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IGMIS – a computer-aided information system on Indian Gondwana megaspores

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The Indian Gondwana Megaspore Information System (IGMIS) is an information system developed for storage and retrieval of Indian Gondwana megaspore (female reproductive unit of early land plants) records in a selective manner. At present, it provides information on 45 genera and 159 species recorded from Palaeozoic and Mesozoic sediments of India. The use of the database is to store and organize information on Indian Gondwana megaspores accrued over the past 70 years. This information system is a significant step towards ensuring safety and accessibility of the data on the dispersed Indian fossil megaspores, besides providing accessibility for handling the information in

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future, including new and emerging types of data format. Each record has a unique code number for further reference. Addition, deletion, modification and search facility are provided by this software. Additionally, search can be performed in terms of different morphotaxonomical characteristics (single or combination of characters). The program is useful for a quick and classified megaspore search on datagrid, especially of the published information on fossil megaspores and their horizontal and vertical distribution in India. The program and associated database are capable of computer-aided identification of Indian Gondwana megaspores and help avoid assigning multiple/different genera or species to the same category. Here we report our attempt to digitize and provide an updated knowledge on various aspects of Indian Gondwana megaspores, including their morphotaxonomical characters, distribution and photodocumentation in an information system.

Keywords: Computer-aided information system, distribution, megaspores, morphotaxonomical characters, photo-documentation.

MEGASPORES are the female reproductive units produced by the heterosporous early land plants, which on germination give rise to the female gametophytes and measure more than 200 μm in size[1]. Heterospory is a significant evolutionary stage in the history of plant life and is intermediate between homospory and development of seed habit. The megaspores are produced by pteridophytes such as lycopsids, filicopsids and sphenopsids. The fossil megaspores are found in dispersed condition in the Indian Gondwana sediments. Their affinity is now well established with the lycopsids[2]. Besides, being significant in evolution, the megaspores are indicators of source vegetation since they indicate the presence of lycopsids which are not well represented in the Indian Gondwana sediments, useful in biostratigraphy and in interpretation of palaeoclimatic conditions.

The megaspores are classified on the basis of their external and internal structures. There are several reports of megaspores from various formations (Talchir, Karharbari, Barakar, Barren Measures, Raniganj, Maitur, Tiki, Jabalpur Umia, Athgarh)[3–5] of different Indian Gondwana basins, namely Damodar, Mahanadi, South Rewa, Satpura and Wardha–Godavari. Besides, megaspores are also reported from the Mesozoic sediments (Early Cretaceous, Bhuj Formation) of Kutch region in Gujarat[6].

Till date, 45 genera and 159 species are recorded from India (Figure 1). In this age of electronic communication which has made the whole world a global village and considering the wealth of information accrued on the Indian Gondwana megaspores, a careful, detailed, comprehensive and precise update is required on the subject to preserve the relevant data in digitized form. To facilitate this, the Indian Gondwana Megaspore Information System (IGMIS) software has been developed, which will expedite the study of Indian Gondwana megaspores in an easy manner. The database presently developed in the form of desktop application is being converted into web-based application for wider dissemination.

Traditionally, megaspore study starts with maceration of samples and their isolation by picking them up individually. They are then photographed in incident light/SEM for the study of external characters. Further, the megaspores are treated with nitric acid and 5% KOH for study of internal characters under transmitted light with the help of a high-power microscope. The megaspores are again photographed at this stage. Both the external and internal characters are useful for their precise identification. The megaspores are then compared with the previously described ones. This is a time-consuming and tedious process as the information is spread in various journals – both national and international. Accessing all previously published literature at one place at a time becomes a limiting factor for correct identification and in creating a new genus or species. According to Riedel and Budai[7], the major problem with palaeontological information is that the names by which fossils are recorded tend to change in meaning over the years, since they are treated differently by different authors. To solve this problem a computer-based application is required, which can provide precise knowledge about a particular taxon with regular updating.

