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Status of Mycology : Teaching and Research in India*

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Fungi are known to mankind since time immemorial. In the wide and diverse field of biology, they are important components. They are critically important terrestrial organisms as symbionts of most plants, as pathogens of plants and animals causing diseases as food sources for hu-

mans and other animals, as sources of valuable chemicals and in food and beverage processing. They are important for sustainable life on this planet. They are nature's recyclers and without them, mankind's existence will be in jeopardy. Fungi are an incredibly speciose, biologically and morphologically diverse group. They come in various shapes, colours and sizes, exude all kinds of smells, are they ecological jacks-of all-trades, produce much of our food, drink and medication and yet, surprisingly, comprise a scientifically neglected eukaryotic kingdom-even today. They are among the most poorly understood organisms on earth and their importance unappreciated by most people. Many are unnamed, overlooked or ignored and the public awareness of their importance is very low. Mycology is an 'orphan', lacks close relatives, is misunderstood and often excluded from 'family' events (Hawksworth, 2009).

Biodiversity, even today, is still widely portrayed as 'flora and fauna' of 'plants and animals'. Such

misleading descriptions can even be found on websites of major biological institutions and scientific societies, which should and do know better. Biodiversity is so much more than 'animals and plants'. The five kingdom classification of life, which recognizes fungi in a kingdom of their own, has been generally accepted by scientists since 1970s and with an estimated 1.5 million species of fungi on this planet and a presence in all major ecosystems-freshwater, marine and terrestrial alike, this kingdom is megadiverse. There are far more fungi than all the plants and vertebrates put together. To ignore them thus is not a sensible option.

Mycology, the study of fungi, is an endangered discipline. It does not feature as a separate subject in the categories of science recognized by UNESCO. Due to the lack of human capacities, national monographs of biodiversity in most countries rarely encompass fungi. This not only leads to an unfortunate bias in the complete assessment of biodiversity, but also pertains to the unawareness of public and decision markers of fungi as important organisms.

The first alarm of neglect was sounded in a nondescript middle page of New York Times, published on June 13, 1897, cozily tucked in one corner of the page, with a small headline 'THE STUDY OF MYCOLOGY – It has been neglected in This Country, and a Food Supply Overlooked in Consequence'. Professor Lucien C. Underwood, a Professor of Botany, Columbia College, New York and a contemporary of J.B. Ellis. (1829 – 1905) the pioneering North American mycologist known for his study of the Ascomycetes, rued that there was not much knowledge of Mushrooms in particular and fungi in general, in the country and

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emphasized their significance as food. In his attempt to popularize the study of fungi, Prof. Underwood started the New York Mycological Club in 1897 and was its first President.

The status

For several decades it has been widely acknowledged that fungi are distinct from plants, animals, bacteria, but as new ultrastructural and molecular data have been obtained this distinction has become more apparent. Not only is the Kingdom Fungi well separated from plants; it is closer to the animals than to the Plant Kingdom.

By conservative estimates there are about 1.5 million fungal species worldwide, of which 75-1,20,000 have been described and far few were characterized (Hawksworth, 2009). On a group-by-group basis, the number of described species is about 712,000 (Schmit and Muller, 2007). This roughly constitutes about 7-13% of the projected 1.5 million fungal species on this planet. This is in marked contrast to plants, where 90% of the estimated 30,000 species occurring worldwide have been described (Rodriguez, 2000).

The rate of discovery and its description, on an average is 800 species per year. 26% of the fungi described since 1980's have been by a mere 50 authors, several of whom are dead or retired (Hawksworth, 2006). The non-described species are not only to be found in the tropics but continue to be discovered even in the best - studied countries of Europe & N.America

The index of Fungi, published by the International Mycological Institute, United Kingdom, records that in the decade extending from 1981-90, only 16,013 new fungi were described. USA recorded 1623 (10.1%) species closely followed by India with 1554 (9.7%). in the UK total was 459, while 22 countries generated more than 1% of the total. This evidence shows that most countries are imperfectly known mycologically (Hawksworth, 1997). Reports from India suggest that about 28,000 fungal species have been described in the country (Mukherji and Manoharachary, 2010).

Fungal components of any ecosystem are seldom characterized and almost never included in biodiversity data in India. Proper fungal invento-

ries and databases are largely nonexistent in the country, while those that exist contain only scanty and basic information. Fungal biodiversity does not feature in biological checklists and red data listings of most countries including India.

