في البيئة السورية، والتي توفر معلومات إضافية لقاعدة بيانات بنك المورثات GenBank، وقد تسهّل تدجين هذه الأنواع البرية وتسويقها.

كلمات مفتاحية: فطر بري، تحديد، سورية، *Agaricus qilianensis*، *Agaricus sinodeliciosus*، *Agaricus bisporus*، rDNA.

عناوين الباحثين: بشرى هولا[1*]، رمزي مرشد[1] وموفق جبور[2]. (1) قسم البساتين، كلية الزراعة، جامعة دمشق، سورية؛ (2) الهيئة العامة للبحوث العلمية الزراعية، دمشق، سورية. *البريد الإلكتروني للباحث المراسل: boushra2.hola@damascusuniversity.edu.sy

References

Ahmad, L. 2020. Study of ecological and biological diversity of *Pleurotus* spp. in Southwest Hama for selection and culture of high quality strains. PhD. dissertation, Damascus University Faculty of Agriculture. 122pp. *(In Arabic)*.

Alabi, M.M. and A. Ahmad. 1996. Contributing to the study and classification of pileus fungi in Maskanah area of Aleppo governorate. Aleppo University Research Journal, Agricultural Science Series, 25:105-125 *(in Arabic)*.

Alsohaili, S.A. and B.M. Bani-Hasan. 2018. Morphological and molecular identification of fungi isolated from different environmental sources in the northern eastern desert of Jordan. Jordan Journal of Biological Sciences, 11(3):329–337.

Baghdadi, W. 1972. Studies on flora of fungi, lichens and chippies in Syria. Science Week Book II 13 Basic Science Studies and Research, Science Supreme Council, Syria *(In Arabic)*.

Baghdadi, W., A.A. Nizam and H.S.H. Agha. 2001. Contribution in the biodiversity study of Ascomycetes and Basidiomycetes in Barada Basin. Department of Botany, Faculty of sciences, Damascus University, Syria. *(In Arabic)*.

Bawadikji A.H. and A. Ahmad. 2003. Contribution to the identification of wild fungal species (Macromycetes) in the Arid and semi-arid zones of Aleppo Governorate (Syria). (*In Arabic*).

Bruns, T.D., M.I. Bidartondo and D.L. Taylor. 2002. Host specificity in ectomycorrhizal communities: what do the exceptions tell us? Integrative and Comparative Biology, 42(2):352-359. https://doi.org/10.1093/icb/42.2.352

Callac, P. and J. Chen. 2018. Tropical species of Agaricus. Pp. 25-38. In*:* Updates on Tropical Mushrooms. Basic and Applied Research. J.E.S. Vázquez, G.Mata and D.J. Royse (eds.). EcoSur, San Cristobal de Las Casas, Chiapas, Mexico.

Callac, P., I.J. de Haut, M. Imbernon, J. Guinberteau and I. Theochari. 2003. A novel homothallic variety of *Agaricus bisporus* comprises rare tetrasporic isolates from Europe. Mycologia, 95(2):222-231. https://doi.org/10.2307/3762033

Chang, S.T. 1999. World production of cultivated edible and medicinal mushrooms in 1997 with emphasis on *Lentinus edodes* (Berk.) Sing in China. International Journal of Medical Mushrooms, 1(4):291-300. https://doi.org/10.1615/IntJMedMushr.v1.i4.10

Chang, S.T. and P.G. Miles. 1992. Mushroom biology: A new discipline. Mycologist, 6(2):64–65. https://doi.org/10.1016/S0269-915X(09)80449-7

Chen, J., P. Callac L.A. Parra, S.C. Karunarathna, M.Q. He, M. Moinard, A. De kesel, O. Raspé, K. Wisitrassameewong, K.D. Hyde and R.L. Zhao. 2017. Study in *Agaricus* subgenus *Minores* and allied clades reveals a new American subgenus and contrasting phylogenetic patterns in Europe and Greater Mekong Subregion Persoonia. Molecular Phylogeny and Evolution of Fungi, 38(1):170-196. https://doi.org/10.3767/003158517X695521

Chukunda, F.A. and W.S. Simbi-Wellington. 2019. Effects of crude oil on the growth of oyster mushroom, *Pleurotus ostreatus* (Jacaum ex. fr. Kummer). Journal of Applied Sciences and Environmental Management, 23(10):1787-1793. http://dx.doi.org/10.4314/jasem.v23i10.4

Desjardin, D.E., M.G. Wood and F.A. Stevens. 2015. California Mushrooms: The Comprehensive Identification Guide. Timber Press, London. 559 pp.

