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Vidya Prasarak Mandal's
B. N. Bandodkar College of Science, Thane

NAAC re-accredited 'A' grade and Best College Award (University of Mumbai)
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Proceedings of National Conference on
New and Emerging Trends in Bioinformatics and Taxonomy
'NETBT 2015'
January 14th and 15th 2015



Edited by

Dr. (Mrs.) Madhuri Pejaver, Dr. (Mrs.) Medha Mulgaonkar and Dr. Moses Kolet

Organized by

Department of Botany and Research Committee, VPM's B.N. Bandodkar College of Science,

In Collaboration with

Association for Plant Taxonomy, Dehradun and Blatter Herbarium, St. Xavier's College, Mumbai

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Glimpses of pre-conference workshops



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Dr. (Mrs.) Medha S. Mulgaonkar
Dr. Moses J. Kolet**

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PROGRAMME

National Conference on New and Emerging Trends in Bioinformatics and Taxonomy

NETBT 2015

14th and 15th January 2015

Day 1: 14th January 2015

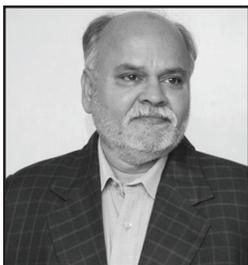
Time	Session	Activity/ Invited Speaker
8.00 - 9.30 AM	Registration	Registration of participants and breakfast
9.30 - 11.10 AM	Inaugural Session	National Anthem Lighting of the Inaugural lamp Welcome by Convener Release of Volume of Proceedings of the Conference Inauguration of the National Conference: Dr. Santosh Kumar Agarwal , Managing Editor, Phytotaxonomy Opening Remarks by Invited Dignitaries Addresses by Co-convener, Chairman VPM Thane
	Inaugural address	RET Taxa: Documentation And Conservation Dr. Santosh Kumar Agarwal Managing Editor, Phytotaxonomy
	Key note address	Bioinformatics: Advancing Biotechnology for Novel Bioprocess Development Dr. Pattanathu, K.S.M. Rahman , Biotechnology Programme Leader, School of Science and Engineering, Teesside University UK
	Vote of Thanks	Organizing Secretary
11.30- 1.15 PM	Scientific Technical Session No.1	Lead Lecture 1. 'CSIR-NBRI Botanic Garden: A Repository of Plant Diversity Ideal for Systematic Studies Dr. Anil Kumar Goel , Chief Scientist and Head, Botanical Garden, NBRI Lead Lecture 2. 'DNA Barcoding: From theory to applications in Taxonomy and Molecular Phylogenetics Dr. Abhishek Baghela Scientist, National Fungal Culture Collection, MACS, Agharkar Research Institute, Pune, India Session Chairman: Dr. B. F. Rodrigues Rapporteur: Dr. R. R. Temburne
		Posters will be displayed at allotted locations after Technical Session 1.
1.15- 2.15 PM	Lunch	Interaction between participants over Lunch
2.15-3.00 PM	Scientific Technical Session No.2	Lead Lecture 3. Biodiversity and Habitat Diversity : Two sides of the same coin Dr. Shashi Kumar Menon TDM Laboratories, Mumbai Chairman: Dr. A. R. Kulkarni Rapporteur: Dr. A. P. Dixit

