

Electronic herbarium and floristic diversity of dicot plants of Nagpur district (Maharashtra, India)

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Abstract

Electronic herbarium (digital database) is prepared by selecting various morphological characters (>200) with a number of possible variable states as a model. This work is done using software, DELTA (Description Language for Taxonomy) is a flexible and powerful method of recording taxonomic descriptions for computer processing is used for organizing a database of dicot plants of Nagpur district. The database contains about 856 species belonging to 498 genera and 120 families were incorporated along with full plant descriptions, family, botanical names (ICBN) and their synonyms, references, common and vernacular names, distribution in Nagpur district, present status of the plants in nature, socio-economic (including medicinal) uses of these plants and digital photographs. During the preparation of digital database of dicot plants of Nagpur district and after going through the literature it was found that some of plant species were recorded to be new to this region. It forms an important centre of data storage system for faster dispersal of plants information from one place to anywhere in the world.

Keywords: electronic herbarium, digital database, nagpur district, dicot plants.

1. Introduction

Taxonomy, one of the oldest and dynamic branches of biological science is “the theory and practice of classification”. The wealth of vegetation that adorns the earth shows a vast array of diversity of forms and various modes of life are covered under head ‘Taxonomy of plants’. The plants furnish most of our food, shelter, clothing, fuel, medicine, paper and a host of other useful products, which is possible only by conservation of biodiversity. The present study deals with advantages of evolving innovative trends in taxonomy over the conventional techniques.

Herbaria are permanent repositories of plant specimens and are sources of information about plants and vegetation. Systematic collection of plants in herbaria provides a permanent record of the earth’s flora and its diversity. Faced with both increasing costs and demands for services, herbarium managers have a constant challenge to maintain financial security. Thus, it is essential for herbaria to develop and use modern management techniques. Continued development of computer software for data processing, database management, word processing, bibliographic aids and management aids will result in the development and increased use of cost effective computer methodology in collection management^[1-3].

Over the years computers have been increasingly used in data collection, processing and integration. Computers have been found to be quite useful in plant identification, whereby we no longer need trained botanists for this task.

Realizing the need for and the importance of documenting biological diversity of the country, we have embarked a novel technology of Electronic herbarium for digital database preparation of dicot flora of Nagpur district. Electronic herbarium is defined as “high resolution virtual images of plant specimens in digital format”^[4]. Electronic herbarium (digital database) is prepared by selecting various morphological characters (>200) with a number of possible variable states as a model. This work is done using software, DELTA (Description Language for Taxonomy) is a flexible and powerful method of recording taxonomic descriptions for computer processing is used for organizing a database of dicot plants of Nagpur district^[5]. This technology has several advantages (permanent, original colors are retained, eco-friendly, no biodegradation, pathogenic/insect attack etc.) over the traditional method, which is usually happened.

DELTA (DEscription Language for TAXonomy) is helpful for the young taxonomist to build larger or smaller databases for various organism groups. The program was developed by Scientists from CSIRO (Commonwealth Scientific & Industrial Research Organisation) in Australia to handle taxonomic data (e.g. all kinds of characters). Although the program has been around for a while, DELTA is still the state of the art tool in modern taxonomy.

Digital documentation of the vegetation is very important aspect in the field of plant taxonomy. Without documentation many important plant species may be ignored from notice from a particular region. Due to this reason there are chances of extinction of some endemic or important species which can be proved to the great loss to biodiversity.

Nagpur is the most popular district of eastern Maharashtra with District and Divisional headquarters. It is the largest city in central India and third largest city in Maharashtra after Mumbai and Pune. It is also winter capital of Maharashtra. Nagpur is one of the districts in the Vidarbha (Maharashtra) with rich biodiversity of plants, many of them are economically and medicinally important plants and some of them are rare, endangered plants which need immediate attention and conservation. The flora of Nagpur District was earlier studied by Ugemuge^[6]. Later on some attempts have been made to upgrade the flora of Nagpur District. But the flora of Nagpur District has not been studied especially after recent industrialization and urbanization. Hence, it was thought worthwhile to undertake current study to know biodiversity of Nagpur District by using new technology i.e. electronic devices, computer software and digital images in the preparation of electronic herbarium and digital database of dicot flora of Nagpur District. This technology has several advantages over the traditional method, (which were mentioned already) was followed for the preparation of herbarium. This new technique is well accepted one in advanced countries in Europe, America, Australia and India. As this work has not been carried out anywhere in India

except for Mumbai, hence, it is thought worthwhile to study and prepare electronic herbarium and digital database of plants which will help us to identify dicot plants of Nagpur District with accuracy as well as faster and also provide information in conservation point of view to preserve the rare and endangered plants.

