



## RESEARCH ARTICLE

### New records of macrofungi species in Israel

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#### ABSTRACT

The Fungarium at the Steinhardt Museum of Natural History, Tel-Aviv University, was founded 50 years ago by the late Prof. Nissan Binyamini. Over the last decade a group of amateur mycologists, led by Bruria Gal, have restored and digitized Binyamini's vast collection. They have performed fungi surveys throughout Israel to renew this collection and preserve new specimens for future research, which will also be available for molecular research. Twenty-two new records of macrofungi in Israel were acquired during these surveys. The role of citizen science is emphasized in enhancing ecological surveys, through the collective effort of non-professionals in gathering extensive data across diverse habitats.

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#### Introduction

In Israel, macrofungi have been studied in the last 80 years by several mycologists. Altogether ca. 850 species of macrofungi have been identified (Avizohar-Hershenzon and Binyamini 1973, 1974; Biketova et al. 2015; Binyamini 1973, 1974, 1975a,b, 1976a,b,c, 1980, 1984a,b,c,d, 1989, 1994; Binyamini and Avizohar-Hershenzon 1973; Kosakyan et al. 2008; Rayss and Reichert 1952; Reichert 1940a,b,c, 1944; Reichert and Avizohar-Hershenzon 1959; Wasser 1992, 2002; Wasser and Binyamini 1992). The late Professor Binyamini studied the fungi of Israel between 1970–1998. Binyamini established a fungi collection at Tel Aviv University comprising over 5,500 specimens, representing 810 species. He identified the various specimens and preserved them in paper envelopes that contained the fruiting bodies of higher Basidiomycetes. When he retired his collection was neglected, and over time 10–15% of the collection became corrupted by rats and humidity. The Steinhardt Museum of Natural History at Tel-Aviv University (SMNHTAU), took on the task of recovering and housing the collection; and, since 2014, Bruria Gal, an amateur naturalist and nature conservation activist, has worked to clean and

digitize this collection, with the help of enthusiastic volunteers. This group of volunteers has also added 1,500 new specimens, belonging to 250 species, to the SMNHTAU Fungarium.

Professional mycologists are too few by far to meet the needs of sampling large areas. Consequently, collaborations between professional mycologists and citizen-scientists (CS) are gaining momentum throughout the world. In Greece, a collaboration between the Greek Mushroom Society and the University of Athens has resulted in several studies publishing the first national records of certain mushroom species (Polemis et al. 2023). In northwestern Siberia, a regional mycological club has contributed 15,000 observations of fungi and myxomycetes, 50% of which have been given Research Grade status by experts. These observations resulted in 195 records representing 90 taxa new to their respective regions (Filippova et al. 2022). Haelewaters et al. (2024) reviewed the CS-based projects to record and monitor fungal diversity. They stress the importance of these projects in building support and understanding regarding fungi conservation, which lags behind the conservation programs for animals and plants.

Here we present for the first time 22 species of macrofungi new to the Israeli mycobiota, all collected by amateur mycologists. None of these new records have been previously published in peer-reviewed literature, although some may have been published in Hebrew in the social media, with only partial data, and without the specimens being collected or samples being deposited in any herbaria. All these species are known from Europe or India but had not been recorded to date from Israel.

## Materials and methods

### Sample collection

The specimens were collected in the winter season, November through February, mostly from the forests of the northern and central parts of Israel, all featuring a Mediterranean climate: Golan Heights, Lower and Upper Galilee, and Carmel and Judean mountains. Most of the species were associated with *Quercus calliprinos*, *Q. itaburensis*, *Eucalyptus*, and *Pinus halepensis* trees. One specimen was collected in the desert sands of the Arava valley.

The specimens were morphologically identified based on descriptions in the literature. Nomenclature is based on MycoBank (<https://www.mycobank.org>, accessed between 2023–2024).