Ez, A. 2007. Eco-Geographic survey and genetic diversity assessment of *Pleurotus ostreatus* (Jacq. ex: fr.) Kummer in Syria. M.Sc. thesis, Faculty of Agricultural Engineering, Aleppo University, Syria. 138 pp (*In Arabic*).

Gaddeyya, G., P.S. Niharika, P. Bharathi and P.K.R. Kumar. 2012. Isolation and identification of soil mycoflora in different crop fields at Salur Mandal. Advances in Applied Science Research, 3(4):2020-2026.

Grigson, J. 2008. The Mushroom Feast. Grub Street Cookery. 336 pp.

Hall, I.R., W, Yun and A. Amicucci. 2003. Cultivation of edible ectomycorrhizal mushrooms. Trends in Biotechnology, 21(10):433-438. https://doi.org/10.1016/s0167-7799(03)00204-x

Hawksworth, D.L. 2004. Fungal diversity and its implications for genetic resource collections. Studies in Mycology, 50(1):9–17.

He, M.Q., J. Chen, J. L. Zhou, C. Ratchadawan, K.D. Hyde and R.L. Zhao. 2017. Tropic origins, a dispersal model for saprotrophic mushrooms in *Agaricus* section *Minores* with descriptions of sixteen new species. Scientific Reports, 7(1):5122. https://doi.org/10.1038/s41598-017-05203-5

Hussein, M.A. 2011. Study of the fungal diversity in Al-Sheer region coastal soils of fields cultivated by wheat, and the effect of some environmental conditions on their diversity. Tishreen University Journal for Research and Scientific Studies, Biological Sciences Series, 33(6):217-236. (*In Arabic*).

Imes, R. 1990. The Practical Botanist: An Essential Field Guide to Studying, Classifying, and Collecting Plants. Quatro Publishing plc. 160pp.

Jordan, P. 1995. The New Guide to Mushrooms. The Ultimate Guide to Identifying, Picking and Using Mushrooms. Sebastian Kelly. 128pp.

Karunarathna, S.C., J. Chen, P.E. Mortimer, J.C. Xu, R.L. Zhao, P. Callac and K.D. Hyde. 2016. Mycosphere essay 8: A review of genus *Agaricus* in tropical and humid subtropical regions of Asia. Mycosphere, 7(4):417–439.

Kaya, A. 2009. Macrofungal diversity of Adiyaman Province (Turkey). Mycotaxon, 110(1):43-46. https://doi.org/10.5248/110.43

Kerrigan, R.W. 2016. Agaricus of North America. Memoirs of the New York Botanical Garden, Volume 114. 574pp.

Kirk, P.M., P.F. Cannon, D.W. Minter and J.A. Stalpers. 2008. Ainsworth and Bisby's Dictionary of the Fungi 10th Edition. CABI Publishing, Wallingford, UK. 771pp.

Largent, D., D. Johnson and R. Watling. 1978. How to identify mushrooms: III. Microscopic Features. Mad River Press, Eureka, California, USA. 148pp.

Largent, D.L. 1986. How to identify mushrooms to genus I: macroscopic features. Mad River Press, Eureka, California, USA. 166 pp.

Lincoff, G.H. 2011. National Audubon Society Field Guide to North American Mushrooms. Mad River Press, Eureka, California, USA. 928pp.

Loizides M, J.M. Bellanger, P. Clowez, F. Richard and P.A. Moreau. 2016. Combined phylogenetic and morphological studies of true morels (*Pezizales*, *Ascomycota*) in Cyprus reveal significant diversity, including *Morchella arbutiphila* and *M. disparilis* spp. Nov. Mycological Progress, 15(4):1-28. https://doi.org/10.1007/s11557-016-1180-1

Loizides, M., J.M. Bellanger Y. Yiangou and P.A. Moreau. 2018. Preliminary phylogenetic investigations into the genus *Amanita* (Agaricales) in Cyprus, with a review of previous records and poisoning incidents. Documents Mycologiques, 37:201-218.

Loizides, M., J.M. Bellanger, B. Assyov, P.A. Moreau and F. Richard. 2019. Present status and future of boletoid fungi (*Boletaceae*) on the island of Cyprus: Cryptic and threatened diversity unraveled by ten-year study. Fungal Ecology, 41:65-81. https://doi.org/10.1016/j.funeco.2019.03.008

Lücking, R. and D.L. Hawksworth. 2018. Formal description of sequence-based voucherless fungi: promises and pitfalls, and how to resolve them. IMA Fungus, 9(1):143-165. https://doi.org/10.5598/imafungus.2018.09.01.09

Parra, L.A. 2008. Fungi Europaei *Agaricus* L. Allopsalliota, Nauta & Bas. Edizioni Candusso, Alassio, Italy. 824pp.