3.00-4.00 PM	Poster Session	Presentation of Posters
4.00-5.30 PM	Scientific Technical Session No.3	Lead Lecture 4. ‘Advances in Arbuscular Mycorrhizal (AM) Biotechnology’ Dr. B.F. Rodrigues, Professor and Head, Dept. of Botany, Goa University, Goa. Oral Paper Presentations Chairman: Dr. M .C. Srinivasan Rapporteur: Dr. Dileep Shimpi
Day 2: 15th January 2015		
Time	Session	Activity
8.30 - 9.30 AM	Pre- session	Interaction of participants and breakfast
9.30-11.00 AM	Scientific Technical Session No.4	Lead Lecture 5. ‘Biodiversity of India’. Dr. Sanjay Deshmukh, Professor, Dept. of Life Sciences, University of Mumbai; Oral Paper Presentations Chairman: Dr. Santosh Kumar Agarwal Rapporteur: Dr. Ujwala Bapat
11.20- 1.30 PM	Scientific Technical Session No.5	Lead Lecture 6. Computational Analysis of Proteins for Functional Residue Prediction Ashish Tendulkar, Data Science, Directi Organisation, Mumbai Lead Lecture 7. Microbial Genome Mining in Drug Discovery Dr (Mrs.) S.A. Verekar, St. Xavier’s College, Mumbai. Oral Paper Presentations Chairman: Dr. P. K. S. M. Rahman Rapporteur: Dr. Avneet Pal Singh
1.30-2.30 PM	Lunch	Interaction between participants over Lunch
2.30- 3.45 PM	Scientific Technical Session No.6	Lead Lecture 8. Relevance of Taxonomy in an Era of Industrial Biotechnology with special Reference to Fungal Systems Dr. M.C. Srinivasan, Scientist (Retd.) National Chemical Laboratory, Pune; Oral Paper Presentations Chairman: Dr. M. R. Almeida Rapporteur: Dr. Charuta Vaidya
3.45-5.00 PM	Valedictory Session	Valedictory addresses/ remarks Dr. M. R. Almeida Renowned Taxonomist and Author Dr. A.R. Kulkarni Member, National Afforestation and Ecodevelopment Board, MOEF. Closure of conference events followed by National Anthem

**Conferences / Workshops / Seminars conducted by
B. N. Bandodkar College of Science, Thane**

Events	Department	Topics
2013-2014		
National Conference	Zoology and Environmental Science	Biodiversity: Status and Challenges in Conservation FAVEO 2013
2012-2013		
National Conference	IT	FUTECH
National Conference	Chemistry	Phytochemistry: Recent Trends and Challenges
National Seminar	Mathematics	Recent Research Trends in Mathematics
2011-12		
National Conference	Biotechnology	Biotechnological diagnosis
National Seminar	Dept. of Chemistry & Research Committee	Avenues on Scientific Research Proposal Grants.
National Seminar	Botany	"Evolving of Scientific terminology in Environmental Science in regional language."
National Conference	IT	Cloud Technology
2010 - 11		
National conference	IT	"Intelligent System"
2009-10		
National conference	Botany	"Orchid Genetic Diversity: Conservation and Commercialization"
State level seminar	Library	"Re-engineering of Libraries"
Seminar	BARC and VPM's B. N. Bandodkar College of Science.	"Dr. Homi Bhabha commemorative seminar "New Vistas in Research in Physics"
2008 -09		
National seminar	Zoology	"Wonderful world of insects"
2007 – 08		
National seminar	Chemistry	"Contaminants in food and beverages"
2006-07		
National conference	IT	"Linux Thane 2006"
University level Workshop	IT	"Linux Training Programme for Faculties"
University level Seminar	Maths and Statistics	"Financial Mathematics"
Workshop	Chemistry	"Refreshing chemistry for biologist 2006"
2005- 2006		
National conference	Physics	"Einstein's Theories and present scenario"
Workshop	Physics	"Vedic Mathematics"
University level workshop	Statistics	"Statistics for Non-statisticians"
2004 - 2005		
National conference	Botany	"Human health and nutrition : A Biotechnological Approach"
State level seminar	Physics	"Indian Mathematics"
2003 -2004		
Workshop	Chemistry	"Laboratory Safety"
2002 – 2003		
National seminar	Zoology, UGC sponsored	"Creeks, Estuaries and Mangroves: Pollution and conservation"

Message From the Chairman



I have an honest feeling of great joy and pleasure in presenting this volume of proceedings of the scientific papers presented in this two day National Conference on New and Emerging Trends in Bioinformatics and Taxonomy 'NETBT 2015' organized by B.N. Bandodkar College of Science under the auspices of Vidya Prasarak Mandal, Thane on 14th and 15th of January 2015. I also take this opportunity to welcome all our invitees, guests, honourable delegates, academicians, scientists and student participants.