After publication of Flora of Nagpur District, several floristic inventories have been progressed throughout the district. Those had resulted in the compilation of a number of checklists *viz.* New records for Nagpur district (Maharashtra) [7, 8], 'New (Fabaceae members) records to Nagpur district' [9], 'New plant species records to flora of Nagpur district' [10], 'Diversity of medicinal and economically important plants of Nagpur district' [11], 'New Plant Species records to Flora of Nagpur district (Maharashtra)' [12], 'Some New Plant Records to Flora of Nagpur District (Maharashtra, India)' [13], 'Some noteworthy addition to the Flora of Nagpur district (M.S.), India' [14], New additions to the Flora of Nagpur District, Maharashtra [15]; New Record of Some Rare Plants to the Flora of Nagpur District, Maharashtra. [16]; Some new plant reports to the Flora of Nagpur District, Maharashtra [17]; New additions to the Flora of Nagpur District, Maharashtra [18]; New additions to the Flora of Nagpur District, Maharashtra [19]; Diversity of Wetland Plants from Umrer Tahsil of Nagpur District – A Preliminary Study [20], Studies on the medicinal uses of the wild trees of Nagpur district [21], Aquatic and wetland plants of Futala and Gorewada lakes of Nagpur city – A Preliminary Study [22], etc.

Electronic herbarium and digital database preparation technique is well accepted technique in advanced countries in Europe, America, Australia *viz.* databases of Angiosperms (Flowering plants) families [23], An electronic world grass flora [24] and also databases of other organisms. In India, this work was done in Mumbai as Electronic herbarium and database of plants of Mumbai [4], and also other parts of India, *viz.* Digital herbarium database of some rainy season weeds of Khadar area of Hastinapur District [25] etc. and also carried out in some parts of Vidarbha such as 'Electronic Herbarium-A Novel Technology for Digital Database Preparation of Dicot Flora of Nagpur District' [26], 'Digital Database of Trees of Nagpur District' [27], 'Digital database of medicinal and economically important plants of Nagpur district' [28], 'Electronic Herbarium of Chandrapur District in Special and Gondpipri, Rajura and Ballarpur Talukas in particular' [29], 'Digital Database of Aquatic dicot plants of Nagpur District (Maharashtra)' [30], 'Digital Database of medicinal weeds of Nagpur District (Maharashtra, India)' [31]. Digital database is helpful in maintaining the wealth of plants, so now days it is important to maintain the digital database of each group of plants for their conservation as plants play a vital role in human life.

2. Materials and Methods

The present work deals with the dicot species of the Nagpur district and is mainly based on plant specimens observed through extensive field survey. The floristic inventory of Nagpur district was done by using area maps and regular field visits. It is an outcome of five years (2010-2015) extensive and intensive field studies in fourteen talukas of the district.

To prepare the electronic herbarium and digital database of dicotyledon plants of Nagpur district, hilly regions, forests, the vacant spaces, near railway tracks, roadsides, crop fields, water bodies, wet lands, botanical gardens, dams, other sites, etc. were explored for natural vegetation.

The exploration tours for plant collection were conducted in various seasons such as pre- and post- monsoon, winter and summer. During the study period several short and long field trips were undertaken including visits to lakes, tanks and rivers for aquatic vegetation. The essential field data of plants such as the fragrance of flowers, local names of the plant, their uses if any, plant height, the associated species, the details regarding habit, habitat, frequency of distribution, etc. have been noted along with characters. The plant specimens were collected in large and thick polythene zip bags, easy to carry from the field. In case of parasitic plants their host plants have also been collected to document the parasite host relationship.