Paz, A., J.M. Bellanger, C. Lavoise, A. Molia, M. Ławrynowicz and E. Larsson. 2017. The genus *Elaphomyces* (Ascomycota, Eurotiales): a ribosomal DNA-based phylogeny and revised systematics of

European 'deer truffles'. Persoonia-Molecular Phylogeny and Evolution of Fungi, 38(1):197-239. https://doi.org/10.3767/003158517X697309

Peintner, U., S. Schwarz, A. Mešić, P.A. Moreau, G. Moreno and P. Saviuc. 2013. Mycophilic or mycophobic? Legislation and guidelines on wild mushroom commerce reveal different consumption behavior in European countries. PloS One, 8(5):e63926. https://doi.org/10.1371/journal.pone.0063926

Petrini, O., L. Cocchi, L. Vescovi and L. Petrini. 2009. Chemical elements in mushrooms: their potential taxonomic significance. Mycological Progress, 8(3):171-180. https://doi.org/10.1007/s11557-009-0589-1

Polemis, E., D.M. Dimou, D. Tzanoudakis and G.I. Zervakis. 2012. Annotated checklist of Basidiomycota (Subclass Agaricomycetidae) from the islands of Naxos and Amorgos (Cyclades, Greece). Annales Botanici Fennici, 49:145–161.

Savoie, J.M., M. Foulongne–Oriol, G. Barroso and P. Callac. 2013. Genetics and genomics of cultivated mushrooms, application to breeding of *Agaricus*. Pp. 3-33. In*:* Agricultural Applications. F. Kempken (ed). Springer. Berlin and Heidelberg, Germany.

Sneath, P.H.A. and R.R. Sokal. 1973. Numerical Taxonomy. WH Freeman and Co., San Francisco, USA. 573pp.

Tamura, K., G. Stecher, D. Peterson, A. Filipski and S. Kumar. 2013. MEGA6: molecular evolutionary genetics analysis version 6.0. Molecular Biology and Evolution 30(12):2725-2729. https://doi.org/10.1093/molbev/mst197

Taşkın, H., H.H. Doğan, S. Büyükalaca, P. Clowez, P.A. Moreau and K. O'Donnell. 2016. Four new morel (*Morchella*) species in the elata subclade (*M. sect. Distantes*) from Turkey. Mycotaxon, 131(2):467-482. https://doi.org/10.5248/131.467

Torrejón, M. 2014. Annotated checklist of fungi in Cyprus Island. 1. Larger Basidiomycota. Acta Mycologica 49(1):109-134. https://doi.org/10.5586/am.2014.011

Vrinda, K.B. and C.K. Pradeep. 2014. Wild edible mushrooms from Kerala forests-a source of food and income (final project report submitted to department of planning and economic affairs, WGDP, Government of Kerala). Jawaharlal Nehru Tropical Botanical Garden and Research Institute, Palode, Thiruvananthapuram. 124pp.

White, T.J., T. Bruns, S.J.W.T. Leen and J. Taylor. 1990. Amplification and direct sequencing of fungal ribosomal RNA genes for phylogenetics. Pp. 315-322. In: PCR Protocols: A Guide to Methods and Applications. M.A. Innis, D.H. Gelfand, J.J. Sninsky and T.J. White (eds.). Academic Press, USA.

Zhang, M.Z., G.J. Li, R.C. Dai, Y.L. Xi, S.L. Wei and R.L. Zhao. 2017. The edible wild mushrooms of Agaricus section Bivelares from Western China, Mycosphere, 8(10):1640-1652.

Zhao, R.L., S. Karunarathna, O. Raspé, L.A. Parra, J. Guinberteau, M. Moinard, A. De Kesel, A. Barroso, G. Courtecuisse, R. Hyde, K.D. Gelly, A.K. Desjardin and P. Callac. 2011. Major clades in tropical *Agaricus*. Fungal Diversity, 51(1):279-296. https://doi.org/10.1007/s13225-011-0136-7

Zhuo-Ren, W., L.A. Parra, P. Callac, J.L. Zhou, W.J. Fu, S.H. Dui, K.D. Hyde and R.L. Zhao. 2015. Edible species of *Agaricus* (Agaricaceae) from Xinjiang Province (Western China). Phytotaxa, 202(3):185–197. https://doi.org/10.11646/phytotaxa.202.3.2

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