

Contents lists available at Egyptian Knowledge Bank

Microbial Biosystems

Journal homepage: <http://mb.journals.ekb.eg/>

Mapping fungal ignorance: Checklists of fungi and fungal-like organisms known for Egypt in two centuries

Abdel-Azeem AM^{1*}, Abo Nahas HH² and Abdel-Azeem MA³



¹Botany Department, Faculty of Science, Suez Canal University, Ismailia 41522, Egypt

²Zoology Department, Faculty of Science, Suez Canal University, Ismailia 41522, Egypt

³Pharmacognosy Department, Faculty of Pharmacy, Suez Canal University, Ismailia 41522, Egypt

ARTICLE INFO

Article history

Received 15 July 2020

Received revised 15 July 2020

Accepted 15 July 2020

Available online 16 July 2020

© Abdel-Azeem et al. 2020

Corresponding Editor:

Darwish AMG

Balbool BA

Keywords

Biodiversity

Checklist

Climate change

Conservation

Fungal analogues

ABSTRACT

Information concerning biodiversity and conservation of plants and animals in Egypt are fully available, but for fungi and fungus-like organisms (other organisms traditionally studied by mycologists), still missing and overlooked till 2010 when Abdel-Azeem published a full review of the history of mycology in Egypt, together with a checklist of 2281 species of fungi for the country, and an assessment of future perspectives for mycology in Egypt. Until that review, information about fungi from Egypt had been fragmentary and highly dispersed in many often obscure and difficult to obtain publications. Abdel-Azeem's checklist greatly increased the number of fungi recorded from the country and, significantly, is the first fully documented checklist of fungi for any country in the Arabic speaking world. Records of fungi in Egypt from the Global Biodiversity Information Facility (GBIF) database (4491 occurrences represented by 602 taxa), and that of the former International Mycological Institute fungal reference collection (IMI) (650 species) were also considered. Updated checklists of fungi are very limited in Egypt even they are one of the most important and critical tool for conservation. With this Mini-review we aim to provide an up-to-date overview on the recent developments on biodiversity and documentation of fungi and fungus-like organisms in Egypt. The documentation of fungal diversity in Egypt is urgently needed because natural habitats worldwide are being lost on a large scale through climate change and to promote proper exploration as a tool to facilitate fungal identification and to aid conceptualization and justification of future research projects.

Published by Arab Society for Fungal Conservation

Introduction

To date, worldwide, approximately 135,000 species of fungi have been described (Kirk 2019). Total global fungal diversity is, however, undoubtedly much greater. A figure of 1.5 million species (Hawksworth 1991) was, for many years, used as a working estimate. Currently, most mycologists believe the number is even greater, with

a conservative estimate now placed in the range of 2.2–3.8 million species (Hawksworth and Lücking 2017).

One of the most important fungal conservation steps is update your information concerning what are you going to conserve. How many species of fungi are there in Egypt? That is our important question!

* Corresponding author

E-mail address: ahmed_abdelazeem@science.suez.edu.eg (Abdel-Azeem AM)



Very little information about fungi from the Middle East and North Africa is currently available online. For most countries within this region, the relevant published information is scattered and often difficult to access.

As previously mentioned, the information concerning the fungi of Egypt is still incomplete and cannot be fully documented without an updated checklist of all taxa reported for the country.

The goal of the present study is to gather the information available on fungal species diversity for Egypt, based on records available in scientific publications and to assess the efforts carried by mycologists to document fungi in Egypt since (1813).

How many checklists in Egypt?

Taxonomy requires continual updates and checklists are important tools in taxonomy, systematics and conservation (Söderström et al. 2007, 2008; Abdel-Azeem and Salem 2013). Records of Egyptian fungi are scattered through a wide array of journals, books, and dissertations, but preliminary annotated checklists and compilations are not all readily available and this is the main reason that Egypt lacks recent checklists (Abdel-Azeem et al. 2020).

Saprobic and phytopathogenic fungi on wild and domesticated plants of economic importance have been attracted the attention of many researchers in the late 19th/early 20th century in Egypt e.g. Delile (1813), Decaisne (1835), Thüemen (1878, 1879, 1880), Ascherson (1879), Roumeguère (1881, 1887), Patouillard (1895), Sickenberger (1901), Magnus (1910), Fletcher (1902), Reichert (1921), Fahmy (1923), Shearer (1924), Britton-Jones (1922, 1923, 1925), Bishara (1928) and Melchers (1931). Delile (1813) described the gastromycete, now known as *Itajahya rosea* (syn. *Phallus roseus*) which he had collected in Damietta and Assiut in 1798 and 1799, respectively (Abdel-Azeem 2010).