The use of computers in the field of palynology dates back to the mid-1950s and since then it has been utilized in various countries. Kremp[8] established a computer-based research centre in Arizona, USA. Hart[9,10] computerized the palynological literature with respect to Karoo sediments of South Africa, and Guppy *et al.*[11] utilized the computer-based applications in the identification of spores and pollen grains[12]. The main objective of the present communication is to evolve a database system which can be used as an information pool and give complete reference, including photographs to study the finer details of the taxonomical features of the exosporia and mesosporia of the Indian Gondwana megaspores. Besides, the distribution of megaspores in different horizons and sedimentary basins of India has also been taken into account. A Windows-based computer software is being developed to generate knowledge base on Indian Gondwana megaspores. This software is capable of reproducing the published and reported literature under different categories, e.g. serial number, name of the genus and species, type species and authors, year of publication, title of paper, journal name, page number, type of megaspore, shape, nature of trilete mark, nature of exosporium, nature of mesosporium, age, formation, coalfield, area of collection, GIS coordinates of the area, district, state, images, plate number, figures, reference and slide number.

The use of computer programming will accelerate the process of identification of megaspores and retrieve their

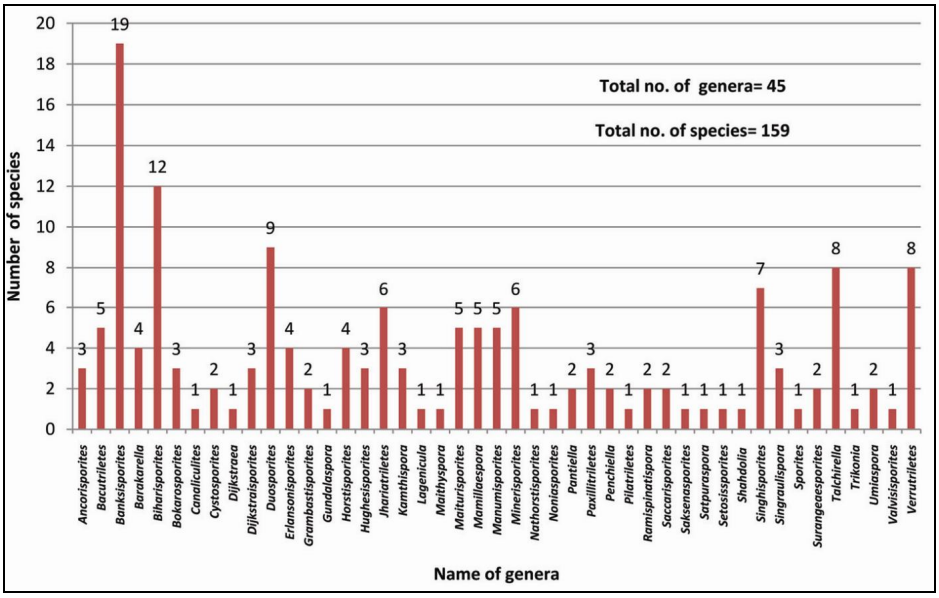

Figure 1. Species distribution graph.

Table 1. Transaction table

Table name	Description
Type	Information about the specific structure of megaspore
Genus	Information about the genus
Species	Information about the species
Type species	Information about the first species of specific genera
Author	Information about the authors
Formation	Information about the formations from where the sample was collected
Age	Information about different ages of samples
Coalfield	Information about the coalfield from where the sample was collected
District	Information about the district from where the samples were collected
State	Information about the states from where the samples were collected
Journal	Information about the particular journal from where the data have been procured

complete details. Consequently, the whole process will be easy, fast and precise.

To develop the core database, the information on megaspores has been collected from both the primary and secondary resources like research papers, journals, abstracting services, textbooks, monographs, catalogues[13,14] and logically integrated in accordance with the database management system[15].

The goal of a database is to organize information and automate tasks[16] (for example, searching through text for a specific criterion or matching text). It has a structure, information and way to query information that fits into that structure besides a way to retrieve subsets or full sets of that information.

Methodology followed for the database is the collection and compilation of different datasets of megaspores, their scientific validation by subject experts, entry into the structured database (Microsoft SQL2005) and user-friendly retrieval of the data through a Windows-based interface to assist the researchers on Indian Gondwana megaspores. This database makes available repository data of megaspores with basic and advance search.