The plants were brought to the laboratory and their morphological characters were studied in detail. Efforts were made to identify the plants using fresh materials. They were identified with the help of different floras [The Flora of the presidency of Bombay Vol. I & II [32], Flora of Maharashtra State: Dicotyledons Volume 1 & 2 [33, 34], Flora of Maharashtra by Almeida [35-38], Flora of Marathwada [39] and the flora of Nagpur District [6] etc. and available literature. The plant specimens were also checked with the authentic herbarium specimen available at the Department of Botany, Rashtrasant Tukadoji Maharaj Nagpur University, Nagpur. Various experts were also consulted whenever needed for identification, their systematic position and nomenclature of the species, genera and families.

To prepare the digital database of plants, desktop/laptop, digital camera and DELTA software package were used. The digital photos of plants were taken in their natural habitat and feeding of plant specimens' observations and identification was done in the laboratory during the study period. The digital photographs were processed in computer and sorted out into their respective families and then transferred to image folder (created) in the DELTA software package.

The standard set of characters (>200) were prepared indigenously by selecting several morphological (vegetative and reproductive) characters for various plant parts (root, stem, leaf, inflorescence, flower parts, fruits, seeds, etc) and fed into software package called DELTA (Descriptive Language for Taxonomy). All these characters were categorized into five types, which are ordered multistate, unordered multistate, Real numeric, Integer and Text form.

The digital images of taxa were processed and sorted out in respective family folders (after identification) were attached to the respective plant descriptions in the database. Other important information such as distribution, flowering and fruiting period, references, status of plant in nature, common name of the plant, medicinal and socio-economic importance of plants [40-44] etc. were also added to the digital database to make it complete informative.

3. Results and Discussion

The Electronic herbarium and digital database of dicot plant species of Nagpur district is an outcome of several botanical explorations during 2010-2015. The database now contains about 856 species belonging to 498 genera and 120 families were incorporated along with full plant descriptions, family, botanical names (ICBN) and their synonyms, references, common and vernacular names, distribution in Nagpur district, present status of the plants in nature, socio-economic (including medicinal) uses of these plants and digital photographs. Few important and common cultivated species are also included here along with the wild species for the general interest. Floristic data is tabulated below:

Table 1

Group	Families	Genera	Species	Subspecies	Varieties
Dicotyledons	120	498	856	20	84

Table 1: Total No. of Dicotyledonous Families, Genera, Species, Subspecies and Varieties

The total number of families, genera, species, subspecies and varieties of polypetalae, gamopetalae and monochlamydeae is given below:

Table 2

	Families	Genera	Species	Subspecies	Varieties
Polypetalae	70	231	415	14	45
Gamopetalae	32	207	327	06	28
Monochlamydeae	18	60	114	-	11
Total	120	498	856	20	84

Table 3: Details of Families, genera, species, subspecies and varieties of Polypetalae, Gamopetalae and Monochlamydeae.

The total 856 dicot species of 120 families recorded in the present work categorized into trees (186), climbers, twidders and lianas (119), shrubs (154), undershrubs (64) and herbs (440). This data is retrieved by INTKEY (interactive key) facility available with DELTA package.

The following list shows the ten largest families of the district.

Table 3

Family	Genera	Species	Subspecies	Varieties
Fabaceae	44	97	02	19
Asteraceae	43	61	01	01
Euphorbiaceae	20	46	-	-
Caesalpiniaceae	09	35	-	-
Malvaceae	13	34	05	07
Acanthaceae	20	33	01	06
Rubiaceae	18	28	-	04
Mimosaceae	13	28	01	01
Scrophulariaceae	17	24	-	01
Convolvulaceae	08	23	01	-

Table 3: Ten largest families with no. of Genera, species, subspecies and varieties.

The descriptions were generated using DELTA database. The program 'Key' generates conventional identification key. In selecting characters for inclusion in the key, the program

determines how well the characters divide the remaining taxa, and balances this information against subjectively determined weights which specify the ease of use and reliability of the characters. The interactive key allows free choice of characters, is easy to use, and can lead to correct identifications in spite of occasional errors.