Vidya Prasarak Mandal, Thane and its group of institutions have a long and healthy tradition of successfully organizing conferences, seminars, symposia, and workshops, at all levels inclusive of International levels. Our recently concluded International Conference on 'Bhaskaracharya 900' coincided with the 900th birth anniversary of the great Indian mathematician who paved the way for modern mathematics. An inherent feature of each mega event under the umbrella of VPM, Thane, is the conduct of two pre- event workshops, as in this case two pre-conference preparatory workshops were conducted on 12th August and 13th December 2014, culminating in this National Conference. The basic idea of such pre-conference workshops is to enhance the intellectual levels of under- and post-graduate student participants and to bring them up to a certain common level with the high end academicians and scientists forming the core faculty of the final event. The concept has worked wonders. Another feature is the publication of the volume of proceedings of the conference, with full length papers of delegates and participants, during the inaugural session of the conference. This is eventually uploaded on our website and is available to all. The conferences are broadcast live and can be seen from all over the world.

A basic motive of organizing such events is to provide opportunities to student learners to interact with eminent scientists, constituting who's who of the world scientific scenario; the top brains working for the welfare of mankind, and derive valuable insights. The home platform provided to these young researchers goes a long way in boosting up confidence levels, shaping their careers and creating scientifically aware better citizens of tomorrow.

Taxonomy is a very ancient branch of biological sciences; its roots go deep into ancient times, much beyond the conventionally defined time borders of modern science. Current concepts and technology available 'at the push of a button' have not yet undermined classical taxonomy, but are no doubt posing challenges to the latter. The aim of our organizers in bringing classical taxonomists, vouching by their on-site field work, and followers of new high end technologies of modern taxonomy, functioning from hi-tech laboratories, 'on a common platform' in Thorle Bajirao Peshwe Sabhagruha on our Jnanadweepa is appreciable. During deliberations, the conference will seek to address current and unsolved issues in microbial, animal and plant taxonomy.

I wish healthy interaction and success to this National Conference NETBT 2015.

Dr. Vijay V. Bedekar
Chairman
Vidya Prasarak Mandal, Thane

Message from the Principal & Convener

Happy 2015 to all of you



I am happy to conduct the National Conference on “New and Emerging Trends in Bioinformatics and Taxonomy” in our college campus.

While working in the field of research we are finding it difficult to identify various specimens which are observed during our Biodiversity studies. Basically Taxonomy is a very important branch when we do Biodiversity survey Taxonomy also has evolved from the age of the Father of Taxonomy “Linnaeus” where specimens were identified with the help of morphological characters.

Now we have various branches where other than morphological characters chemical composition, genetic make up, bioinformatics studies, are considered and hence use of ICT in Taxonomy field becomes inevitable.

We have tried to give the platform to the researchers who are working in the field of Taxonomy let it be animal / plant or microbes and bring the scope in front of the students and motivate them to select the branch for further research. Let us get more and more taxonomist before this race becomes extinct.

Dr. Madhuri Pejaver

Message from the Co-Convener



It gives me pleasure to write a few words for the Proceedings of NETBT 2015, based on the National Conference being held at B. N. Bandodkar College, Thane on 14th & 15th Jan. 2015. During my long association with teaching of Botany and Taxonomy, I always felt the need to find new techniques and vistas in Taxonomy for awareness of the students. It is often rightly said that Taxonomy is a dying branch and taxonomists are an endangered species. The study of Taxonomy is the backbone of all biological sciences. It has occupied a leading position in recent years due to advances in research in the fields of biotechnology, molecular biology, bioinformatics and biodiversity conservation. We know only the tip of the iceberg of the vast biodiversity on earth and elsewhere. In the wake of the fast depleting biodiversity throughout the globe, survey, mapping, documentation, conservation and sustainable utilization have become key words. The realization of the fact that in-depth knowledge and coordinately decided policies are the prerequisites for conservation programmes, there is an urgent need to discuss the various relevant topics on one platform through such scientific meets. The present NETBT 2015 is an honest attempt in this direction.