### Molecular identification

To support the morphological identification of the specimens the ITS1 region was sequenced. DNA was extracted with Presto™ Stool DNA Extraction Kit (Geneaid). A fragment of 600–700 bp (depending on the species) was amplified using ITS1 (5'-AACAAAGTT TCCGTAGGTGAACCTGC-3') and ITS4 (5'-TTCTTTTCCT CCGCTTATTGATATGC-3') primers (White et al. 1990). To identify the sequences, a BLASTN search was performed against the nucleotide collection in GenBank (Zhang et al. 2000). Sequences were submitted to GenBank.

## Results

We hereby present the list of twenty-two inaugural Israeli national records of macrofungi. The specimens were identified through their general morphology, with confirmation provided by the ITS1 sequence. All sequences showed 95–99% identity in BLASTN

searches with sequences corresponding to the species identified morphologically, except for two cases, which will be discussed below.

## Class Agaricomycetes

### Order Agaricales

#### Family Agaricaceae

*Leucoagaricus cupresseus* Migliozi & Forin 2022

General Morphology: Pileus 7 cm in diameter, color pinkish-light brown. Lamellae free, crowded, white. Stipe 8 cm. Material examined: Yizre'el Valley; *Quercus calliprinos* forest. Two other specimens were found under *Cupressus* trees. Collected by: Yair Ur and Bruria Gal, 30/12/2023, Fig.1a, voucher SMNHTAU:Fu.23.147, GenBank PQ310613

#### Family Amanitaceae

*Amanita torrendii* (Bresadola) Justo 2010

General Morphology: Pileus 1.5 cm diameter, white, with a finely grained surface. Stipe 3 cm long, scaly and breaks easily. Grows in groups of 4–5. Material examined: Golan heights; On grass near *Quercus* trees. Collected by: Yair Ur, 22/12/2018, Fig.1e, voucher SMNHTAU:Fu.18.360, GenBank PQ310585

#### Family Clitocybaceae

*Lepista panaeola* (Fries) Karsten 1879

General Morphology: Pileus 8–12 cm. Smooth, grayish-brown with small darker spots around. Lamellae crowded, light-gray. Stipe 7 cm long. Material examined: Uper Galilee; *Quercus calliprinos* forest. Collected by: Bruria Gal, 11/01/2023, Figs.1g,1h, voucher SMNHTAU:Fu.23.036, GenBank PQ310607

#### Family Cortinariaceae

*Cortinarius aleuriosmus* Maire 1910

General Morphology: Pileus 9 cm. Lamellae crowded, white-yellowish, occasionally becoming violet. Spore print rusty brown, Stipe 7 cm long and 1.5 cm thick. Odor distinctly floury. Material examined: Golan heights; *Quercus calliprinos* forest. Collected by: Yair Ur, 22/12/2018, Figs.1b,1c, voucher SMNHTAU:Fu.18.387, GenBank PQ310586

*Phlegmacium aurilicis* (Chevassut & Trescol) Niskanen & Liimatainen 2022

General Morphology: Specimen dried to preserve for the collection, so no measurements available.

Material examined: Carmel Ridge; A mixed forest of *Pinus* and *Quercus* trees. Collected by: Arnon Shadmi, 30/04/2023, Fig.1j, voucher SMNHTAU:Fu.23.046, GenBank PQ310608

*Phlegmacium caligatum* (Malençon) Niskanen & Liimatainen 2022

General Morphology: Pileus 7 cm, grayish-brown. Lamellae crowded, pale-violaceous color. Stipe 4 cm, dull brown, covered with rings of scaly layers. Material examined: Uper Galilee; Forest, mostly *Quercus Calliprinos* trees. Collected by: Bruria Gal, 11/01/2023, Fig.1f, voucher SMNHTAU:Fu.23.035, GenBank PQ310606

### Family Entolomataceae

*Lulesia nigrescens* (Maire) Vizzini, Consiglio, Alvarado, Angelini & Marchetti 2023