Riedel[17] introduced a program in Turbo Prolog to assist users to identify fossils consistently and expeditiously. The program required familiarity of the user with command strings of the respective programming language, as graphic user interface (GUI) was not in vogue at that point of time. This was a major disadvantage as the user has to be conversant with the programming language at command level to use the database and acquire the desired information, thus limiting its use by a common researcher. This program was designed for the palaeontological applications.

The programming language of the present system is coded in Microsoft Visual Basic Dot NET 2010 used as front end and Microsoft SQL Server 2005 used as a back end. The application can run on a PC with at least Core 2 Duo processor or higher version and 1 GB RAM or higher version on Windows 7/Windows 2000/Windows 2003 server or higher version. The information gathered from the field was entered in Microsoft SQL Server 2005 database management system, which also served as back end of the software. All the tables are linked through primary keys[18] with one-to-one and one-to-many relationships[19].

The database can be separated into two basic types: the transaction table (Table 1) and the master table (Table 2). The transaction table holds all the information related or pertaining to a particular idea or object; for example, author table contains all relevant information with respect to the original author of the megaspore genus and the subsequent authors who have added to the knowledge of the megaspore data. The master table provides description

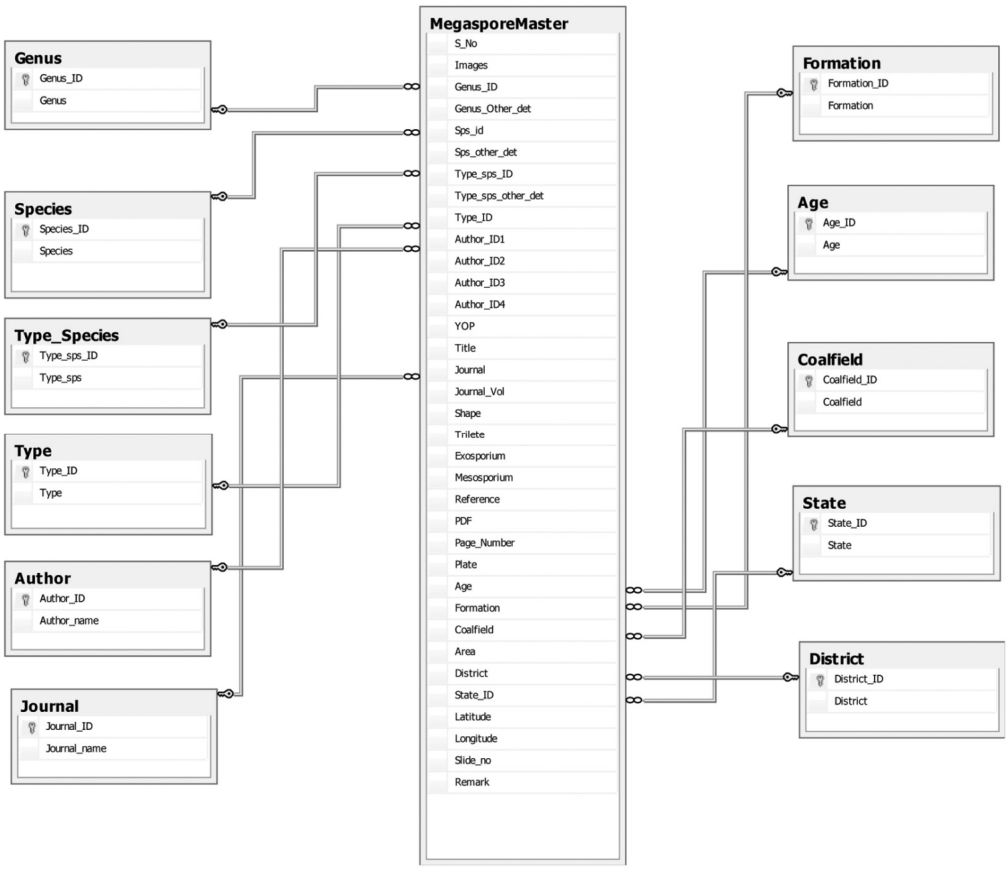

Figure 2. Relationship between different tables in IGMIS software.

Table 2. Master table

Table name	Description
Megaspore master	Complete record of megaspore data with images in binary form

and photo-documentation of all the known Indian Gondwana megaspores.

