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IMD: The first online database of documentation on Myxomycetes fungi from India

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Abstract

The Indian Myxomycetes Database (IMD) is the first on-line database of information on Myxomycetes in India. The database contains 394 records from 11 families, 50 genera and 351 species, and can be accessed at www.fungifromindia.com. Every species from this much neglected group of fungi has been given a unique identity number that can be cited in publications where a new species is described. Every entry in this database has been linked with the globally recognized myco-database (www.mycobank.org). The IMD is part of an Indian initiative to promote international biodiversity documentation and form a global network of databases on biological information.

Key words – Indian Myxomycetes Database – MycoBank – Mycology

Introduction

Fungi and fungi like organisms are among the most important organisms in the world, not only because of their vital roles in ecosystem functioning but also because of their influence on humans and human-related activities. Fungi are essential to such crucial activities as decomposition, nutrient cycling, and nutrient transport and are indispensable for achieving sustainable development (Palm & Chapela 1997). Although the diversity of fungi and fungus like organisms is daunting, we believe that variety, numbers, and importance mandate their inclusion in conservation dialogues and biodiversity projects. We also believe that they are tractable in a meaningful way. If the estimate is correct, then sites share enough species to make broad-scale inventory work possible yet harbors sufficient number of unique species to make valuable contributions to our understanding of fungi biodiversity and the ecological, evolutionary and genetic processes of these fungi and their associated organisms (Mueller et al. 2004). The ultimate aims of the present study were to study the occurrence and distribution of Myxomycetes from India and to give easy access for the information of Indian Myxomycetes to researchers and the students all over the world.

The present work has tremendous mycological significance and it will update the knowledge of Myxomycetes of India. This is the first Indian database on a much neglected group of fungi. The user friendly database will inspire the students as well as researchers to study the Myxomycetes taxonomy from India. Such type of database gives the information in very short period which will help researchers to save their energy and time for further research.

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Myxomycetes are plant-like in their manner of reproduction but resemble animals in the characteristics of their assimilative phase. The organism exhibits two alternating phases in its life cycle, the assimilative phase and the sporulating phase. The former consists of a free-living, acellular, mobile mass of protoplasm i.e., the plasmodium. The plasmodium absorbs nutrients from the surroundings and also engulfs solid particles including bacterial and fungal spores. The sporulating phase (sporocarp) bears spores externally on, or inside, a spore case. The spore case consists of an outer, generally persistent peridium, which envelops a free thread-like netted structure, the capilitium, which aids in spore dispersal. Myxomycetes are a cosmopolitan group of organisms that can be found in a variety of habitats including well-manicured lawns and flower beds, and damp places, especially on old wood or other plant material undergoing decomposition. Slime molds are also common on dung and a few species may be restricted to this substratum. Another more recently recognized, specialized niche is dead branches attached to living trees.

The important taxonomic treatises available on slime moulds include Lodhi (1934), Farr (1962), Martin & Alexopoulos (1969), Alexopoulos (1963, 1967 & 1969), Thind (1977), Lakhanpal & Mukherji (1981). Several workers also reported Myxomycetes from different parts of India, which were published under the banner of Fungi of India. Martin GW (1932), Martin et al. (1957), Uppal BN et al. (1935), Mundkur BB (1938), Patel MK et al. (1948), Ramakrishnan & Subramanian (1952), Subramaniam & Ramakrishnan K (1956), Roy (1948), Vasudeva (1962), Mathur (1964), Subramaniam & Tyagi (1964), Tilak & Rao (1968), Rangaswamy et al. (1970), Kamat et al. (1971), Kowalski & Lakhanpal (1973), Mukherji & Juneja (1975), Sarabhoy et al. (1975, Sekhon (1976), Sekhon (1978), Sekhon (1979a,b), Bilgrami et al. (1979), Mishra & Ranade (1979), Sood & Lakhanpal (1980), Sarabhoy et al. (1980), Sarabhoy et al. (1986), Hosagoudar et al. (1996), Jagtap & Singh (2002), Jamaluddin et al. (2004). Dr. Wight was perhaps the first person to collect a slime mould, *Physarum cinereum* (Batsch.) Pers., from Madras (Chennai), India on grass leaves in 1830.

Bruhl & Gupta (1927), published the second paper on Indian Myxomycetes describing 16 species from West Bengal. Butler & Bisby (1931, 1960), compiled a list of Indian Fungi and remarked, "The Myxomycetes have not been studied in India but many of these widely-distributed organisms occur there". They did not include any representative of this group in their compilation. However, Lister (1924, 1925), had already mentioned (under habit only) the occurrence of 18 species in different parts of India. Lodhi (1934), published a monograph of Indian slime moulds describing and illustrating 43 species. The period between 1952–1976 can be considered the Golden Period for the studies of Myxomycetes in India. Around 1952 interest was revived in this field. Dr. K.S. Thind in North India, and Dr. V. Agnihothurudu in South India, started work on Indian Myxomycetes almost simultaneously. Thind and other workers in a series of 24 research papers have described about 175 species from the North Western and Eastern Himalayas and the Punjab Plains. Thind & Rehill (1957), Thind & Sehgal (1960, 1964), Thind & Manocha (1963), Thind & Khara (1969). Their contributions include 19 new species and two new varieties. Agnihothrudu and his collaborators (Agnihothrudu 1954a, b, 1955 &1956a, b c; Agnihothrudu & Chinnappa 1966 & 1969), (Indira 1968a & b, 1975), have described 78 species from South India, including one new species.