General Morphology: Pileus 6 cm, convex with wavy margins, yellowish-gray. Lamellae crowded, sloping on the stipe. Spores print pinkish color. Flesh turns from white to gray when cut. Stipe 7 cm long, 1 cm thick. Material examined: Yizre'el Valley; *Pinus halepensis* forest. Collected by: Arnon Shadmi, 22/02/2024, voucher SMNHTAU:Fu.24.098, GenBank PQ310619

*Rhodocybe asanii* Sesli & Vizzini 2017

General Morphology: Pileus 5 cm, reddish-brown, wavy edges. Material examined: Carmel Ridge; *Quercus* forest. Collected by: Bruria Gal 15/12/2018, Fig.1l, voucher SMNHTAU:Fu.18.240, GenBank PQ310584

*Rhodocybe asyae* Sesli & Vizzini 2017

General Morphology: Pileus 4 cm, wavy margins, smooth, reddish-brown. Stipe 5 cm, light brown. Material examined: Uper Galilee; *Pinus* and *Quercus* forest. Collected by: Bruria Gal, 22/01/2018, voucher SMNHTAU:Fu.18.034, GenBank PQ310582

### Family Psathyrellaceae

*Lacrymaria lacrymabunda* (Bulliard) Patouillard 1887

General Morphology: Pileus 6–8 cm, convex when young, rusty-brown, fibrillose, scaly. Lamellae attached to stipe, grayish then black. Stipe 10 cm long, scaly below ring zone. Material examined: Upper Galilee; *Quercus* forest. Collected by: Nir Yvgi, 08/12/2022, Figs.1j,1k, voucher SMNHTAU:Fu.24.105, GenBank PQ310622

### Family Strophariaceae

*Hebeloma subtortum* Karsten 1889

General Morphology: Pileus 6 cm. Lamellae pale buff then brown. Stipe 8 cm long. Material examined: Golan heights; *Quercus* forest. Collected by: Dalia Bones, 13/01/2018, voucher SMNHTAU:Fu.18.017, GenBank PQ310580

*Leratiomyces squamosus* (Persoon) Bridge & Spooner 2008

General Morphology: Pileus 3 cm, convex, yellow-brown. Stipe 7 cm long, lower half covered with white scales, a small ring on the middle of the stipe. Material examined: Golan heights; *Quercus* forest. Collected by: Nitzan Ilisar, 25/12/2020, Fig.1d, voucher SMNHTAU:Fu.20.225, GenBank PQ310592

### Order Boletales

#### Family Boletaceae

*Alessioporus ichnusanus* (Alessio, Galli & Littini) Gelardi, Vizzini & Simonini 2014

General Morphology: Pileus 7 cm, gray-brown surface, when cut the flesh is yellow and quickly turns blue. Stipe 5 cm long, 2.5 cm diam. Binyamini in his 1975 book described a species with similar description – *Xerocomus silverii*, but this name is not found in any mycological literature. Material examined: Judea foothills; Eucalyptus Forest. Collected by: Ashot, 28/11/2022, Figs.2a, 2b, voucher SMNHTAU:Fu.22.044, GenBank PQ310604

### Order Phallales

#### Family Phallaceae

*Itajahya galericulata* Möller 1895

General Morphology: Fruit-body starts from a whitish egg, 3 cm diam, then grows up to 8 cm long. Head black. Resembles *Phallus impudicus* but *Itajahya* head is topped by white hat. Material examined: Central Coastal Plain; Open grass field. Collected by: Yonatan Gur, 22/11/2023, Fig.2f, voucher SMNHTAU:Fu.23.084, GenBank PQ310611. The ITS1 sequence of SMNHTAU:Fu.23.084 was only 93% identical to sequence MF506819 of *I. galericulata* from India, and 96% identical to sequences of *Itajahya rosea* from Pakistan. *I. rosea*, however, is a synonym of *Phallus roseus* Delile. When aligning our sequence to sequences of *Phallus impudicus* and *Phallus dongsun* from the





**Figure 1.** Nine Agaricales species new to Israel. a) *Leucoagaricus cupresseoides*, b+c) *Cortinarius aleuriosmus*, d) *Leratiomyces squamosus*, e) *Amanita torrendii*, f) *Phlegmacium caligatum*, g+h) *Lepista panaeola*, i) *Phlegmacium aurilicis*, j+k) *Lacrymaria lacrymabunda*, l) *Rhodocybe asanii*. The photos were taken by the collectors.