The credit of the first list of fungi for the Nile Valley should be given to Reichert and Melchers. They considered as the pioneer scientists in the documentation of the local mycobiota.

The Polish born **Israel Reichert** (1891–1975) went to study in Germany around the First World War. There he prepared a doctoral thesis entitled ‘Die Pilzflora Ägypten’, in which he listed 237 species; among the latter 42 were then proposed as being new to science (Reichert 1921). The corresponding specimens of the reported fungi had been collected earlier by the famous German biologist C. G. Ehrenberg (1795-1856) during his botanical exploration of the Middle East region. Unfortunately, none of his specimens were retained in Egypt, or if they were, there is no record of their whereabouts today. However, earlier material collected before 1914 was present in the Botanisches Museum in Berlin-Dahlem, which Reichert used when compiling his list of (1921), but it is not known

if these specimens survived World War II.

In (1927), the American phytopathologist **Leo E. Melchers** visited the Nile Valley upon an invitation by the Egyptian Ministry of Agriculture as chief mycologist for 18 months. During his stay he met a series of local difficulties such as the absence of records referring to the occurrence, distribution, or dates of any mycological observations conducted previously by any investigator in Egypt. Melchers also underlined the absence of a local mycological reference collection. During his stay he could establish a notable checklist of about 345 fungal species, in particular of taxa responsible for plant diseases. Melchers published this notable checklist upon his return to the States (Melchers 1931).

In (1963) and (1966), **Abas Fathy El-Helaly** (Faculty of Agriculture, Alexandria University) and his co-workers updated the checklist of Melchers by surveying plant diseases and pathogenic organisms in Egypt (UAR).

Few decades later, **Samy M. El-Abyad** (Faculty of Science, Cairo University) and **Amira Abu-Taleb** (1993), were the first local mycologists to summarize the habitat diversity of fungi reported from Egypt. Few years later, **El-Abyad** (1997) also achieved his pioneering checklist of the local mycoflora (Mycobiota): a total of 1246 species of fungi were then reported. Among the latter, 173 names referred to the subdivisions Mastigomycotina, 41 to Zygomycotina, 222 to Ascomycotina, 143 to Basidiomycotina, and finally 667 to Deuteromycotina.

In this major checklist, different ecological and taxonomic groups were not, however, separated; this concerned in particular the protozoan fungal analogues, as the Myxomycota and the Plasmodiophoromycota, the lichens, yeasts, aquatic and marine fungi, the entomopathogenic and nematophagous species and finally the mycorrhizal ones. Besides, a large number of taxa either reported in routine isolations or as novel species, proved to be completely absent from his list. These omissions may have resulted from the inability of the authors to trace the majority of the relevant references; this difficulty is actually regarded as the basic reason why updated information documenting the fungi of Egypt is presently strongly needed.

In 2003, **Ahmed M. Abdel-Azeem** (Faculty of Science, Suez Canal University) in his PhD thesis, surveyed all the available data and prepared a preliminary checklist for 262 ascospore taxa reported from soil as well as many other habitats in Egypt. He recorded 69 taxa in his study which considered the first study focusing mainly on the ascospore forms. Abdel-Azeem recorded 19 new records (Moustafa and Abdel-Azeem 2006) with a novel taxon to the science (Moustafa and Abdel-Azeem 2008).

The first checklist on genus *Chaetomium* recovered from different habitats in Egypt with 53 species and one variety with a dichotomous key published by Moustafa and

Abdel-Azeem (2005).

Abdul Wahid F. Moustafa (Faculty of Science, Suez Canal University) in (2006), published an updated checklist of Zygomycetous fungi in Egypt for the first time in the country.