Agnihothrudu (1952–1968), in a series of four papers described 56 species including two new species from North-East India. Ghosh & Datta (1962 a, b, c & 1963), from Orissa, Pathak & Ghosh (1962), from Uttar Pradesh, Kar (1964), from Calcutta, Singh & Pushpavathy (1965 &1966), Singh et al. (1979) from Delhi, Patwardhan & Joshi (1975), Patil & Ranade (1975), Ranade & Mishra (1977), Ranade (1978), Chavan & Kulkarni (1974), Thite (1975) from Maharashtra, Dhillon (1976, 1977a & b), and Dhillon et al. (1978), recorded more species of Myxomycetes from their respective places. In 1977, Prof. Thind published "Myxomycetes of India" describing and illustrating 182 species recorded up to 1973. Lakahanpal began work on Myxomycetes of Kulu and Simla in 1966 (Lakhanpal 1966, 1978), later extending the work to other parts of Himachal Pradesh. From 1965 to 1978 he collected about one thousand specimens, including about 75 from Delhi (1969–1975). In his doctoral thesis, Lakahanpal described and illustrated 156 species.

In this work he recorded 7 genera and 43 species for the first time from India and described 22 species new to science. He also reported 50 species (and one variety) from Delhi, and 83 species from Himachal Pradesh for the first time. He also amended the diagnosis of *Metatrichia vesparium* and *Physarum laevisporum* and resolved the controversy regarding the delimitation of the species of *Lycogala* on the basis of the ontogeny of their corticals scales. Lakhanpal (Lakhanpal & Mukherji 1981), in a series of 19 papers entitled "Taxonomic studies on Indian Myxomycetes – I–XVII" and "Experimental studies on Indian Myxomycetes – I and II" described and illustrated more than 62 species from Himachal Pradesh and Delhi and have recorded their observations on the life cycle and sporangial development of some important species such as *Licea scyphoides* Keller & Brookes and *Clastoderma debaryanum* Blytt. They also conducted cultural studies on some species of *Didymium* i.e., *Didymium muscorum* Lakhanpal & Mukherji, *D. karstenii* Nann.-Bremk., *D. intermedium* Schroet. and *Didymium squamulosum* (Alb. & Schwein.) Fr. & Palmquist. Earlier, Thind & Lakhanpal (1968a, b, c) described 16 species and Lakhanpal (1971–1973), 56 species from Himachal Pradesh, including some already described by him with Prof. Thind. Kowalski & Lakhanpal (1973) and Lakhanpal (1972 a & b), described one genus and ten species from Delhi. Lakhanpal (1972 a & b) recorded five species from Nainital in Uttar Pradesh. Many species have been collected from natural habitats since 1976 and some more interesting forms have been obtained, in moist chambers, from the bark of living trees. The work after 1976 has seen contributions from Nannenga-Bremekamp et al. (1958a, b & 1967), Farr (1962), Singh & Pushpavathy (1965, 1966 & 1979), Tandon et al. (1964), Patil & Mishra (1977), Ranade & Mishra (1977), Mishra & Ranade (1979), Nanir (1979), Bhide et al. (1987), Nanir et al. (1987), Rokade & Nanir (1993), Kaur & Mukerji (1996), Wrigley and Lado (2005), Tembhurne & Nanir (2011), Ranade et al.(2012). Distribution of Myxomycetes in India: Temperature, humidity, rainfall, and topography are the main factors that determine the distribution of Myxomycetes. It is suggested that Myxomycetes attack wood after it has been partially degraded by Basidiomycetes, but their role in the decay of conifer wood may be understated. The present study provides a checklist containing 373 species of Mxyomycetes, 17 varieties and 4 forms within 50 genera, 11 families and 6 orders (Table 1). Liceales is the dominant order with 3 families. Stemonitaceae is the dominant family with 12 genera and *Physarum* is the dominant genus with up to 76 species in India. Worldwide, these 50 genera recorded in India are represented by 2344 species, 523 varieties, 4 subspecies and 58 forms (Table 2). Various classification systems of Kingdom Fungi have been proposed by mycologists, among which is the recent classification system given by Alexopoulos et al. (1996). However, the present study has taken into consideration the Ainsworth system of classification of Fungi (Ainsworth et al. 1973). For classification of Myxomycetes (also called Acellular slime moulds or True slime moulds), a system proposed by Martin (1932) is used.

Materials & Methods

Digitization work – Database preparation (Indian Myxomycetes Database i.e. IMD)

Card preparation

More than 400 reference cards of size 17.5 × 12.5 cm were prepared from extensively surveyed Indian literature including reference books, research papers and explanatory notes. The latest nomenclatural change has been added on the card by different coloured ink. The basic reference is quoted at the right-hand corner of the ruled card. The important references of the same species are added on the back side of the reference card. The information on the card is kept in similar format for all the cards as follows.

Digitization

India has been the cradle of knowledge for thousands of years. Today there is a felt need to preserve and propagate indigenous knowledge and culture along with the acceptance of universal knowledge through globalization in this age of technological developments. The IT oriented environment has brought in opportunities of a revolutionary nature in archiving and accessing

knowledge in the digitized form which were known to exist in conventional libraries mainly in the print form. India has undertaken many initiatives to digitize its documented knowledge base and set up digital libraries for better access to its diverse client. India needs well planned and policy based digitization efforts to be effective in the present situation. Digitization has become the buzz word in every field of information generation, processing, preservation and access. There are many prestigious nationally and internationally funded activities which are being undertaken simultaneously by many institutions and agencies. Indian digitization programmes are in their initial stages and it is now considered to be the most favored activity in the field of information generation, processing, dissemination and preservation. In this situation of hype, it is hardly understood that applying digital technologies will be a complex process of experimentation with gains and losses, triumphs and failures (Nagarkar 2000, Dasgupta 2005).

Digital technology has raised the hopes and expectations of people to face the challenges of not only bridging the gap between the information rich and the information poor in the country, but also uplifting the level of development in all its different facets. Major responsibility now rests on the decision makers, technological experts, librarians, educationists, social workers, legal experts, publishing industry as well as the local institutions to play their respective roles in bringing digital information in need based comprehensible form and language to the diverse clientele of the country. No agency can really work in isolation to reach the expected goal in the right manner. Therefore, coordinating agencies may have to be established on a distributed regional basis to understand local requirements and thereby assist policy planners in preparing proper guidelines for useful and sustainable digitization programmes.