GenBank, because it was clear that the sequences annotated as *Phallus* differed from sequences annotated as *Itajahya*, we therefore identified our specimen as *Itajahya galericulata*.

### Order Polyporales

#### Family Ganodermataceae

*Ganoderma mbrekobenum* Otto, Blanchette, Held, Barnes & Obodai 2016

General Morphology: Fruit-body surface hard and glabrous, rounded, 30 cm across, waxy coating, chestnut color, with bow-shaped radials. Specimen was attached to a large root underground. Resembles *Phaeolus schweinitzii*. Material examined: Central Coastal Plain; In a garden. Collected by: Dalia Bones, 21/12/2023, Fig.2d, voucher SMNHTAU:Fu.23.121, GenBank PQ310612

### Order Russulales

#### Family Russulaceae

*Lactarius atlanticus* Bon 1975

General Morphology: Pileus 7 cm, depressed in the center, margins wavy, deep red. Lamellae attached to the stipe or running slightly down it, ocher-yellowish. Stipe 9 cm long. The hairy base serves as an important identification character. Material examined: Central coastal plain; *Quercus calliprinos* forest. Collected by: Nitzan Ilsar, 21/12/2020, Fig.2e, voucher SMNHTAU:Fu.20.185, GenBank PQ310591

*Lactarius ilicis* Samari 1993.

General Morphology: Pileus 8 cm, yellow-brown. Lamellae crowded, milk on the lamellae white to grayish. Stipe 5 cm, yellow-brown. Material examined: Carmel Ridge; *Quercus calliprinos* forest. Collected by: Arnon Shadmi, 23/04/2023, Fig.2c, voucher SMNHTAU:Fu.23.069, GenBank PQ310609

*Lactarius sanguifluus* (Paulet) Fries 1838

General Morphology: Pileus 9 cm, rounded, then flattens with central depression, margins curved downward with purple-orange. Lamellae crowded, pinkish-orange. Milk orange, then turns wine-red. Green patches appear when exposed to air. Stipe 5 cm long, cylindrical, pink-orange with some darker spots. When cut – a reddish ring appears. Scent is fruity. Material examined: Judea foothills; *Pinus halepensis* forest. Collected by: Nitzan Ilsar, 19/02/2021, Fig.2h, voucher SMNHTAU:Fu.21.074, GenBank PQ310595

### Order Thelephorales

#### Family Bankeraceae

*Hydnellum amygdaliolens* (Rubio Casas, Rubio Roldán & Català) Larsson, Larsson & Kõljalg 2019

General Morphology: Pileus diameter 5 cm, brown, spines on the hymenium. Material examined: Judea foothills *Pinus* and *Quercus* forest. Collected by: Nitzan Ilsar, 11/11/2022, Fig.2i, voucher SMNHTAU:Fu.22.036, GenBank PQ310602

### Class Geoglossomycetes

#### Order Geoglossales

#### Family Geoglossaceae

*Geoglossum cookeanum* Nannfeldt ex Minter & Cannon 2015

General Morphology: Fruit-body 3 cm long, 8 mm wide, shape is cylindrical infertile, spatulate or compressed, black color. Material examined: Lower Galilee; Pine forest under *Rhamnus lycioides*, associated with moss. Collected by: Yaniv Segal, 09/02/2021, Fig.2g, voucher SMNHTAU:Fu.21.064, GenBank PQ310594