Basis for lack of disregard

Perhaps the current situation of neglect may not have arisen had not Linnaeus (1753) included the fungi along with plants in *Species Plantarum* rather than in *Systema Naturae*, as is now clear, would have been more appropriate in view of the fact the fungi have a more closer relationship with animals than plants (Hawksworth, 2009). This led to the fungi being embraced in Botany Departments and later Microbiological ones in the Universities and research institutes. Thus Mycology designated positions failed to be created in university departments. The very few Mycology posts that existed in research institutes were without security and were often replaced by researchers from other disciplines. In the universities, lack of separate departments meant that mycology teaching formed a part of a paper or was more often clubbed with plant pathology. The penchant for creation of large Biological or Life Science Departments further worsened the situation. Results of this poor coverage of mycology was reflected in the training of biologists with inadequate knowledge of fungi, the complexities of their biology and importance in earth processes and human well-being did not receive attention commensurate with their significance.

The slowness of mycologists to organize themselves separately on the international stage was another major contributory factor for the neglect of the subject, especially in India. Among the eighty six mycology journals listed in the world, only one, *Kavaka*, is published in India. Of the 389 listed Plant Pathology journals worldwide, twenty two from India. Though major papers published in these journals are researches in plant pathology, mycology research published is insignificant. All Indian journals are without SCI impact Factor rating. The number of publications of Indians working in India in the last decade, in foreign journals such as *Studies in Mycology* (IF -10.625/2011), *Fungal Diversity* (IF-4.769 /2011), *Mycological Research* (IF-2.809/2011), *Mycorrhiza* (IF-2.63/2011), *Mycologia* (IF-2.031/2011), *Mycopathologica* (IF-

1.654/2011) is 0, 3, 8, 12, 14 and 4 respectively.

A look back at the dates of establishment of scientific societies related to mycology indicates that the first two were The Indian Phytopathological Society established after Independence in 1947 the Mycology Society, Calcutta, founded in 1954. This was followed by the establishment of Indian Society of Mycology and Plant Pathology, Udaipur in 1970 and the Mycology Society of India Chennai in 1973. However, the focus of the official organs of the first two societies mentioned viz., *Indian Phytopathology* (1948) and *Indian Journal of Mycological Research* (1955). *The Journal of Mycopathological Research* (1995) and *Journal of Mycology & Plant Pathology* (1970), are more on plant pathology researches than on mycology. The Mycology Society of India publication, Kavaka (1973), is the only Indian journal dedicated to fungi, Mycology, as a separate subject, thus lost its distinctiveness and became clubbed with Plant Pathology.

That this initiative of organizing themselves took so long, is no small measure a consequence of most professional mycologists being isolated and unused to being gregarious !!!

Other factors which might have contributed to sidelining mycology was that at international gatherings, Mycology has mostly been either a part of International Botanical Congress or International Congress of Plant pathology. The International Mycological Association founded in 1971, is the only body that organizes the International Mycological Congress every four years.

A study of the contents of microbiology textbooks and proceedings of microbiological congress further show that fungi other than yeasts and those of the medical importance are not accepted as full members of the microbiological fold.

The fallout

The consequences of the negligence of the subject are manifold. It has lead to insufficient proficiency to support the needs of fungal expertise in the different areas of direct and indirect human concern. The quality of investigations in pure and applied sciences that depended on aspects of

mycology is suboptimal. Accumulated corpus of knowledge of fungi, their properties, ecologies and life cycles is proportionately poor compared with that of other organisms. There is a tendency among biologists to discount the value of descriptive mycology due to increasing demand to scientists of other disciplines. The cascading effect has resulted in there being few academics in universities working in taxonomic mycology or to supervise research students.

Taxonomic expertise in mycology has been dwindling over the past decade, especially in the university sector. What remains of india's

Table 1 : Number of publications in mycological taxonomy in international and national journals and number of active mycologists in Asia.

Country/ region	1989		1994		1999	
	Public- ations-	Active- mycolo- gists	Public- ations-	Active- mycolo- gists	Public- ations-	Active- mycolo- gists
Bangla- desh	-	-	-	-	-	-
Brunei	-	-	-	-	-	-
Cambodia	-	-	-	-	-	-
China	6	2	4	2	18	3
Hong Kong	-	-	13	2	54	21
India	30	7	4	-	4	-
Indonesia	-	-	-	-	-	-
Japan	15	3	17	6	22	6
Korea	1	-	-	-	3	1
Laos	-	-	-	-	-	-
Macau	-	-	-	-	-	-
Malaysia	3	2	1	-	2	1
Mongolia	-	-	-	-	-	-
Myanmar	-	-	-	-	-	-
North Korea	-	-	-	-	-	-
Pakistan	-	-	-	-	-	-
Papua New Guinea	-	-	-	-	-	-
Philippines	1	-	-	-	-	-
Singapore	-	-	-	-	-	-
Taiwan	6	3	3	-	13	6
Thailand	-	-	-	-	1	-
Vietnam	-	-	-	-	-	-
Total	62	17	42	10	117	38
Total excluding	49	13	22	6	32	8