I have been associated with the Association for Plant Taxonomy since its inception. Established in 1998, the aim of APT is to promote research in Plant Taxonomy and provide intellectual and moral support to all researchers in Plant Taxonomy. It provides financial support of travel to unemployed research students, honours renowned taxonomists with various medals, inspires young researchers by giving away prizes for best papers published in its journal and to best Ph.D. thesis in taxonomy every year. The APT publishes an internationally quoted Journal, *Phytotaxonomy*. It publishes original research papers in taxonomy of all groups of plants. Presently it has over 400 life members and Fellows. It is our pleasure to be associated with the APT in this National Conference.

Dr. Medha S. Mulgaonkar

Message from the President, Association for Plant Taxonomy



Taxonomy, the science that identifies, describes and classifies living organisms is the key science for the sustainable utilization and conservation of biological resources. Taxonomy identifies and enumerates the components of biological diversity providing thereby the basic knowledge for the appropriate and effective management of biological resources. A sound taxonomic base, therefore, is a prerequisite for environmental assessment, ecological research, conservation, management and sustainable utilization of biological resources.

India is considered as one of the megadiversity countries of the world. Its enormous floral and vegetational wealth apart from providing endless opportunity to study the plant systematics also opens several new vistas of plant science like biotechnology, economic botany, ethnobotany, phytogeography, endemism and many more. The history of the study of plants in India dates back to Vedic period. One of the earliest works '**Virkshayurveda**' (science of plants) dealing with plant science was compiled by Parashar Rishi (250-120 BC), an Indian scholar. It provides information with regard to the morphology and anatomy of plants, soil properties and forest types of India during that period. Unfortunately, at present the taxonomic expertise available to study our vast floral wealth is inadequate and fast dwindling. The existing taxonomic base is fast eroding due to non-availability of professionals and lack of trained man-power to substitute a few available specialists who are at the verge of or already superannuated. In order to manage India's vast biological resources and to meet the challenges of the century, this issue must be addressed urgently.

The present National Conference being organized by the Department of Botany, VPM's B. N. Bandodkar College of Science, Thane (Maharashtra) and The Association for Plant Taxonomy and Blatter Herbarium, Mumbai on the 'New and Emerging Trends in Bioinformatics and Taxonomy–NETBT 2015' dealing with different aspects of the study of plant, animal and microbial taxonomy along with modern approaches of study will certainly play an important role in inspiring researchers to take up such studies thus strengthening the fast diminishing taxonomic base.

I am sure that the botanists/ researchers from all over the country assembled under this umbrella of the National Conference will contribute their best to highlight the recent trends and development in the plant science research, thus, successfully igniting the minds of the young scientists and young post-graduate students to prepare themselves for a bright carrier in future as a taxonomist.

Dr. H. J. Chowdhery, F.N.A.Sc.

Message from the Director, Blatter Herbarium



In the fast changing industrial world, which generates and caters to needs of consumerist society, there are reports of certain species being extinct and more species are facing the threat of extinction. It is important to stall this trend and preserve biodiversity. The first step in any such effort is to catalogue components. There is a long history of taxonomical study where plant and animal species are described through detailed external characters. The sample specimens are preserved in herbaria for the future reference. Blatter Herbarium at St. Xavier's College, Mumbai is one of the leading prestigious herbarium of national importance.

To keep pace with the evolving world and ever expanding role of new technologies, we recognize the importance and need to modernize the workspace of taxonomists which may include internal structures, molecular analysis and DNA level characterization.