### Class Pezizomycetes

#### Order Pezizales

#### Family Tuberaceae

*Tuber lusitanicum* Antonio Rodríguez & Muñoz-Mohedano 2020

General Morphology: Diameter 2 cm. Irregular lobal form. Peridium light-yellow, smooth, somewhat shiny. Gleba brownish. Material examined: Carmel Ridge; *Quercus* forest. Collected by: Arnon Shadmi, 08/04/2021, Fig.2j, voucher SMNHTAU:Fu.21.089, GenBank PQ310596

### Class Sordariomycetes

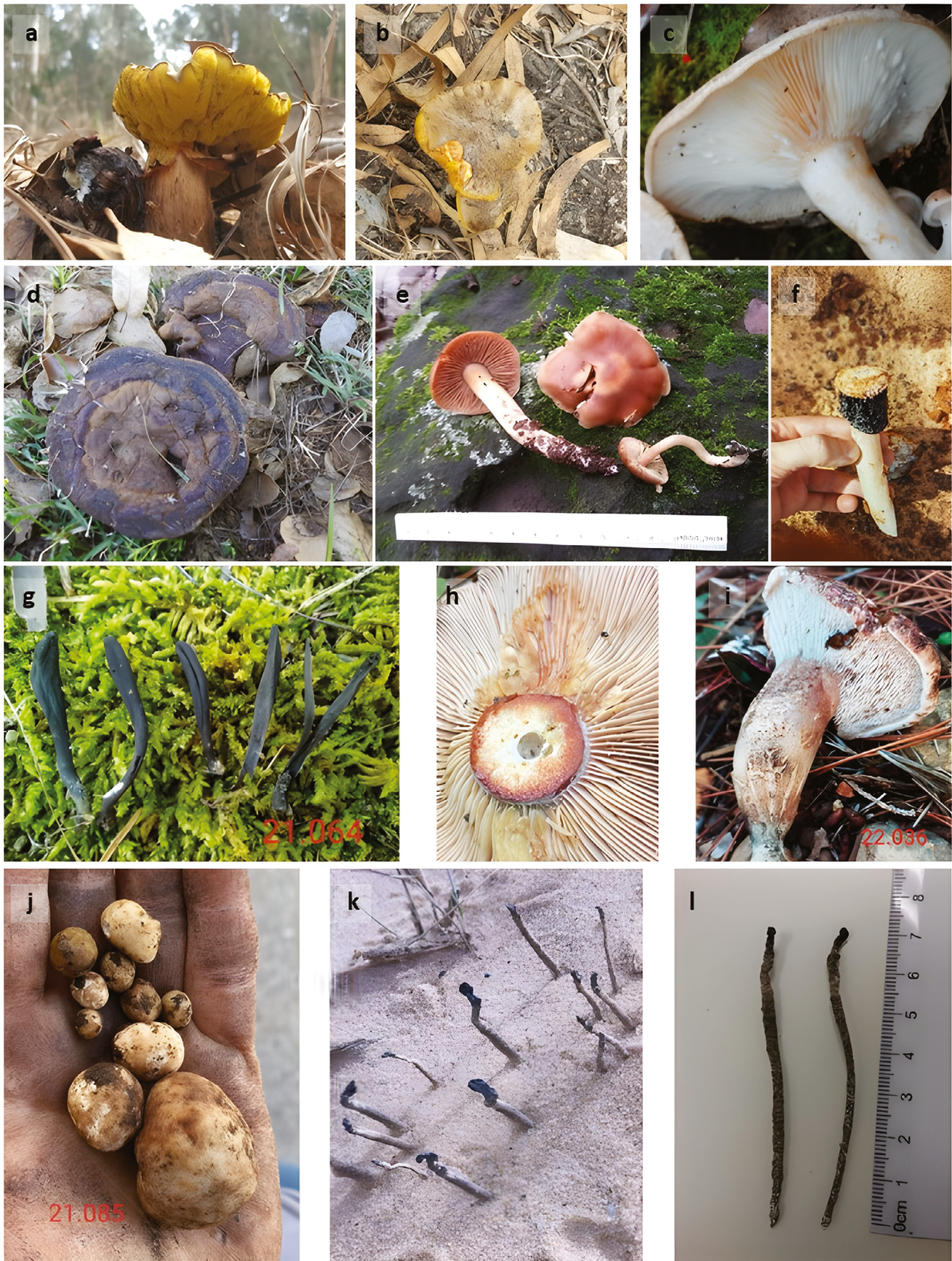
#### Order Xylariales

#### Family Xylariaceae

*Xylaria* sp. Hill ex Schrank 1789

General Morphology: The specimen was in a group of 5, resembling hard nails hidden deep in the ground, 7 cm long, only 2 cm reaching above the surface, brown-gray. Material examined: Arava; Arava valley. Collected by: Dalia Bones, 24/01/2019, Figs.2k, 2l, voucher SMNHTAU:Fu.19.045, GenBank PQ310588. The similarity of the ITS1 sequence of specimen voucher SMNHTAU:Fu.19.045 to *Xylaria* sequences in the GenBank was 89%. Therefore, we also sequenced the 18S rRNA gene for this specimen. Because the





**Figure 2.** Ten macrofungi species new to Israel. a+b) *Alessioporus ichnusanus*, c) *Lactarius ilicis*, d) *Ganoderma mbrekobenum*, e) *Lactarius atlanticus*, f) *Itajahya galericulata*, g) *Geoglossum cookeanum*, h) *Lactarius sanguifluus*, i) *Hydnellum amygdaliolens*, j) *Tuber lusitanicum*, k+l) *Xylaria* sp. The photos were taken by the collectors.



18S sequence was 98% identical to sequence of several *Xylaria* species we could not determine the species of the specimen from Israel.

Supplementary Table S1 includes a list of 5,631 specimens from Prof. Nissan Binyamini's collection that were digitized as part of this citizen science initiative. The specimen names are presented as they appear on the original labels and have not been updated to reflect current taxonomy.