The database is simple and has a user-friendly structure. It will help in creating general awareness about Indian Gondwana megaspores along with promoting scientific temperament in the local community by disseminating information and is additionally useful to those interested in the traditional methods of investigation of megaspores. Hence, this database serves as an information bank for future research[20] as the computer program is of a generalized nature and can be easily modified to meet similar needs for other branches of science as well. Being Windows-based, it is user-friendly and can be easily accessed by any person familiar with general computer usage[21]. The flow chart depicting the retrieval strategy is given in Figure 2.

The front end of the present system is divided into two major parts: data management form (data entry) and data manipulation form (basic search and advance search).

In order to perform various tasks directly on the raw data, a set of data manipulation forms has been developed (Table 3). The tasks include viewing and exporting the data along with adding, deleting or editing the records within the database exclusively by the administrator. This allows the user to access and also have overall control of the data stored within the database (Figure 3). This information helps describe and update the raw data. Due to its relational database design, while editing the database table information, changes need to be applied once from within the master megaspore table. These changes are automatically reflected the next time when the data are queried. Records can be entered one by one using the data entry form. In this form, the data are recorded digitally. The whole procedure requires a short time to answer the questions, view the newly formatted data and import them to the database.

The data manipulation form helps in advance data retrieval tasks by any of the files related to megaspores, which can be achieved through queries. Data retrieved and displayed by these forms cannot be altered in any manner. Under the section of basic search, users can access records from the database on the datagrid by entering any text in the textbox. Under the section for advance search, records can be searched by a combination of different fields together. In both the search techniques,

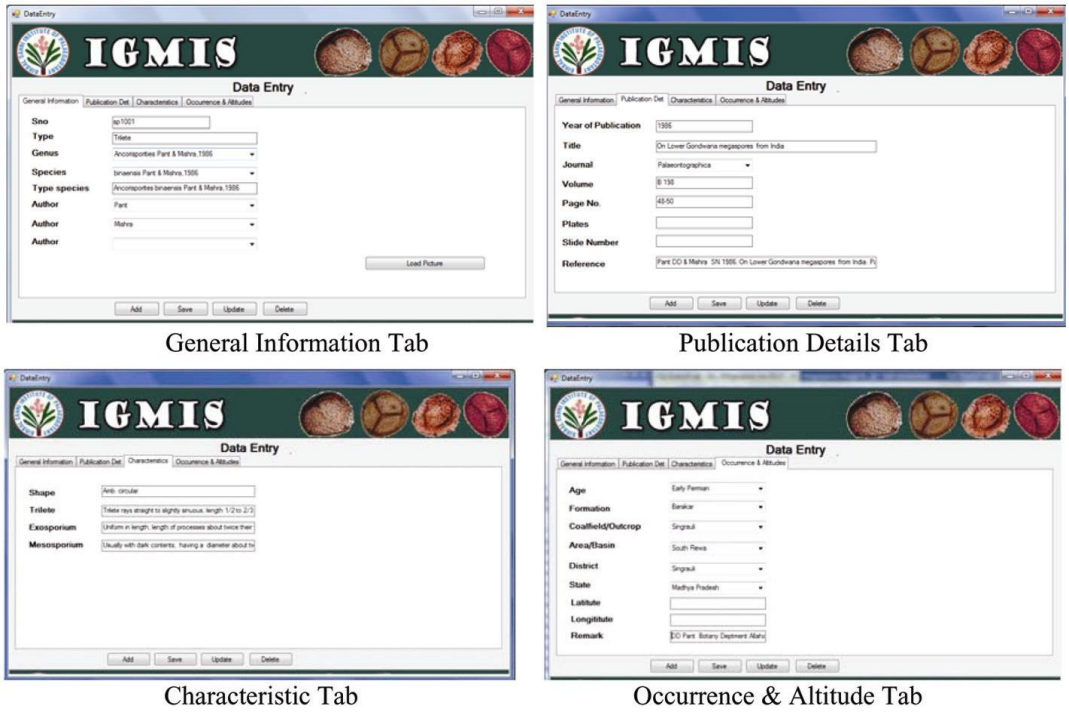

Figure 3. Data management form.