*Publications in journals listed in the Bibliography of Systematic Mycology. Publications in taxonomy and checklists only considered (i.e plant pathology, biology, industrial mycology excluded). After Hyde(2003).

mycological systematics community now resides in just a handful of universities, and even in these remaining 'strongholds' there has been a sharp decline in the number of PhD-level taxonomic

mycologists. The trend of dwindling numbers of active mycologists and publications made by them is seen not only in India, but also in many other countries (Hyde, 2003; Gryzenhout *et al.*, 2012) (Table 1.) Universities and scientific institutions internationally use impact factors as a basis for evaluating a scientist's performance or appraising whether they should be promoted. This is proving problematic to taxonomic mycologists, as there are very few mycology journals with high impact factor.

An overview of researches in mycology done till 1991, throughout the world indicates (Table 2) that many major groups of fungi are neglected (Richardson and McKenzie, 1992) There have been very few monographs or treatments of microfungal groups, very few research groups in the world are carrying out microfungal diversity research. Additionally, it is important to note that the loss of taxonomic expertise within fungal groups has been uneven. Much of the current research is limited to the Kingdom Fungi (particularly the Ascomycetes and Basidiomycetes). Other lineages of fungal organism are no longer the focus of taxonomic study; in particular, Oomycetes (Peronosporomycetes), a relatively small group of major economic impact are no longer studied (with

the exception of the important plant pathogen genus *Phytophthora*). Other groups, such as the slime moulds, Labyrinthulids, Thraustochytrids and Hyphochytrids, representatives of which are significant components of many habitats are largely ignored, despite their importance in ecosystem function. It is also important to note that these groups are underresearched due to their 'peripheral' position; and are ignored by the mycological research community as they are viewed as 'pseudo-fungi' but also by the protistologists who tend to ignore them for comparable reasons or believe that they are the purview of the mycological/botanical community.

In most of the Indian Universities, Mycology is taught as a part of a paper of 100 marks along with the lower plant groups Algae and Bryophyta as well as Bacteria to the undergraduates, barely emphasizing on the varied aspects of fungi. At the postgraduate level, the Mycology course content emphasizes more on fungal biotechnology than on the biology and taxonomy of the group. Mycology courses thus lack depth, content and the vital field experience. Thus in the absence of generation of interest and curiosity of the students in the subject, practically no mycological, taxonomists are

Table 2 : Groups of fungi for which no publications has been produced from 1988-1991

Myxomycota				
Mastigomycotina excluding Perenosporales (<i>Phytophthora</i>)				
Zygomycotina				
Ascomycotina				
Arthoniales	Elaphomycetales	Helotiales	Trichosphaeriales	Sordariales
Ascospaerales	Endomycetales Erysiphales	Onygenales Laboulbeniales	Ostropales Peltigerales	Spathulosporales Taphrinales
Calciales	Eurotiales	Lahmiales	Pertusariales	Teloschistales
Clavicipatales	Graphidales Gyalectales	Meliolales	Pezizales	Verrucariales
Corneliales	Gymnoascales	Microascales	Pyrenulales	Leotiales
Cyttariales		Opegraphales	Calosphaeriales	Glaziellales
Diatrypales				
Basidiomycotina				
Ustilaginales	Exobasidiales	Phallales	Podaxales	
Tremellales	Brachybasidiales	Sclerodermatales	Gautieriales	
Auriculariales	Dacrymycetales		Tulostomatales	
Septobasidiales	Tulasnellales	Lycoperdales	Melanogastrales	
	Hymenogastrales	Nidulariales		
Phylloporales		Sphaerobolales		

*Table reproduced from Richardson and McKenzie (1992).

being nurtured and trained in these universities and it will not be before long that there will scarcely be anyone capable of identifying even the more common fungi with authority.

The approach to teaching mycology to the undergraduates in the United States based universities is however different from their counter parts in India. Mycology courses are more innovative and field based so that by the end the course, students are able to read and interpret scientific journal articles focused on fungal biology, locate and use fungal biology resources to interpret fungal nomenclature and systematics, identify major groups of fungi based on morphology (both in the field and in the lab), read and interpret a phylogenetic tree and understand and explain the ecological roles and trophic modes of major fungal groups.