## Discussion

The interest in mushroom foraging in Israel has grown significantly over the past 30 years, with the immigration of over a million citizens to the country following the dissolution of the Soviet Union. However, most of the information regarding mushrooms in Israel comes from old manuscripts, some of which are in Hebrew. There is thus a need to update the historical data to align with the current taxonomy of mushrooms. Bruria Gal has taken upon herself the task of restoring the fungi collection of the late Prof. Binyamini, and of educating a new generation of passionate collectors. Over the past decade the fungi collection at the Steinhardt Museum of Natural History, Tel Aviv University, has been digitized and curated to match the current taxonomy of mushrooms. Many volunteers have provided specimens with collection details for the Fungarium. Due to these efforts, 22 new species of macrofungi have been identified in Israel, one of which is considered near threatened (*Amanita torrendii*) and the other vulnerable (*Alessioporus ichnusanus*) by the IUCN (<https://www.iucnredlist.org/>).

The contribution of citizen-science to advancing fungal research and conservation has been demonstrated previously (Filippova et al. 2022, Polemis et al. 2023, Haelewaters et al. 2024). Haelewaters et al. (2024) have shown that following iNaturalist designated projects there has been a tremendous increase in reports on fungal observations. In Israel, however, fungi reports count for only 1.6% of the total Research Grade observations of all animals, plants, and fungi, and still lag far behind the observations on the various groups of vertebrates, while constituting only half the number of arachnid observations (iNaturalist 2024). Citizen-science observations may be biased towards groups that produce macroscopic fruiting bodies that may be edible and more easy to identify, or they may lack the necessary information for data

curation (Haelewaters et al. 2024). In order to advance the research and conservation of fungi, it is important that professional mycologists engage amateur naturalists in pre-planned projects and share the final project results with the participants. With the help of CS, it may be possible to overcome the lack of funding necessary for extensive fungi surveys and collection.

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