Table 3. Interface for front end module of IGMIS

Modules of IGMIS interface	Description
Data management form	This form is used to enter records in the database with photographs in IGMIS software
Data manipulation form	
Basic search	This form is used to search any character in IGMIS software
Advance search	This form is used to search different available fields in IGMIS software

megaspore details along with their images are displayed on the datagrid.

The sample output of basic search and advance search in IGMIS software is given in Figure 4 *a* and *b* respectively. The significance of this program is to obtain complete details of megaspores as a whole or in desired combinations of datasets in a speedy manner. The logical order is an additional asset of a data processing system. Database of megaspores can be generated in desired format to provide significant information within a short period of time. Availability of the database, irrespective of time and geographical zone, makes it an important link of exchange of information between academicians and palaeobotanical researchers. However, the data contained within such a system entirely depend upon human skill. The current datasets of Indian Gondwana megaspores updated in the database are validated by experts and are generally error-free. The flexibility of the system allows incorporating valuable information published in scientific journals, research papers, scholar research reports and books published on the related subjects.

The IGMIS has the potential to contribute substantially to megaspore systematics by providing information to any megaspore researcher who has access to a computer. It provides access to state-of-the-art validated and updated information on megaspores of Indian Gondwana basins through distributed databases to users who seek answers to their own systematic and taxonomic queries. The IGMIS software helps in computer-aided identification of megaspores. In doing so, it facilitates both research and educational objectives. Moreover, it is easy to access the megaspore knowledge, especially for researchers who have limited or no access to megaspore information, work in relatively remote localities and lack access to frequently updated specialized libraries and expertise. The IGMIS is a pioneer and unique application resulting from a global attempt to develop a holistic database on Indian Gondwana megaspores and provide simple, straightforward database access.

The IGMIS holds promise to bring precision through computer-aided identification of megaspores and thus helps in reducing/minimizing the avoidable information load due to new species creations based on incomplete or fragmented past knowledge. The photo-documentation of megaspores provides a graphical view for scientific comparison and identification of old/new species/genera.

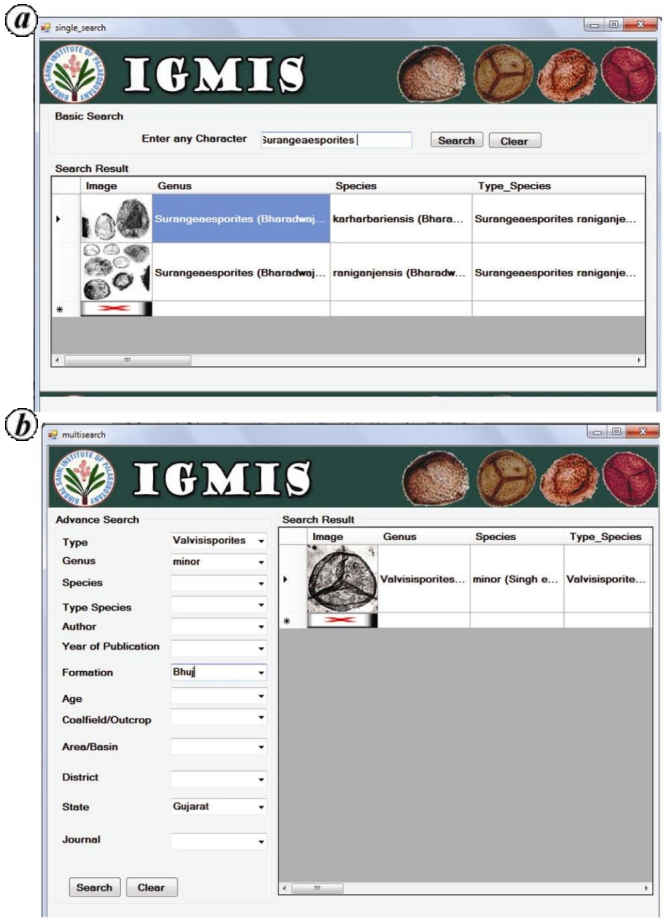

Figure 4. ***a***, Basic search; ***b***, Advance search.

Photographs along with the data are additionally helpful for precise identification of the megaspores.

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Observations on reproductive performance of Indian mouse deer (*Moschiola indica*) in captivity

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The study reports some observations on reproductive biology of mouse deer (*Moschiola indica*) maintained under the conservation breeding programme at the

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