Herbarium, St. Xavier's College, Mumbai, Forest Research Institute (FRI), Indian Council of Forestry Research and Education, Dehra Dun, Botanical Survey of India Northern Circle, Dehra Dun and National Fungal Culture Collection of India at Agharkar Research Institute, Pune, all are reported to house fungal specimens, both dried and pickled. The last mentioned institute maintains pure cultures of about 2,600 fungi and 39,000 dried samples of lichens and fungi and offers fungi identification service. The number of fungi collections in the herbaria of the other three institutes is not known. The FRI herbarium, however, is a forest pathology museum which houses 900 exhibits of various economically important tree diseases and timber decays. The largest collection of fungal cultures is, however, maintained at the institute of Microbial Technology, Chandigarh and Indian Agricultural

Herbarium	Total Vascular	Bryophytes	Lichens	Algae	Fungi	Total Collection
PERTH*	450	2	1	4	5	462
AD	611	25	11	61	13	722
BRI	490	6	2	20	0	518
MBA	10	0	0	0	0	10
BRIP	0	0	0	0	17	17
NSW	1099	46	12	43	0	1200
DAR	0	0	0	0	70	70
MEL	902	35	38	59	20	1052
HO	94	20	22	12	3	151
CANB	432	7	4	5	2	450
DNA	125	0	0	0	0	125
CBG	129	71	20	0	2	222
KPBG	21	0	0	0	0	21
Total	4362	212	110	204	131	5019

*PERTH : Western Australian Herbarium; AD : State Herbarium of South Australia; BRI : Queensland Herbarium; MBA: Herbarium, Botany Branch, Department of Primary Industries, Mareeba, Queensland; BRIP: Herbarium, Plant pathology Branch, Department of Primary Industries, Indooroopilly, Queensland; NSW : National Herbarium of New South Wales; DAR : Plant Pathology Branch Herbarium, Biological and Chemical Research Institute, NSW Agriculture & Fisheries; MEL : National Herbarium of Victoria; HO : Tasmanian Herbarium; CANB : Australian National Herbarium, CSIRO, Canberra; DNA : Northern Territory Herbarium; CBG : Herbarium, Australian National Botanic Gardens, Canberra; KPBG : Herbarium, Kings Park and Botanic Garden.

In a survey of the major herbaria in Australia and holdings by plant group in each of them, an interesting data (Table 3) was provided by Richardson and McKenzie (1992). The data revealed the number of specimens in the country's herbaria reflected the number of described species, with the vascular plants making up the bulk of the collections. It showed that fungi were poorly represented in all except Adelaide (AD), Melbourne (MEL), Rydalmere (DAR) and Indooroopilly (BRIP). BRIP and DAR were mainly plant pathology herbaria, whereas Adelaide and Melbourne had mainly macrofungal collections.

Among the four herbaria listed in India viz Blatter

Research Institute, New Delhi, who also offer various types of services including identification and accessioning the newly discovered species.

Inadequate knowledge of mycological taxonomy means that India will find it impossible to meet its obligations under the Conservation of Biological Diversity (UNEP, 1992) - an international legally-binding treaty. To fulfill her commitment to the Convention on Biological Diversity (CBD), fungal taxonomic expertise is vital for effective implementation since the Global Taxonomy Initiative (GTI) states that "understanding taxonomy is a priority in implementing CBD". Fungi, in particular, are a group of organisms where most countries lack tax-

onomists to carry out the roles of the CBD.

Problems facing fungal systematics and fungal biodiversity inventory

While funding is difficult to obtain, funding for basic mycology is even scarcer, and can usually only be obtained for applied projects in fields where fungi play an important role, such as plant pathology, food microbiology, bioactive compounds, and/or applications in forest regeneration. Herbaria and living culture collections are battling to maintain high standards or even to survive, due to lack of interest for investment and scarcity of funds and expertise. These collections are in danger of being lost when these funds become unavailable or the researchers discontinue their project. Even internationally, fewer mycologists and funding are available to actually identify and describe new fungi. On the other hand because of CBD, it has become more and more difficult to obtain permission to collect fungi from reserve forest areas and sanctuaries.

The way forward

As an 'orphan group' all mycologists should support each other in any way possible. By building capacity through postgraduate training and extensive field work involving students, by stimulating teaching and fetching research projects, by positive reviews of grant applications, as reviewer, helping to improve manuscripts rather than negative

rejection, extending supportive references in job applications, collaboration and training and avoiding territorialism. There are enough fungi for everyone to study without having an effect on the scientific advances of others.

As existing expertise is rapidly, disappearing and our tribe vanishing - we cannot be complacent...

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