National Conference on New and Emerging Trends in Bioinformatics and Taxonomy, organized by Department of Botany and Research Committee; VPM's B.N. Bandodkar College of Science, is aimed at highlighting recent trends in science of classification and documentation. We at Blatter Herbarium, St. Xavier's College, Mumbai value the theme and are extremely happy to collaborate in this endeavor.

We appreciate huge efforts of the VPM's B.N. Bandodkar College team in organizing the conference and preparatory workshops and wish the Conference a great success!

Dr. (Mrs.) Ujwala Bapat
Director, Blatter Herbarium

Message from the Organizing Secretary



On behalf of the entire organizing committee, it gives me great pleasure to present this volume of the proceedings of the National Conference on New and Emerging Trends in Bioinformatics and Taxonomy 'NETBT2015'. Studies in taxonomy have indeed come a very long way from the earlier classical techniques of identification of flora and fauna. With the times, microbes have also gained a prominent position in biodiversity lists in the national and international scenario. Biodiversity in general has received a lot of attention in recent years, especially since the implementation of the Convention on Biological Diversity. The maxim 'nothing is permanent' is amply evident in the fact that fungi have been traditionally taught under Botany along with plants, with botanists contributing to enrichment of mycology; but the recent concept of classification has brought out phylogenetic differences and altogether alienated the fungi from plants. A similar scenario exists in the rest of the biological sciences, with reclassifications of several species.

Modern technology based methods of classification are now competing with the classical visual observation based techniques, the implications of which are mind boggling. It is clear that the very foundations of classical taxonomy, based on field studies, although very strong; are under challenge from the newer laboratory and technology based concepts. It is one of our main objectives to bring both, classical taxonomists and techno savvy followers of newer techniques related to taxonomy, on a common platform, for sharing their respective views with the gathering, and offer authentic guidance to the next generation of budding scientists. The Department of Botany and Research Committee selected New and Emerging Trends in Bioinformatics and Taxonomy as the central theme of this National Conference, on essential inputs from Principal (Dr.) Madhuri Pejaver, who rightly envisioned its importance in the future.

We, the Bandodkar College, thank the Association for Plant Taxonomy, Dehradun, and Blatter Herbarium, St. Xavier's College, Mumbai, for extending support by way of collaboration. We thank the National Bank for Agriculture and Rural Development- NABARD, for supporting printing of this volume of proceedings. We also thank all our kind donors and well wishers. The organizing committee extends heartfelt thanks and a warm welcome to all our guests, invitees, delegates, contributors, participants who have come from far and near and student participants. I take this opportunity to thank our parent body, Vidya Prasarak Mandal, Thane, our Patron Dr. Vijay Bedekar, Principal and Convener Dr. (Mrs.) Madhuri Pejaver, Co-convener Dr. (Mrs.) Medha Mulgaonkar, members of the national advisory and local organizing committees, support staff and all our enthusiastic students for their trust and unfailing support; all support services especially, the Administrative Office, Department of Library and Information Science, Department of Information Technology, printing and catering services, and above all, all my colleagues from Teaching and Non-teaching staff. I extend sincere thanks to all those who have contributed towards the success of this National Conference.

Dr. Moses Kolet

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Section 1 :
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Inaugural Address

Orchids of India: Diversity and Status

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Introduction

The family Orchidaceae is one of the largest and the oldest known family of flowering plants in the world. The family has between 25000 to 30000 species distributed in almost all the corners of this globe. Though orchids are highly specialized and could survive in a wide ranging climatic conditions from the frozen Alaska to snow clad mountainous region to dry sandy African and Australian deserts, they prefer humid climate and as a result, are abundant in tropical regions of the countries in south-east Asia, India, China, Japan, Phillipines, Australia, Europe, south and central America and South Africa.

The family Orchidaceae is an assemblage of forms having most exotic, highly attractive, extremely varied flower shapes and colours, etc. and they produce the smallest seeds known in the plant kingdom. The bewildering colours, astonishing shapes and sizes with longer shelf life (2-3 months) and ability to travel long distances has made orchid flowers one among the top ten cut flowers in international market occupying a major share in the global floricultural trade. There is a long list of orchid species that have been and are being used for their therapeutic uses in many countries of the world.