This digital database includes weeds (226), vegetables (45), dye-yielding (20), timber yielding (61), gum and resin yielding (14), tannin yielding (17), oil yielding (18), fruits edible (37), pulses (06), spices and condiments (05), cultivated for its flowers (32), pickles (05), sacred plants (40), fodder plants (38), avenue plants (42), ornamental plants (113), fiber yielding (17), medicinal plants (569) and also some rare (29) to this region, lower risk (1) and endangered (2) plants which needs conservation. This data is retrieved by INTKEY facility of DELTA package.

New species records (additions) for Flora of Nagpur district during the present study

During the preparation of digital database of dicot plants of Nagpur district and after going through the literature it was found that some of plant species were recorded to be new to this region. Some new records published from the current study are

Desmodium scorpiurus (Sw.) Desv., *Indigofera caerulea* Roxb., *Medicago polymorpha* L., *Stylosanthes fruticosa* (Retz.) Alst (Fabaceae)^[9].

Urena lobata L. ssp. *sinuata* (L.) Borss. var. *glauca* (Bl.) Borss. (Malvaceae), *Cassia alata* L. (Caesalpiniaceae), *Neptunia oleracea* Lour. (Mimosaceae), *Cuscuta campestris* Yancker. (Cuscutaceae), *Morinda pubescens* J.E. Sm. (Rubiaceae), *Synedrella vialis* (Less.) A. Gray (Asteraceae), *Ipomoea sinensis* (Desv.) Choisy (Convolvulaceae), *Polygonum plebeium* R. Br. var. *brevifolia* Hook. (Polygonaceae)^[10], *Polycarpon prostratum* (Forsk.) Asch. (Caryophyllaceae), *Acacia ferruginea* DC. (Mimosaceae), *Mollugo nudicaulis* Lam. (Molluginaceae), *Holoptelea integrifolia* (Roxb.) Planch. (Ulmaceae)^[12].

Nasturtium officinale R. Br. (Brassicaceae), *Mimosa rubicaulis* Lam. (Mimosaceae), *Cestrum diurnum* L. (Solanaceae), *Torenia indica* Sald., *T. fournieri* Lind. (Scrophulariaceae), *Ocimum gratissimum* L. (Lamiaceae), *Amaranthus dubius* Mart. ex Thells. (Amaranthaceae) and *Phyllanthus tenellus* Roxb. (Euphorbiaceae)^[31].

Polygala persicariifolia DC. (Polygalaceae), *Erythrina suberosa* Roxb. (Fabaceae), *Caesalpinia coriaria* (Jacq.) Willd. (Caesalpiniaceae), *Acacia campbellii* Arn. (Mimosaceae), *Memecylon umbellatum* Burm. var. *umbellatum* (Melastomaceae), *Wedelia chinensis* (Osbeck) Merr. (Asteraceae), *Justicia glauca* Rottl. (Acanthaceae), *Cannabis sativa* L. (Cannabaceae), *Ficus rigida* Jacq., *F. virens*, *Morus macroura* Miq. (Moraceae)^[13].

The technique of Electronic herbarium and digital database has great scope and it can be adopted not only for angiosperms but also for various other plant groups with different habitats. This Digital database of dicot flora of Nagpur district could certainly role model and provides recent information on new records and species of this region and also gives information to conserve those plant species which

are now rare in their natural habitat. It needs to propagate awareness for the protection of wild plant species which has many values for human welfare. This database can be updated easily at regular intervals of time. At the end, it can be said that this database would be useful to various walks of life such as students, botanists, ecologists, foresters, agriculturist, pharmaceutical companies, plant conservationists, nature lovers and even to layman interested in plant wealth. This database may not be alternative to the existing herbarium but certainly supports and shares existing herbarium functional dynamism (load). It forms an important centre of data storage system for faster dispersal of information from one place to anywhere in the world i.e. bio-informatics of plant species in information technology era.

4. Acknowledgements

Authors are thankful to UGC SAP DRS I for providing us financial assistance and Department of Botany, Rashtrasant Tukadoji Maharaj Nagpur University, Nagpur for providing us necessary facilities during the study period. Authors are also thankful to forest department for their necessary help during the field visit.