The available technical infrastructure and the networks in existence may now be utilized while initiatives for more sophisticated technology becomes successful in creating proper infrastructure to deal with the multi-lingual and multi-sectoral information required for the vast majority of Indians. Just as the audiovisual media such as TV and radio have reached every corner of India, digital technology will one day become a household facility in distant parts of the country. Since Indian decision makers have now understood that Information is power and information based decision making has become the order of the day, the Government of India and other agencies are taking necessary steps to improve the telecommunication and other technical facilities to make IT based Information access a reality in the true sense so that there can be substantial improvement in the quality of life of every Indian (Dasgupta 2005).

Card

Short form of the reference at right hand side top corner
Recent name of the species
Old name of the species
Family
Host
Locality
Distribution
Reference sited

Data Feeding in Excel

The data on the above said cards is feed in different columns sequence wise as that of the card information so that the uniform system is developed in the database. MS Office 2007 has been used for creating the MS Excel sheets. The advantage of the excel sheet data was that we could import the same data in any usable format, which was not possible in other forms so easily. More than 400 entries of the records have been done from all over India very keenly.

Database Building

In this database the software's which are used as follows:

DBMS	: **MySQL Server 5.0**
Serverside script	: **PHP 5.2.9**
Server	: **Apache 2.2**
Javascript library	: **Scriptaculosus**

Being reference data it is not complex in terms of relationships between the files. But the complexity is present in terms of repeating phrases/words and different words with same/similar meaning. The primary key for the record table is defined by the collection of three columns viz. genus, species and original reference. The original reference field had to be added in the primary key since there can be repeating genus-species combination obtained from different sources of data. Uid is the unique identification number for each record. The columns in the database are as follows:

Software

Between the physical database, itself (i.e. the data as actually stored) and the users of the system is a layer of software, usually called the database management system or DBMS. DBMS provides a view of the databases that is elevated somewhat above the hardware level and supports user operations that are expressed in terms of that higher-level view. In this database, the software's which are used are as follows:

Description of All Pages of Database

The website contains the pages as follows Home page, General search (Simple search), Advanced Search, Output of the search, Browse, Card viewer, Card, References page, Contact page, Site Map, Help Page, Publications and Data entry page.

Home page

It contains introductory information and links to other pages. Data statistics given on the front page will change automatically as per the updates in the data records (Fig. 1).

General search (Simple Search) Page (Fig. 2)

It contains a text input field where user can type keywords to be searched. There is also a dropdown box for selecting the operation (AND/OR). A button is added to the page which is used to initiate the querying process. When this search button is pressed on 'onclick' event is fired and subroutine is called. This subroutine (written in java script) takes key words and operator from corresponding fields of the pages and sends it to the serverside script that accesses the database (here it is simple search.php). This script works in backend to search for the data. If the data matching to the query is found, the script generates a tabular output in html format and returns it to the client. Being in the "html format", the data can then be viewed in browser as the html page that contains the search results.

Advanced Search Page (Fig. 3)

This page contains three input fields as follows

a. Dropdown box – For selecting database field to be searched.

b. Text input field – For Keywords, dropdown box for logical Operate.

c. Row join operator – For joining multiple searches.

The set of these three basic input fields mentioned above form a single search. More than one searches can be performed in one go by adding such sets of three field s and joining them by 'row join operator'. For this add and remove buttons are given (Fig. 2).