Orchids found mention as early as in 200 B. C. in the Chinese pharmacopoeia – ‘*The Sang Nung Pen Tsao Ching*’ mentioning the use of *Dendrobium* as a tonic, astringent, analgesic and anti-inflammatory substances. Theophrastus (370- 285 B.C.), known as the ‘Father of Botany’, gave the name ORCHID in his book ‘*Enquiry into Plants*’, based on the Greek word Orchis meaning the testicle, referring to the paired underground tubers of an European terrestrial orchid. Later Dioscorides, the Greek herbalist and a firm believer in the ‘Doctrine of Signatures’ believed and claimed that all plants possessed certain signs given by God, which indicated their usefulness in treating diseases of similarly shaped organs in the human body used the tubers of some orchids to confer virility and potency. He adopted this name to be included in ‘*Materia Medica*’. The first book on orchids named “Ran-Pin” (meaning the varieties of orchids) was written by Joan Matsuoka in Japan in the early 18th Century on the instruction of Emperor Hiyashi-Yama, which was published in 1772 after the death of author (Nagano, 1960). Soon the orchids found place in herbal and other

botanical literature (Lashley & Arditti, 1982), but the formal taxonomic work on orchids started after Linnaeus (1707-1778). A.L. de Jussieu for the first time delineated a family for orchids in 1789. Olof Swartz in the late 18th century recognized orchids as a special group of plants and John Lindley (1799- 1865), gave the family its present name- Orchidaceae.

The oldest record of orchids in India is by **Charak**, who in A.D.100 in his classical book on herbal medicines- ‘*Charak Samhita*’ mentioned medicinal properties of various indigenous herbs including ‘**Vanada**’- a vandaceous plant and several other which are very much similar to present day genera like, *Flickingeria*, *Malaxis*, *Eulophia*, etc. But the first scientific account of Indian Orchids came through in the 17th century by van Rheed, the then Dutch Governor of Malabar in his classical work ‘*Hortus Malabaricus*’ (1635-1691). Rheed for the first time described and illustrated a number of orchid species and also the genera like *Acampe*, *Bulbophyllum*, *Cymbidium*, *Dendrobium*, *Eulophia*, *Liparis*, *Malaxis*, *Rhynchostylis*, *Vanda*, etc. from Malabar region of India. The genus *Cymbidium*, *Rhynchostylis* were later described by Linnaeus (1753) based on the illustrations / plates provided by van Rheed. Linnaeus (1753) included 12 species of Indian orchids in his ‘*Species Plantarum*’. William Roxburgh, 1832; Griffith, 1851; Lindley, 1857, 1858; Atkinson, 1882 and several others subsequently made valuable contributions to the Indian Flora including orchids.

After the establishment of Botanical Survey of India in 1890 with Sir George King as its founder Director, at Royal Botanic Garden, Calcutta (now Indian Botanic Garden, Shibpur, Howrah) the studies on the Indian flora gained significant momentum. George King and Robert Pantling (1898) brought out their classical work ‘*The Orchids of Sikkim Himalayas*’. J.F. Duthie (1906), who was posted at the Saharanpur Botanic Garden published ‘*The Orchids of North-Western Himalaya*’. Several other contemporary workers like, Prain, 1903 (Bengal); Cook, 1908 (Presidency of Bombay); Rao, 1914 (Travancore); Fyson, 1914 (Nilgiri & Pulney hilltops); Haines, 1924 (Bihar & Orissa); Gamble, 1925; Bruhl, 1926 (Sikkim Himalaya); Fischer, 1928 (Presidency of Madras) & 1938 (Lushai hills) etc. published regional floras, which also contributed significantly towards the knowledge of orchids of these regions. But the most