In 2010, a fully revised checklist of the fungi of the Nile Valley including the lichen-forming forms increased the former total number up to 2281 by **Abdel-Azeem**. This figure is approximately double of what had been previously catalogued by **El-Abyad** (1997). When the species richness of the different relevant systematic and ecological groups in this country is compared with the species richness of the same entities elsewhere, it clearly appears that knowledge of the Egyptian groups is still fragmentary. This is particularly evident for the following entities: Agaricales, Glomeromycota, yeasts, lichen-forming, nematode-trapping, entomopathogenic, marine, fresh-water and coprophilous fungi. For some other groups, like the desert and thermophilic fungi, it is already clear that the Nile Valley is a biodiversity hot-spot. It should also be noted that few other entities, such as the Trichomycetes and the black yeasts, have still not yet been locally investigated.

In 2011 and based on the results of Abdel-Azeem's thesis in 2003, **Moustafa and Abdel-Azeem** recorded a range of 310 taxa that could be representing the second updated checklist of Ascomycota in Egypt. In their treatment, concern was given to ascomycetous fungi of almost all terricolous substrates while phytopathogenic and aquatic forms are not included.

A checklist of sixty-one taxa, including 3 varieties, belonging to 29 genera of protozoan fungus-like analogues was came to the light with a dichotomous key by Ahmed M. Abdel-Azeem and **Fatma M. Salem** (2013).

In (1986), late professor Magdy Khalil Bagy (Faculty of Science, Assiut University) and his coworkers, studied the coprophilous fungi of different animal substrates for the first time in Egypt (Bagy and El-Sharouny 1985; Bagy et al. 1985, 1986). In 2015, Abdel-Azeem and Salem published a checklist with a provisional key of coprophilous fungi in arid Sinai based on phenotypic criteria. Taxa distributed within 61 species and 39 genera with *Coprinopsis stercorea* as a new record for Egypt.

Nivien Nafady (Faculty of Science, Assiut University), **Ahmed Abdel-Azeem** and **Fatma Salem** (Nafady et al. 2016), surveyed information about arbuscular mycorrhizal fungi (AMF) and was abstracted based on an intensive search of publications, thesis, and preliminary annotated checklists and compilations. They reported forty-eight taxa belonging to one class (Glomeromycetes), four orders (Archaeosporales, Diversisporales, Glomerales and Paraglomerales) and six families (Acaulosporaceae, Archaeosporaceae, Entrophosporaceae, Gigasporaceae, Glomeraceae and Pacisporaceae) of golmeromycota in

Egypt.

In 2016, **Esraa A. Soliman** (undergraduate student, Faculty of Science, Suez Canal University) with her professor Ahmed Abdel-Azeem and his co-workers published a revised checklist of fungi recorded in Egypt through a revision of 13 publications published since 1813 to 1931. They reported 340 taxa and were taxonomically re-evaluated. Published checklist included two kingdoms and three major groups: zygomycetes (1 spp.), ascomycetes (124 spp.), basidiomycetes (197 spp.) and chromistian fungal analogues (18 species). Taxa of true fungi are distributed among three phyla, ten classes, 38 orders, and 67 families, while Chromistian fungal analogues distributed in only one phylum, two orders and three families.

Recently, **Abdel-Azeem** and his co-workers (2020) published the first check list on genus *Aspergillus* in Egypt. They recorded a range of 150 taxa that could be representing that genus in Egypt and recorded taxa were assigned to 5 subgenera and 25 sections. They provided a comprehensive checklist of species with a provisional key to the identification of reported taxa is given.

How many species of fungi in Egypt?

In his recent estimate, Abdel-Azeem (2020) recorded 2477 species of fungi in Egypt, a figure apparently exceeding that of the higher plants developing in this country. This marked figure resulted from an exhaustive revision of all the existing literature and information sources established since the year 1813 up to the middle of the current one by Abdel-Azeem. On the kingdom level, the group Fungi comes first by its 2230 species; this is followed by the Chromistan fungal analogues (186) and the less provided Protozoan fungal analogues: 61. The Ascomycota form the major largest group within this checklist with about 1762 species; among the latter 158 units are lichen-forming and about 1000 are still presently known only by their conidial (asexual) states. The remaining recorded units are distributed in the following manner: 90 Chytridiomycota, 27 Blastocladiomycota, 70 Zygomycota, 48 Glomeromycota, and 233 to Basidiomycota.