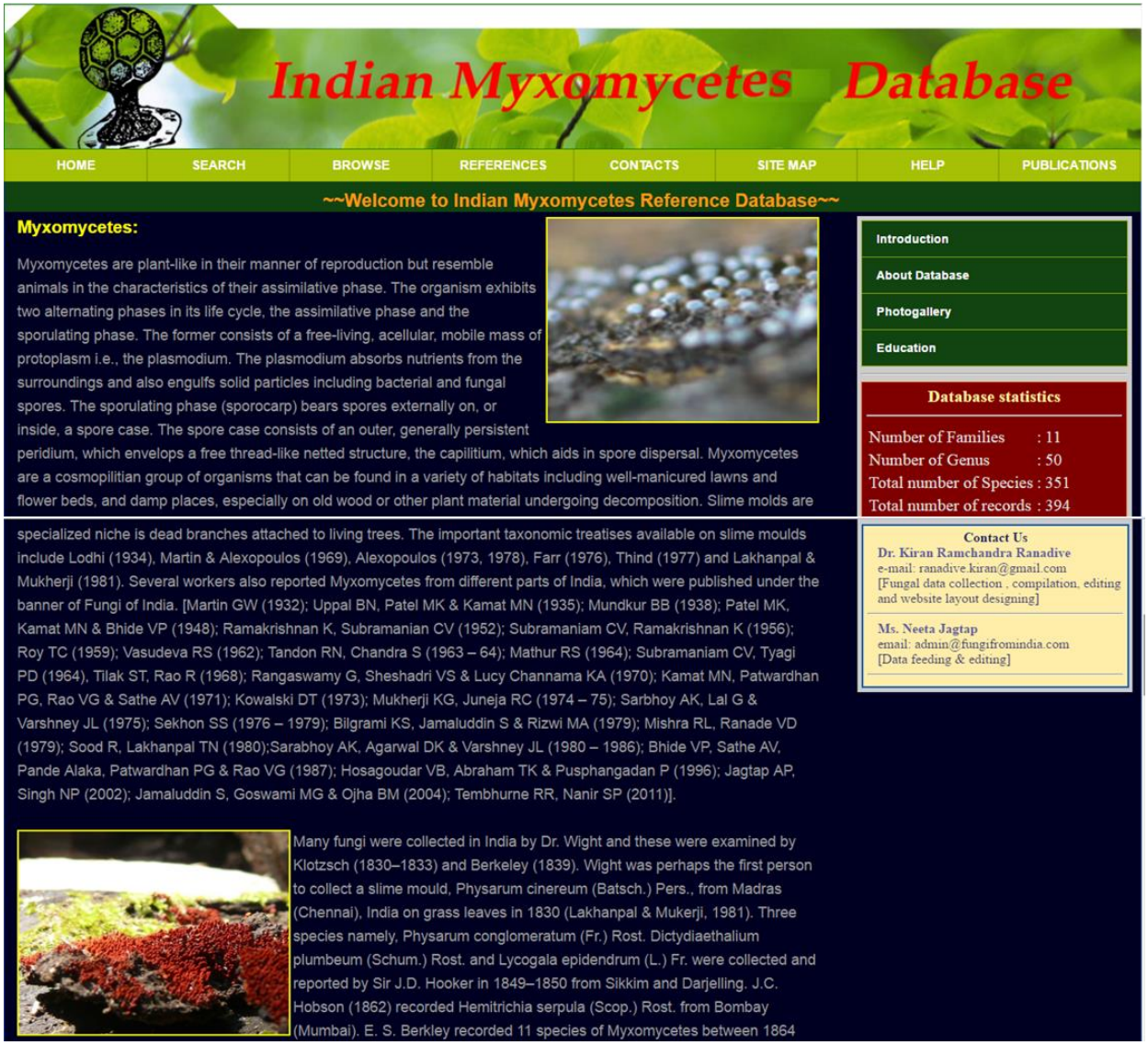

Fig.1 – Indian Myxomycetes Database Home page

Output of the Search

Both simpleSearch.php and advSearch.php generate output in same format. The searched records are presented in a tabular format with serial number, IMD-ID number genus name, species name and family name as the columns. The output generated by this script is in a card format and is not presented to the user as different page but is dynamically embedded in the existing search results page. This achieves the purpose of both user friendliness and the minimum amount of data transfer. The embedded page is formatted in such a way that the user feels as if looking the hardcopy of the card. The card can be closed using the provided 'close' button and other cards can be reviewed in the same page without querying the database again and again (Fig. 4).

Browse page (Fig. 4)

Browse: Family

Browse: species specific query

Output of browse queries is same as that for search queries.

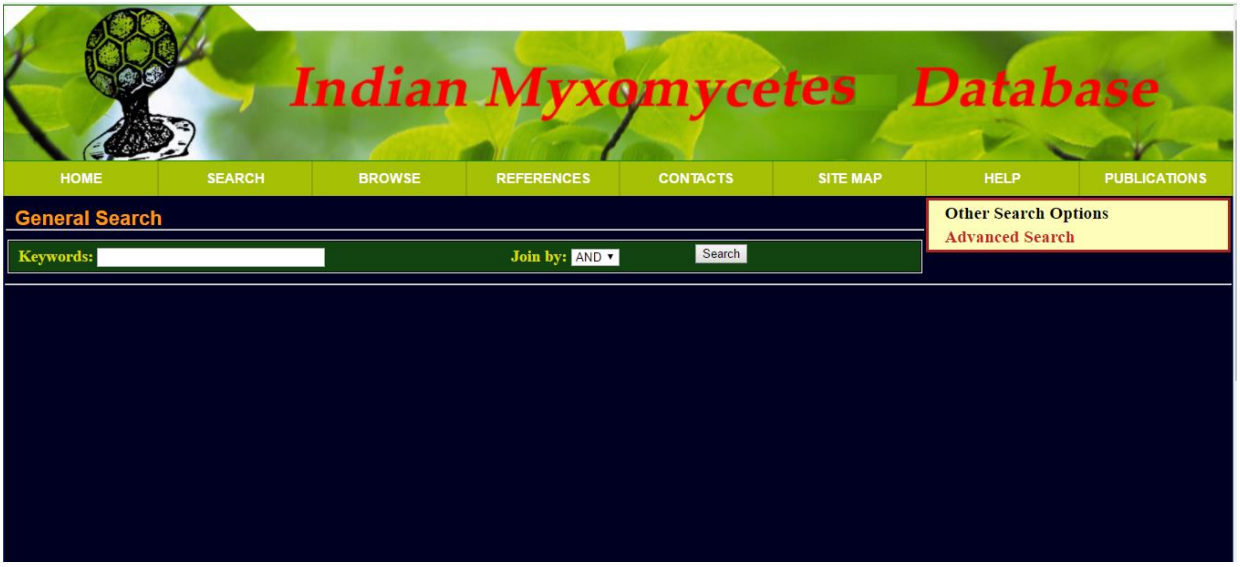

Fig. 2 – Database General Search (Simple Search) and Advanced Search page

Card Viewer (Fig. 6)

This page will display the card as well as the background showing glimpses of the result of the query put by the user/visitor. This function will help the user/visitor to get back to the species in which lies client's second interest.

Card (Fig. 7)

The card is the source of all basic information like

IMD Number (The Unique Indian Myxomycetes Database Number**)**
Name of the species
UID (Unique ID number given to every Record from The Database)
Family Name
Host
Locality
Geographical Distribution
Original Reference (From where the data of the is taken)
Research Work Reference (Any other research reference to be added)

References Page (Fig. 8)

This page includes more than 19 major references used for this Database. Reference books, Ph.D. Thesis of the related subjects are given sequentially.

Contacts Page (Fig. 9)

This page shows the photographs and bio data of the authors Database for any further queries about the Database.

Site Map (Fig. 10)

In this page the short cut links are given for every major part of topics of the Database which occurs on the task bar of the Database. It is very much easier for every visitor of this Database.