5. References

- Morris JW, Glen HF. Précis, the National Herbarium of South Africa (PRE) Computerized information System. *Taxon*. 1978; 27:449-462.
- Morris JW, Mandens R. Information available with the PRECISE data bank of the National Herbarium, Pretoria, with examples of uses to which it may be put. *Bothalia*. 1981; 13:473-486.
- Sarasan L, Neuner AM. (Compilers) Museum Collections and Computers: Report of an ASC Survey, Association of systematic Collections, Lawrence, Kansas, 1983.
- Srinivasu T. Proc. Second National Training Workshop on Electronic herbarium and digital database preparation held at Institute of Science, Mumbai. 2005; 10(11):1-5.
- Dallwitz MJ, Paine TA, Zurcher EJ. User's Guide to the DELTA System: a General System for Processing Taxonomic Descriptions. 4th edi, 2000.
- Ugemuge NR. Flora of Nagpur District. Shree Prakashan, Nagpur, 1986.
- Bhuskute SM. New Records for Nagpur District (Maharashtra). *Ind. Bot. Repr.* 1989; 8(1):39-42.
- Bhuskute SM. New Records for Nagpur District (Maharashtra)-II. *Ind. Bot. Repr.* 1990; 9(2):61-65.
- Thakre MT, Srinivasu T. New (Fabaceae Members) Records to Nagpur District. MFP News, A Quarterly Newsletter of the Centre of Minor Forest Products (COMFORPTS) for Rural development and Environment Conservation, Dehradun (India). 2012a; XXII:4-5.
- Thakre MT, Srinivasu T. New Plant Species Records to Flora of Nagpur District. MFP News, A Quarterly Newsletter of the Centre of Minor Forest Products (COMFORPTS) for Rural development and Environment Conservation, Dehradun (India). 2012b; XXII:6-10.
- Thakre MT, Srinivasu T. Diversity of Medicinal and Economically Important Plants of Nagpur District. Proc. of National conference on "Innovative Research Trends in Biological Sciences" 8th-9th Sept. organized by Department of Life Sciences, Shri Shivaji College of Arts, Commerce and Science College, Akola (MS), 2012c; 63-65.
- Thakre MT, Srinivasu T. Electronic Herbarium-A Novel Technology for Digital Database Preparation of Dicot Flora of Nagpur District. *Journal of Science Information, Special issue*. 2013; 6:21-23.
- Thakre MT, Srinivasu T. Some New Plant Records to Flora of Nagpur District (Maharashtra, India). *Biodiversity of India*. 2015; 8:333-340.
- Gadpayale JV, Somkuwar SR, Chaturvedi A. Some noteworthy addition to the Flora of Nagpur district (M.S.), India, *Int. J. of Life Science, Special issue*, 2014; A2:35-38.
- Kamble RB, Hate S, Chaturvedi A. New additions to the Flora of Nagpur District, Maharashtra. *Journal on New Biological Reports*. 2013a; 2(1):09-13.
- Kamble RB, Hate S, Mungole A, Chaturvedi A. New Records of Some Rare Plants to the Flora of Nagpur District, Maharashtra. *Journal on New Biological Reports*. 2013b; 2(2):103-107.
- Kamble RB, Hate S, Chaturvedi A. Some new plant reports to the Flora of Nagpur District, Maharashtra - III. *Sci. Res. Rept.* 2013c; 3(2):124-128.
- Kamble RB, Chaturvedi A. New additions to the Flora of Nagpur District, Maharashtra - IV, *Bioscience Discovery*. 2014; 5(2):160-162.
- Kamble RB, Somkuwar S, Chaturvedi A, Ugemuge NR. New additions to the Flora of Nagpur District, Maharashtra - V. *Journal of Global Biosciences*. 2015; 4(5):2343-2347.
- Dongarwar NM, Thakur U, Fulzale A, Labhane N. Diversity of Wetland Plants from Umrer Tahsil of Nagpur District - A Preliminary Study. *Journal of Science information Special issue*. 2012; 3:132-135.
- Maurya R, Dongarwar NM. Studies on the medicinal uses of wild trees of Nagpur District. *International Journal of Life Science and Pharma Research*. 2012; 2(1):21-24.
- Jaiswal V, Awachat S, Dongarwar N. Aquatic and wetland plants of Futala Lake and Gorewada lake of Nagpur city - A Preliminary Study. *Indian Streams Research Journal*. 2013; 1-5.
- Watson L, Dallwitz MJ. The families of flowering plants: descriptions, illustrations, identification, and information retrieval. Version: 11th May 2015, 1992.
- Renvoize Steve, Clayton Derek, Cope, Tom and Williamson Helen. An Electronic World Grass Flora, *Aliso: A Journal of Systematic and Evolutionary Botany*. 2007; 23(1):267-270.
- Shishodiya J, Saxena RS. Digital herbarium database of some rainy season weeds of Khadar area of Hastinapur District, Meerut (U.P.), India. *International Multidisciplinary Research Journal*. 2012; 2(6):34-36.
- Thakre MT, Srinivasu T. Digital Database of Aquatic dicot plants of Nagpur District (Maharashtra). Proc. of National Seminar on Taxonomy for managing