significant contribution to the study of Indian orchids was made by Sir J. D. Hooker who described about 1600 species of orchids from the erstwhile British India in his '**Flora Of British India**' (1872 – 1897) and '**A Century of Indian Orchids**' (1895). Subsequent to these works, the taxonomical studies suddenly came to a halt for quite some time, which were revived again after the reorganization of Botanical Survey of India in 1954. The studies conducted by Botanical Survey of India contributed significantly towards knowledge of Indian flora but comprehensive studies on orchids were lacking. In recent years, a large number of publication dealing with detailed accounts of orchids of different phytogeographical regions/ states like, Meghalaya (Kataki, 1986), North-West Himalaya (Deva & Naithani, 1986), Kerala -check-list of orchids (Kumar & Sasidharan, 1986), Manipur (Ghatak & Devi, 1986), Nilgiri (Joseph, 1987), Arunachal Pradesh (H.J. Chowdhery, 1998), Mizoram (Singh et al., 1998), Nagaland (Hynniewata et al., 2000), Kamrup (Barua, 2001), Sikkim & North-East India (Lucksom, 2007) have been brought out making significant contribution to the existing knowledge of Indian orchids. Apart from these publications on the orchid wealth of different regions of India, the census of Indian orchids (guess estimates) has also been attempted from time to time by different workers like U.C.Pradhan (1976, 1979); Bose & Bhattacharyya (1980); Abraham & Vatsala (1981); Jain & Mehrotra (1984); Karthikeyan et al. (1989); Sathish Kumar & Manilal (1994), etc. According to S. Misra (2007),. At present the family Orchidaceae in India is represented by about 186 genera and 1331 species, although after S.Misra (2007), a number of new species and new records of orchid taxa have been discovered and added to the orchid flora of India.

India, with a total geographical area of about 32,87,263 sq. km of which, about 633,397 sq. km (19.27%) is covered by forests. Despite being situated in the subtropical zone, the major part of India experiences typical tropical monsoon climate. The Himalayan ranges in the north play a very important role in governing the climatic conditions. The great variety of climatic conditions and topography has given rise to an extremely wide range of habitat types. The extreme diversity of habitat types is mainly responsible for the development of an enormous Biodiversity. The Indian region though covers only about 2% of the world's land area it harbors about 11% of the world's known flora. As a result, the Indian region is considered one of the most diverse biographic regions of the world, harboring about 47,500 species of flora, about 89000 species of fauna and an equally rich marine life. Out of this estimated 47,500 plant species, angiosperms accounts for about 18043 species including a rich orchid flora.

In India, the family Orchidaceae is widely distributed from alpine to coastal regions and islands but the maximum diversity of orchids occurs in the Himalaya particularly the eastern Himalayas and Peninsular regions respectively. According to S. Misra (2007), there are 186 genera and 1331 species of orchids in India.

A habitat study of the orchid species occurring in India reveals that more than 65 % species grow on tree trunks and branches as epiphytes and are abundant up to an altitude of 2000m while, remaining are terrestrial, which are generally confined to temperate zone, growing in open grass lands, forest floors, alpine meadows or as lithophytes or even grow as saprophytes or mycoheterotrophic.

Distribution of Orchids in India

Based on the altitude, the orchid distribution in India can be categorized into the following 4 zones but many species overlap these zones:

1-Tropical Zone (from sea- level to 1000 m): It has two distinct sub-zones –

a) Extending from sea level up to about 500m, this region has lesser rain fall and the summer temperature in many places reaches as high as 40 C which is not suitable for orchids. However areas having sufficient rainfall have forests, which provide conditions for the growth of few selected orchid species. Few terrestrial forms like species of *Arundina*, *Calanthe*, *Nervilia*, etc. can be seen growing in open grassy places or under forest cover. Epiphytes such as species of *Acampe*, *Aerides*, *Papilionanthe*, *Rhynchostylis*, *Cymbidium*, *Pholidota*, *Luisia*, *Vanda*, etc. are seen on the tree trunks of the forests.

b) Lying between 500 to 1000 m, this region in most of the places receives normal to heavy rainfall and supports tropical humid dense forests. A large number of epiphytic orchids can be seen growing on the forest trees of which species of *Bulbophyllum*, *Dendrobium*, *Coelogyne*, *Eria*, *Luisia*, *Pholidota*, *Aerides*, *Ascocentrum*, *Papilionanthe*, *Rhynchostylis*, etc. are predominant. In addition, a number of terrestrial and saprophytic forms occur on the moist shady, humus rich forest floors or in open grassy places.

