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Fungi: Diversity in India and its Potential Applications

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A B S T R A C T

Fungi are eukaryotic achlorophyllous organisms live in wide array of habit and habitats on earth. Being non-photosynthetic fungi exhibit anabsortive mode nutrition, which lead to Saprophyte, Parasite or Mutualistic existence. Fungi is second largest group of organisms outnumber by insects only. Recent estimate suggested that, around 2.2- 3.8 million fungi are there on planet. Fungi are known to produce many antibiotics, bio-active molecules, organic acids and secondary metabolites etc. Fungi so far have been exploited very poorly and yet have a huge potential in bio-control, bioremediation and novel compound.

Introduction

Fungi are eukaryotic achlorophyllous organisms live in wide array of habit and habitats on earth. Being achlorophyllous fungi exhibit an absortive mode nutrition, which lead to Saprophyte, Parasite or Mutualistic existence. As a saprophyte fungi along with bacteria bring out complete mineralization of plant and animal remains. As a parasite fungi cause many diseases in animals and plants. As Mutualistic fungi live in intimate association with other organisms. Fungi are almost cosmopolitan in their distribution and they exploit the diverse array of macro and micro nutritional niches. The most important factor influencing the distribution and life style of fungi is their heterotrophic nutrition (Cook and Rayner, 1984).

Fungal diversity

Fungi are the largest and diverse group of organisms out number by insects only Tropical belts of the world with high rainfall, humidity and temperature, is known to encompass the most diverse habitats and considered to have the highest diversity for most groups of organisms be it plants, animals or microorganisms and fungi (Pianka,

1966; Hawksworth, 1991; Hillebrand, 2004; Arnold and Lutzoni, 2007). Only 5-10% of fungal species have been described, documented (Hawksworth, 2001). Many estimates have been put forward to elucidate the Fungal species diversity in the world, few are listed in table 1.

Fungal diversity in India

Microfungi

Studies on fungi in India began with advent of foreigners, mainly from Britain who collected fungi and sent specimens to European laboratories for identification. The earliest record of Hyphomycetes in India was made by Corda (1837). Further the studies of Indian fungi were continued by Barcklay and Cunningham. Barcklay (1886) contributed to knowledge of the rusts occurring in the vicinity of Shimla. Cunningham (1927) contributed to Orders Mucorales, Ustilaginales and Uredinales.

Sir E. J. Butler who has been regarded as the 'Father of Indian Mycology', to initiate and organize large–scale mycological and phytopathological research in India. He founded the Herbarium Cryptogamae Indiae Orientalis (HCIO), a national fungal herbarium facility Pusa, Bihar in 1905. In 1934, the HCIO was shifted to the Division of Mycology and Plant Pathology, Indian Agricultural Research Institute, New Delhi. Butler and his associates compiled 'Butler and Bisby's (1931) 'The Fungi of India', which has been revised several times and further updated by Mukerji and Juneja, 1974; Sarbhoy *et al.*, 1986, 1996; Jamaluddin *et al.*, 2004. Mitra (1921, 1923, 1931) studied *Helminthosporium* species on cereals. Mitter and Tandon (1930-38) named and described many species from India. Since then several interesting hyphomycetes were reported by various workers from different parts of the country (Mundkur, 1938; Ramakrishnan, 1941, 1949).

India is one of the richest reservoirs of biodiversity in Asia and can be considered as a center of research of hyphomycetes diversity with high proportion of genera and species particularly of tropical species first described in this country (Bilgrami *et al.*, 1991, Jamaluddin *et al.*, 2004). Comprehensive account on hyphomycetous fungi of India are now available (Subramanian, 1971, 1983; Rao and de Hoog, 1986; Mukerji and Manoharachary, 2010; Bhat, 2010; Kamal, 2010).

The earliest available record of coelomycetes is based on the publication by Léveillé (1846). He published the first report of a pycnidial fungus, *Ascospora sordidula* from India on the leaves of *Saussurea* sp., which was changed to *Septoria sordidula* by Saccardo in 1884. Subramanian and Ramakrishnan (1952, 1953b) were the first Indian workers to initiate studies on this group. They described a coelomyceteous fungus *Plagionema* with lateral and apical appendaged conidia, which was later reduced to synonymy with *Ciliochorella* Syd. (Subramanian and Ramakrishnan, 1953). They further contributed to the taxonomy of coelomycetes with the descriptions of some taxa (Subramanian and Ramakrishnan, 1954, 1955, 1958).

Mathur (1979) in his book "The Coelomycetes of India" provided a checklist of coelomycetes collected/reported from India during 1846-1977. He enlisted 235 genera, 1527 species and 33 varieties.

Muthumary and co-workers (Muthumary 1986 a, b, c, 1987 a, b, c, 1988; Muthumary and Sutton 1986; Muthumary *et al.*, 1986; Muthumary and Masilamani 1989) described some new species and recorded many fungi

from India. Muthumary (1999) published the monograph "First contribution to a Monograph of *Septoria* Species in India". She provided a key to the 83 species included in the monograph based on host taxonomy and conidial measurements. Muthumary (2013) in her book "Indian Coelomycetes" gave description and illustrations of 142 species spreading in 78 genera.