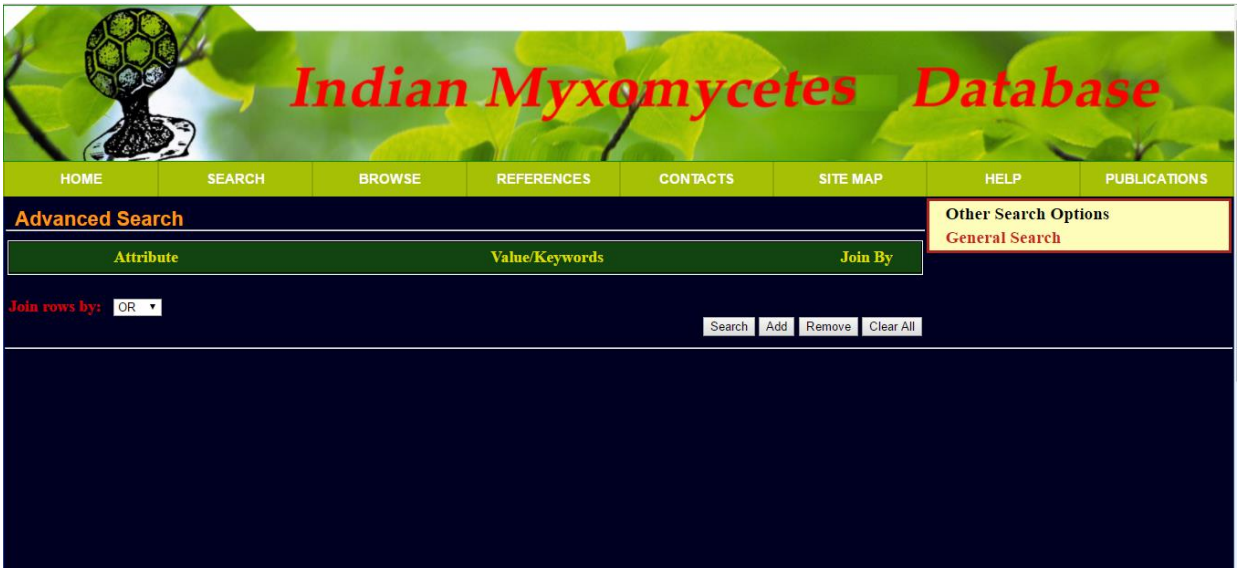

Fig. 3 – Database Advanced Search page

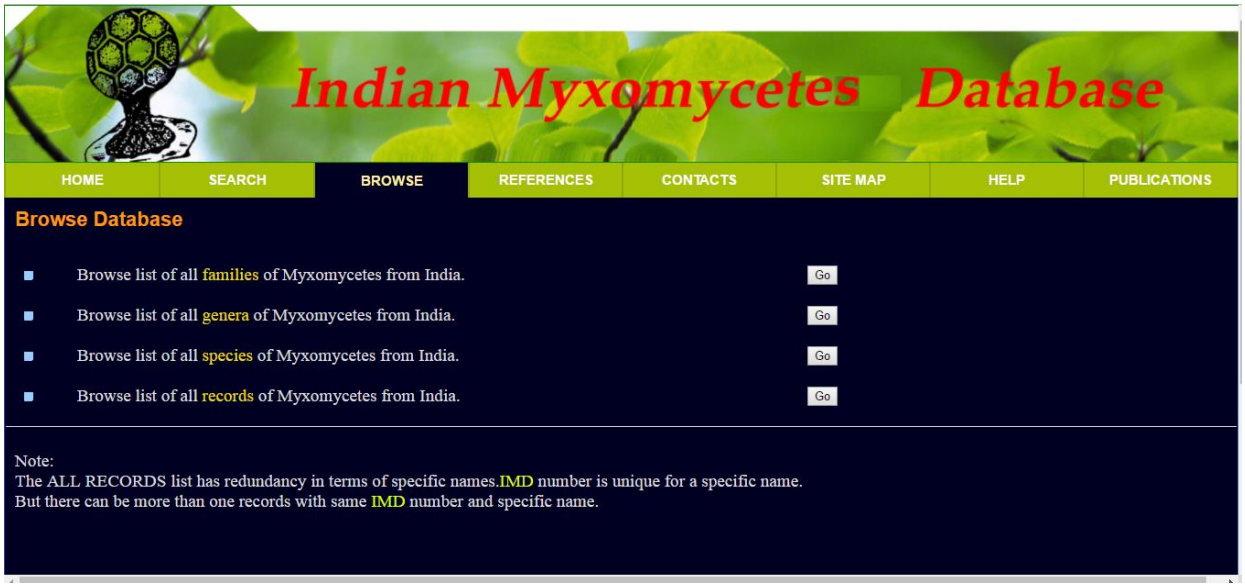

Fig. 4 – Database Browse page

Help Page (Fig. 11)

This page is really the encouraging page for every visitor of the Database because it gives every help regarding (How to use the database?) its use. The page is having the screen shots of all the pages which will help the student as well as researchers to solve their difficulties regarding the use of the Database.

Publications

This is the section is under progress which will be containing the publications done by all authors from India and abroad.

Results

The present work has contributed for the first time in India about the Myxomycetes reference database. In this study more than 400 reference cards were prepared in a standard way. The database shows total 394 records in which total 351 species were recorded from 11 families and 50

genera of Myxomycetes from all over India. This IMD has been launched online on www.fungifromindia.com. Every species of this database has been linked to the www.mycobank.org.