- biodiversity: Present scenario and future challenges organized by Dr. V. S. Krishna Govt. College, Maddilapalem, Visakhapatnam, 2013; 2-5.
27. Thakre MT, Srinivasu T. Digital Database of Trees of Nagpur District. International Journal of Forest Usufructs Management, the Centre of Minor Forest Products (COMFORPTS), Dehradun (India). 2012d; 13(2):66-74.
 28. Thakre MT, Srinivasu T. Digital database of medicinal and economically important plants of Nagpur district. Proc. of Motivational Workshop on "Techniques in Taxonomy: Classical to Molecular approach" 30th-31st March, organized by Department of Botany, Mohota College of Science, Nagpur, 2012e; 16-20.
 29. Dudhe NS, Srinivasu T. Electronic Herbarium of Chandrapur District in Special and Gondpipri, Rajura and Ballarpur Talukas in particular. Journal of Science Information Special issue. 2013; 6:211-213.
 30. Thakre MT, Srinivasu T. New Plant Species records to Flora of Nagpur district (Maharashtra). Journal of Global Biosciences. 2013; 2(6):202-205.
 31. Thakre MT, Srinivasu T. Digital Database of medicinal weeds of Nagpur District (Maharashtra, India). International Journal of Forest Usufructs Management, the Centre of Minor Forest Products (COMFORPTS), Dehradun (India). 2014; 15(2):24-29.
 32. Cooke T. The Flora of the Presidency of Bombay. Vol. I-II Taylor Francis, London; reprinted edition, BSI, Calcutta, 1958.
 33. Singh NP, Karthikeyan S. Flora of Maharashtra State: Dicotyledons. Vol. 1. BSI, Calcutta, 2000.
 34. Singh NP, Lakshminarasimhan P, Karthikeyan S, Prasanna PV. Flora of Maharashtra State: Dicotyledons. Vol. 2, BSI, Calcutta, 2001.
 35. Almeida MR. Flora of Maharashtra. Vol. I, Orient Press, Mumbai, 1996.
 36. Almeida MR. Flora of Maharashtra. Vol. II, Orient Press, Mumbai, 1998.
 37. Almeida MR. Flora of Maharashtra. Vol. III A -B, Orient Press, Mumbai, 2001.
 38. Almeida MR. Flora of Maharashtra. Vol. IV, Orient Press, Mumbai, 2003.
 39. Naik VN. Flora of Marathwada. Vol. I and II, Amrut Prakashan, Aurangabad, 1998.
 40. Kirtikar KR, Basu BD. Indian Medicinal Plants. 2nd edition, Vol. I-III Jayyed Press, Delhi, 1975.
 41. Bhattacharjee SK. Handbook of Medicinal Plants. Pointer Pub. Jaipur, 1998.
 42. Nadkarni KM. Indian Materia Medica, Vol. I. Popular Prakashan, Bombay, 1954.
 43. Ambasta SP. The useful plants of India. National Institute of Science Communication, Council of Scientific and Industrial Research, New Delhi, 2000.
 44. Joshi SG. Medicinal Plants, Oxford and IBH Publishing Co. Pvt. Ltd., New Delhi, 2000.