Macrofungi

Different workers had studied diversity of macrofungi From time to time from different parts of India. Several edible fungi have been identified from Punjab by Chahal (1963). Thirty species of macrofungi belonging to 26 genera spreading over 17 families have been reported by Tapwal *et al.,* (2013) from Jeypore Reserve Forest located in Assam. In Gujrat and Jammu and Kashmir major work on macrofungi was carried out by Chandulal *et al.,* (2013) and Anand *et al.,* (2014) respectively. Karwa and Rai (2010) reported 153 species of mushrooms from Central India (Maharashtra). Pandey and his coworkers also done an intensive survey to identify mycofloral diversity of Central India and worked on different aspects of it (Sharma *et al.,* 2009a, b; 2011a, b; Dwivedi *et al.,* 2012). 778 species of macrofungi belonging to 101 genera of 43 families reported by Swapna *et al.,* (2008) from Karnataka. Soosairaj *et al.,* Thiribhuvanamala *et al.,* (2013) identified 23 species macrofungi from Tamil Nadu. 200 species of wood rotting non-gilled Agaricomycotina which belongs to 27 families spreading over 100 genera have been reported by Prasher and Lalita 2014 from Uttarakhand. Semwal *et al.,* (2014) recorded 23 species of mushrooms of which twenty one were Basidiomycetes and two were found to be Ascomycetes. 13 species of macrofungi belonging to 10 genera and 9 families from Pune and Western Ghats of Mahabaleshwar and Mulshi of Maharashtra was recorded by Senthilarasu (2014). 90 species belonging to 19 families were recorded from Karnataka of which 28 species were found to be recorded for the first time from India Pushpa and Purushothama (2012). Prasher *et al.,* (2012) recorded 13 species of polyporoid fungi belonging to 5 families and 10 genera from Himachal Pradesh. Dhingra *et al.,* (2014) reported 295 taxa belonging to 89 genera of non–poroid Agaricomycetous fungi from Himachal Pradesh.

However, with the advent of the molecular fungal taxonomy a natural classification based on molecular fungal taxonomy has evolved (Hibbett *et al.,* 2007, Shenoy *et al.,* 2007, Thambugala *et al.,* 2015, Tian *et al.,* 2015 and Wang *et al.,* 2015). This has resulted in the intergeneric shifting of species, introduction of new genera for correct placement of species which have been already described, as well as reassignment of genera to different families, orders and classes.

Significance of fungi

Fungi have also been used in commercial production of lignocellulolytic enzymes e.g. laccases, manganese peroxidise and lignin peroxidase (Pointing *et al.,* 2005; Baldrian, 2006; Safari Sinegani *et al.,* 2006; Hoffmeister and Keller, 2007; Kaushik and Malik, 2009; Maciel *et al.,* 2010 and Moore *et al.,* 2011); bio-active molecules (Hanson, 2008; Thirunavukkarasu *et al.,* 2012 and Arora *et al.,* 2012) and organic acids (Jakubowska, 1977 and Mäkelä *et al.,* 2002).

Many filamentous and basidiomycetes fungi have been known to produce organic acids viz. acetic, citric, tartaric, malic, lactic, succinic, oxalic and gluconic acid (Lopez-Garcia, 2002; Mäkelä *et al.,* 2002; Magnuson and Lasure, 2004 and Mandal and Banerjee, 2006; Liaud *et al.,* 2014). Various fungi such as *Aspergillus nigerPycnoporus sanguineus*

and *Talaromyces helices* has been used for the biosorption of heavy metals (Romero *et al.*, 2006; Yahaya *et al.*, 2009 and Zeng *et al.*, 2015)

Many fungi belonging to ascomycetes and basidiomycetes have a potential to act as an antiviral agent against EV7, HIV-1, EV71, HSV-1, H1N1and H3N2 viruses (Ma *et al.*, 2013; Li *et al.*, 2014; Zhao *et al.*, 2017; Pang *et al.*, 2018). The antiviral activity of these fungi is mainly because of the presence of polysaccharides in mycelium and fruiting bodies, and synthesis of triterpenoid secondary metabolites (Chen *et al.*, 2012; Rincão *et al.*, 2012)

Table.1 Popular estimates of species diversity of fungi

Sr. no.	No.	Reference
1.	1,50,000 (Estimate G)	Hawkswoth (1991)
2.	2,270,000	Hawkswoth (2001)
3.	3,500,000-5,100,000	O ' Brien *et al.*, (2005)
4.	712,000	Schmit and Mueller (2007)
5.	611,000 (±SE= 297,000)	Mora *et al.*, 2011
6.	2.2- 3.8 million	Hawksworth and Lucking (2017)

In conclusion, huge research has been made in the understanding of the fungi in India. Many new species of fungi have been established for the region, but much work remains to be undertaken. Many of the fungi are known to produce various therapeutic metabolites with high biological activities. So it became very important to properly characterize not only these compounds, but to carefully identify the species names, so that researchers can identify and screen taxa for future biotechnological applications. Fungi so far have been exploited very poorly and yet have a huge potential in biocontrol, bioremediation and novel compound. With such high novelty, there is a need for extensive research to exploit the biotechnological potential of these fungi.

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