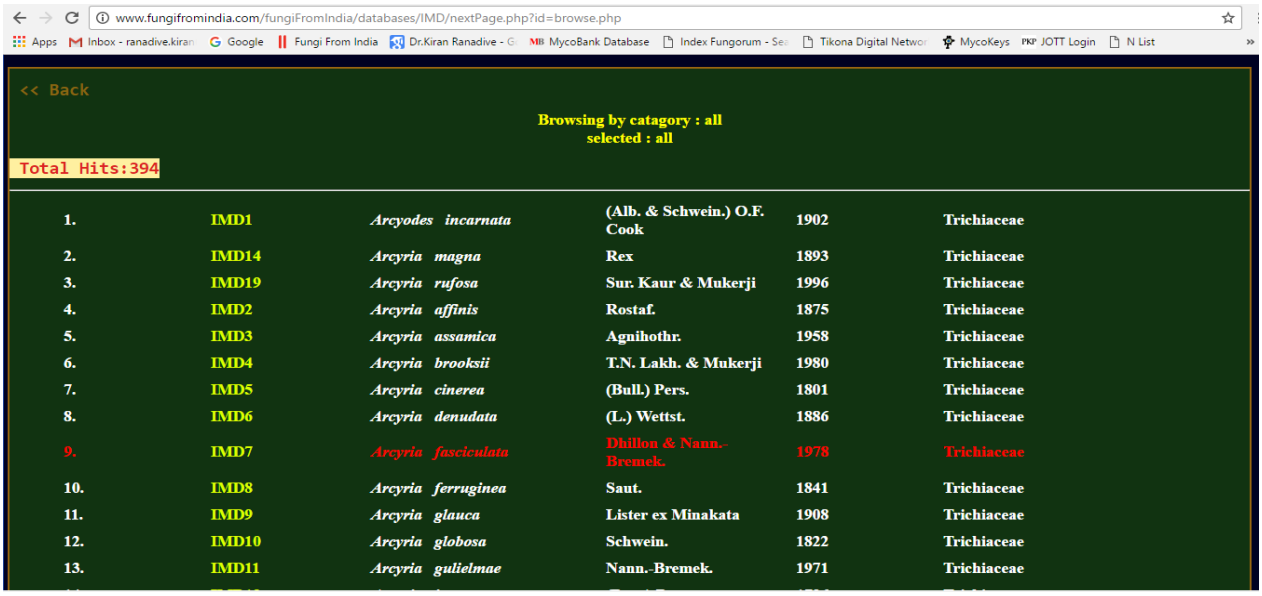

Fig. 5 – Database Search page result

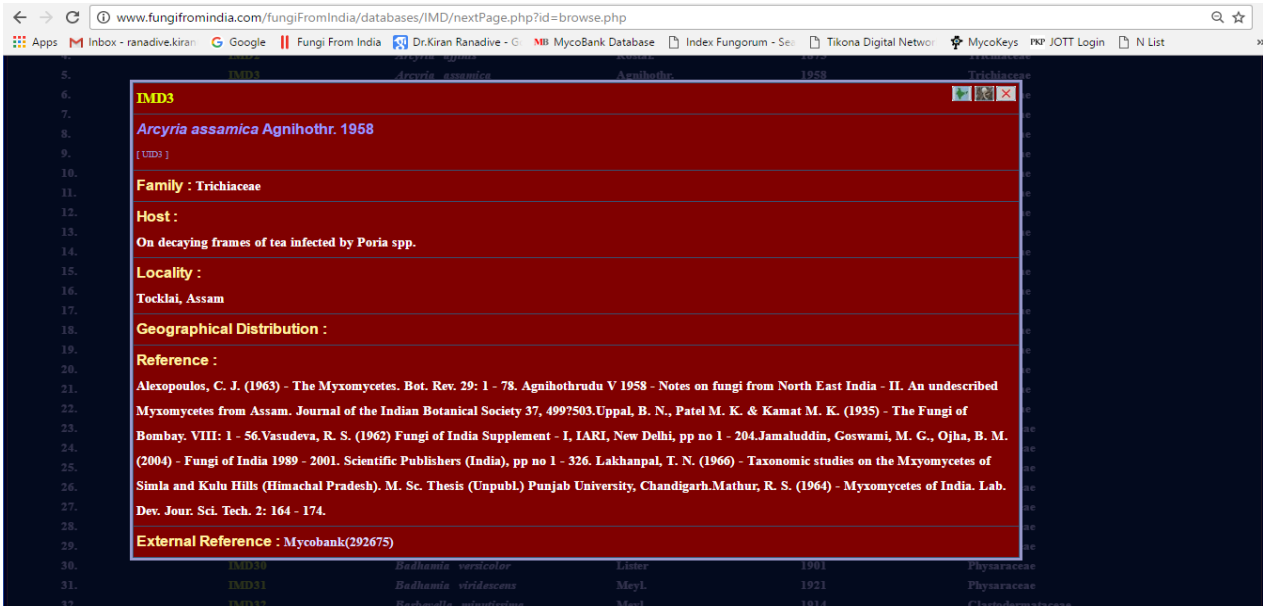

Fig. 6 – Database Card viewer

Discussion

The literature on fungi is scattered in journals, not easily accessible to the Indian students. The unavailability of the related literature may develop the disliking of the subject, so in such case our IMD-Reference Database (The database giving all Myxomycetes references from India on a single click, i.e. on IMD- Indian Myxomycetes Database) will minimize the efforts and time for the survey of literature. This is the first Indian effort to do such contribution in the history of Indian Mycology and just made available free of cost for all researchers from world. This database will help to the new comers in the field and it is available free of cost online. This database work has been completely funded by the author himself only. This is expected to serve as an initial step towards better understanding of the Myxomycetes from any locality of India.