Fungal documentation and conservation in Egypt

Egypt in general, hosts a rich biological diversity of fungi. Conservation of nature by ancient Egyptians was recorded on walls of temples and papyrus sheets. Egypt, known as the cradle of civilisation, has documented its fascination with fungi, when ancient Egyptians produced a number of hieroglyphic depictions of psychedelic mushrooms on temple's walls and through hieroglyphic texts throughout the country (Abdel-Azeem 2010). In contemporary Egypt, however, this is not the case. The documentation of activities related to fungi, whether of collection,

conservation, bioprospecting or biodiversity are extremely limited.

Our survey showed that only **fifteen** checklists of Egyptian fungi were produced in the last two centuries.

In Egypt, the impact of human activities on fungal diversity is unquantified, and the need of fungal conservation is often ignored. Some threats can already be identified; loss of habitat, medicinal plants over-collection, climate change, growth of human population/urbanisation, the Nile's river pollution, continuous bioprospecting in the harsh ecosystems (desert, salt marshes, etc.). Other threats doubtless exist.

Conflict of interest

The authors have no conflicts of interest to declare. All co-authors have seen and agree with the contents of the manuscript.

Acknowledgements

We would like to acknowledge Dr. Paul M. Kirk (Biodiversity Informatics & Spatial Analysis, Royal Botanic Garden Kew, United Kingdom) for providing us with data and his helpful comments on the manuscript.

References

- Abdel-Azeem A M (2020) Fungi in Egypt: A galaxy to discover. The 5th National fungus day of Egypt, 20 February 2020.
<http://www.fungiofegypt.com/20Feb/>
- Abdel-Azeem AM (2003) Ecological and taxonomical studies on ascospore-producing fungi in Egypt. Ph.D. Thesis, Faculty of Science, Suez Canal University, Egypt.
- Abdel-Azeem AM (2010) The history, fungal biodiversity, conservation, and future perspectives for mycology in Egypt. *IMA Fungus* 1:123–142.
- Abdel-Azeem AM, Salem FM (2013) A checklist of Egyptian fungi: I. Protozoan fungal analogues. *Mycosphere* 4(4):794–807.
- Abdel-Azeem AM, Abu-Elsaoud A, Darwish A, Balbool B, Abo Nouh F, Abo Nahas H, Abd El-Azeem AM, Ali N, Kirk P (2020) The Egyptian Ascomycota 1: Genus *Aspergillus*. *Microbial Biosystems* 5(1):61-99.
doi: 10.21608/mb.2020.100044
- Ascherson P (1879) *Beitrag zur Flora Aegyptens*. Berlin.
- Bagy MMK, El-Sharouny HMM (1985) Preliminary study of coprophilous fungi on different dung substrates in Egypt. *Sohag Pure & App Sci, Bull. Fac. Sci., Egypt* 3: 25-38.
- Bagy MMK, Abdel-Mallek AY, Moharram AM (1985) Succession of fungi on camel dung. *Egypt. J Bot* 28: 61-70.
- Bagy MMK, Moharram AM, Abdel-Mallek A (1986) Coprophilous fungi of the camel. *Bull. Fac. Sci., Assiut Univ.* 15(1): 1-10.
- Bishara I. (1928) Cotton insects. *Minist Agric Egypt Monthly Report* 1: 4.
- Briton-Jones HR (1922) The smuts of millet. *Minist Agric Egypt. Tech Ser Bull* 18: 1–9.
- Briton-Jones HR (1923) A wound parasite of cotton bolls. *Minist Agric Egypt. Tech Ser Bull* 19: 1–8. 33.
- Briton-Jones HR (1925) Mycological work in Egypt during the period 1920–1922. *Minist Agric Egypt. Tech Ser Bull* 49: 1–129.
- Decaisne MJ (1835) Notice sur quelques plantes de la Flore d'Egypte. *Annales des Sciences Naturelles Botanique* 4:193–208.
- Delile AR (1813) *Flore d'Egypte*. Paris.
- El-Abyad MS, Abu-Taleb A (1993) II-Soil Fungi. Ecology of fungal flora. In: Publication of National Biodiversity Unit. No. 1. *Habitat Diversity: 237–262*. Egyptian Environmental Affairs Agency, Egypt.
- El-Abyad MS (1997) Biodiversity of Fungal Biota in Egypt. Up-dated check-list. In: Publication of National Biodiversity Unit No. 7. *Egyptian Environmental Affairs Agency, Egypt*.
- El-Helaly A, Ibrahim I, Assawah M, El-Arosi H, Abou El-Dahab M, Michael S, Abdel-Rahim M (1963) General Survey of plant diseases and pathogenic organisms in the UAR (Egypt) until 1962. *Alex J Agri Res* 8: 1–107.