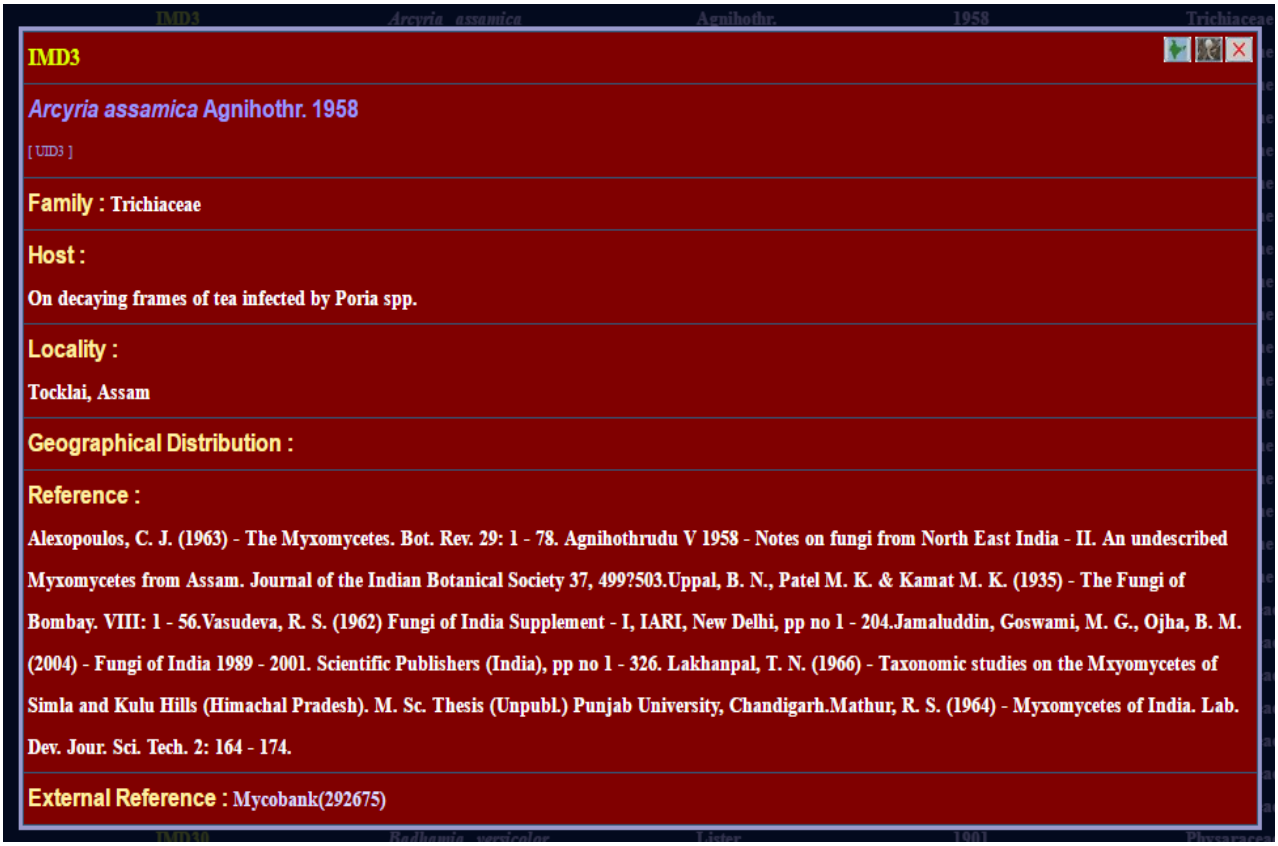

Fig. 7 – Card

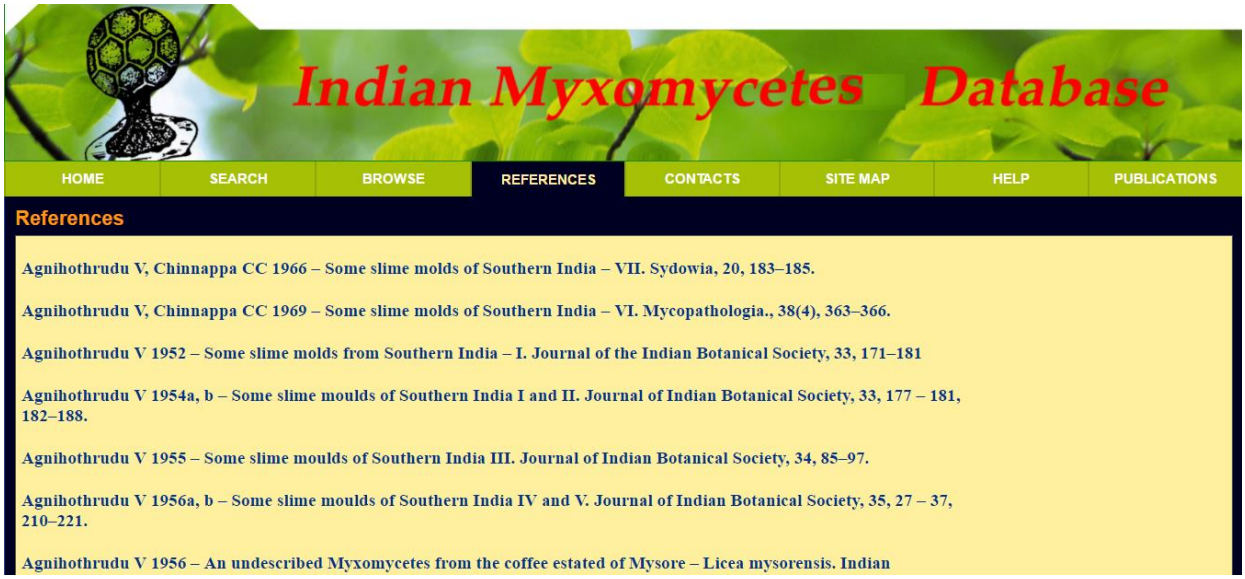

Fig. 8 – Database Reference page

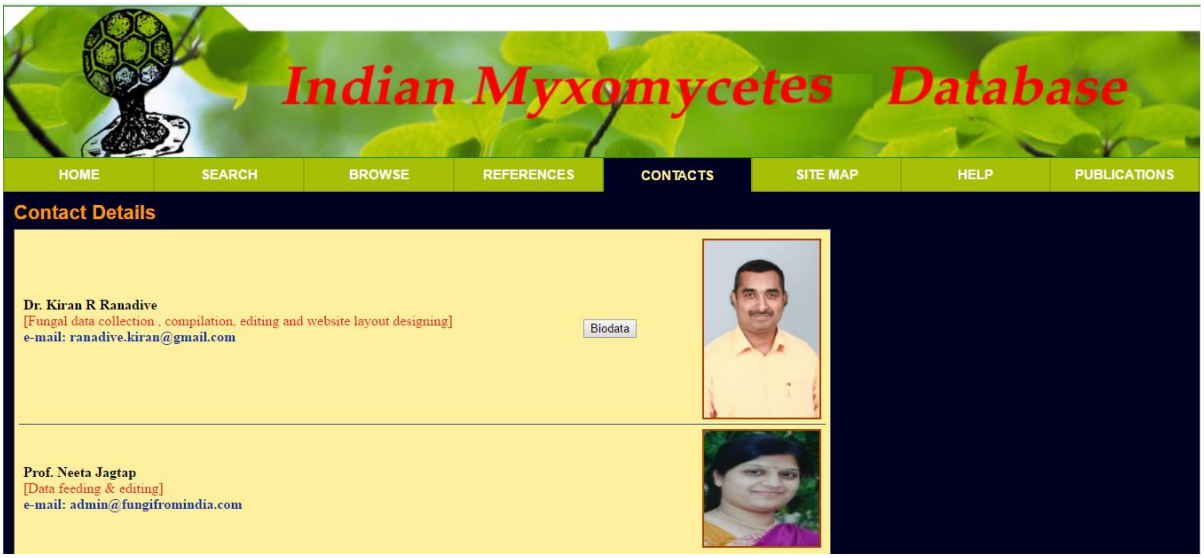

Fig. 9 – Database contact details page

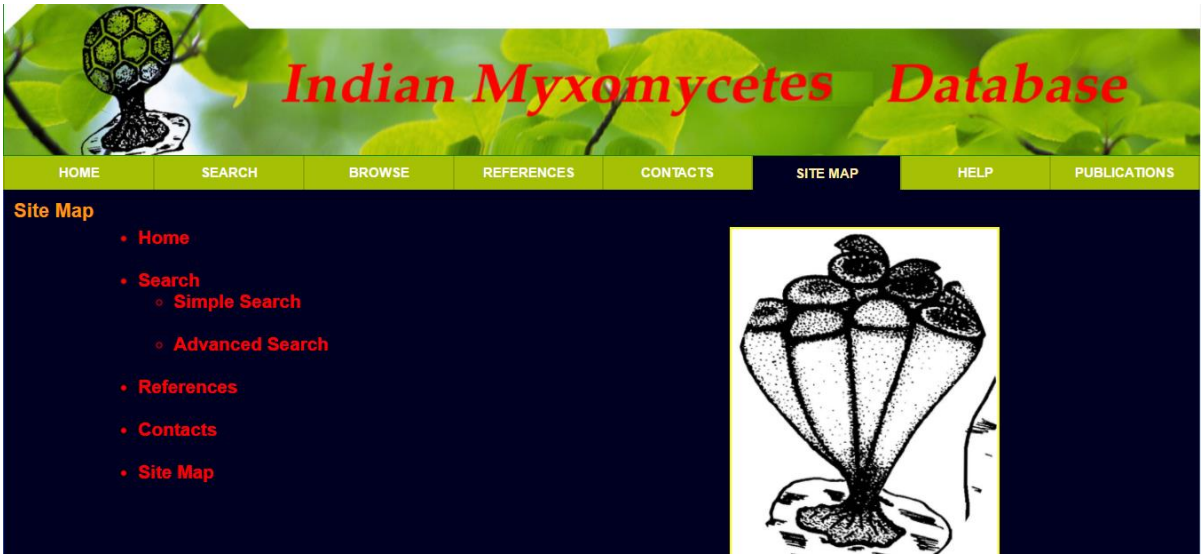

Fig. 10 – Database Site map page

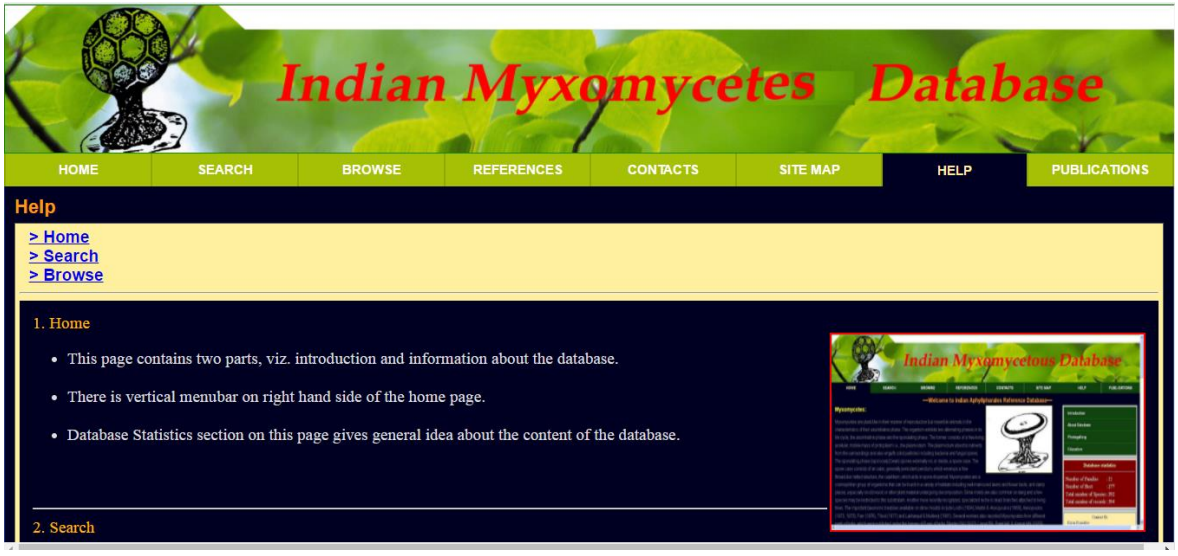

Fig. 11 – Database Help page

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