- El-Helaly A, Ibrahim I, Assawah M, El-Arosi H, Abou El-Dahab M, Michael S, Abdel-Rahim M, Wasfy EH, El-Goorani MA (1966) General Survey of plant diseases and pathogenic organisms in the UAR (Egypt) until 1965. *Alex J Agri Res* 15: 1-153.
- Fahmy T (1923) The production by *Fusarium solani* of a toxic excretory substance capable of causing wilting in plants. *Phytopathology* 13: 543.
- Fletcher F (1902) Notes on two diseases of cotton. *J. Khedive Agri Soc Sch Agri Giza, Egypt* 4, 2.
- Global Biodiversity Information Facility. <http://www.gbif.org>. Accessed 05 July 2020.
- Hawksworth DL (1991) The fungal dimension of biodiversity: magnitude, significance, and conservation. *Mycol Res* 95:641–655.
- Hawksworth DL, Lücking R (2017) Fungal diversity revisited: 2.2 to 3.8 million species. *Microbiol Spectr* 5(4): FUNK-0052–FUNK-0042
- Kirk P (2019) Catalogue of life. <http://www.catalogueoflife.org>. Accessed repeatedly in 2020
- Magnus P (1910) Beitrag zur Kenntnis der parasitischen Pilze Ägyptens. *Hedwigia* XLIX, S. 93
- Melchers LE. (1931) A check list of plant diseases and fungi occurring in Egypt. *Trans Kans Acad Sci* 34: 41–106.
- Moustafa AF (2006) Fungi of Egypt. Zygomycetes. AUMC Descriptions, No. 1. Assiut.
- Moustafa AF, Abdel-Azeem AM (2005) The genus *Chaetomium* in Egypt. *El-Minia Sci Bull* 16 (2): 235-256.
- Moustafa AF, Abdel-Azeem AM (2006) Some new records to the Egyptian Ascomycetes with a provisional key to their identification. *Assiut Univ. J. Botany* 35(1): 87-103.
- Moustafa AF, Abdel-Azeem AM (2008) *Thielavia gigaspora*, a new thermotolerant ascomycete from Egypt. *Microbiol Res* 163: 441-444.
- Moustafa AF, Abdel-Azeem AM (2011) An annotated check-list of Ascomycota reported from soil and other terricolous substrates in Egypt. *J Basic Appl Myco* 2: 1-27.
- Nafady N, Abdel-Azeem AM, Salem FM (2016) A checklist of Egyptian fungi: II. Golmeromycota. *Microbial Biosystems* 1(1): 40-49.
- Patouillard NT (1895) Quelques espèces nouvelles de Champignons africains. *Bull Soc Mycol Fr* 11: 85-88.
- Reichert I (1921) Die Pilzflora Ägypten. *Engler's Botanischen Jahrbüchen* 56: 595-727.
- Roumeguère C (1881) Champignon rapportés en 1880 d'une excursion botanique en Egypte et en Palestine par M. William Barbay. *Rev Mycol (Toulouse)* 3: 23 - 25.
- Roumeguère C (1887) Champignons d'Egypte. *Rev Mycol* 36: 205-207.
- Shearer A. (1924) Cotton wilt 3rd Annual Report, Cotton Research Board, Ministry of Agriculture. Egypt: 37.
- Sickenberger E. (1901) Contribution à la Flore d'Egypte. *Mémoires de l'institut Egypte* 4901, p. 331–332.
- Söderström L, Hagborg A, von Konrat M, Renner MAM (2008) Early Land Plants Today: Liverwort checklist of checklists. *Fieldiana, Bot (nat. s.)* 47: 105–130.
- Söderström L, Urmí E, Váña J (2007) The distribution of Hepaticae and Anthocerotae in Europe and Macaronesia, Update 1-427. *Cryptogam Bryol* 28: 299–350.
- Thümen F (1878) Fungi Egyptiaci, Ser. I. *Grevillea* 6 (39): 102-104.
- Thümen F (1879) Fungi Egyptiaci, Ser. II. *Grevillea* 8 (46): 49-51.
- Thümen F (1880) Fungi Egyptiaci, Ser. III. *Flora* 63 (30): 477-479.