2- Subtropical Zone (from 1000 to 2000 m):

This zone receives lesser rain and supports mixed forests comprising of tall and medium sized trees forming dense canopy through which little light penetrates. The relative humidity is very high reaching as up to 100% during rainy season. The summer temperature varies between 25 to 30 C during day and 18 to 20 C during night. The winter season is cool and dry having 15 to 20 C day temperature which falls up to 10 C at night and the precipitation in the form of dew during night and early morning is common. The

tree trunks and rocks are mostly covered with thick moss cover providing very suitable conditions for the growth of a rich orchid flora. These forests abound in epiphytic species of which species of *Aerides*, *Acampe*, *Bulbophyllum*, *Dendrobium*, *Eria*, *Coelogyne*, *Oberonia*, *Papilionanthe*, *Liparis*, *Cymbidium*, *Cleisostoma*, *Luisia*, *Flickingeria*, *Pholidota*, *Vanda*, etc. are most commonly occurring forms many of which prefer open, sun exposed areas, some partially exposed while many prefer densely shaded areas. Apart from the epiphytes, a large number of terrestrial orchids are also found growing on the moist, shaded forest floors in this zone of which *Phaius*, *Anoectochilus*, *Calanthe*, *Nervilia*, *Thunia*, *Malaxis*, *Habenaria*, *Paphiopedilum*, *Arundina*, *Zeuxine*, etc. are the most dominant ones. In addition, saprophytic orchids like *Epipogium*, *Galeola* species are also found in this zone. The rare Blue Vanda -*Renanthera imschootiana* is known to occur in this zone.

3- Temperate Zone (from 2000 to 3500 m):

This zone has cool climate and the region above 2800 m generally experiences snowfall during winter months and often remains covered with snow for 3-4 months. The winter temperature varies around 10 C whereas summer temperature generally ranges between 18- 20 C. The humidity is high and ranges from 80 to 100% and fog and mist are of common occurrence. The forests in this zone are dominated by species of *Quercus*, *Magnolia*, *Rhododendron* and a number of gymnospermous species of *Pinus*, *Larix*, *Tsuga*, etc. The tree trunks and their branches are densely covered with thick mossy layer providing very congenial conditions for epiphytic orchids. Some of the common species found in this zone are that of- *Aerides*, *Ascocentrum*, *Bulbophyllum*, *Dendrobium*, *Oberonia*, *Coelogyne*, *Cymbidium*, *Otochilus*, *Pleione*, *Gastrochilus*, *Eria*, *Vanda*, etc. while *Calanthe*, *Epipactis*, *Malaxis*, *Cypripedium*, *Dactylorhiza*, etc. are some prominent terrestrial genera of this zone.

4- Alpine Zone (from 3500 to 5000 m):

Situated in the high Himalayan ranges, this zone experiences severe cold condition and is covered with snow for about 5-6 months during the year. The trees are very rare or absent in this zone and the climatic conditions do not support any epiphytic growth and only few terrestrial species are found growing in this zone such as species of *Cypripedium*, *Habenaria*, *Herminium*, *Dactylorhiza*, etc.

In India although the orchids are distributed throughout from the Himalayan region to Andaman and Nicobar islands, but the maximum species diversity has been observed in the following four regions:

I- Himalayan Region:

a- Eastern Himalaya:

Eastern Himalayan region which is also known as the 'Cradle of Flowering Plants' (Takhtajan, 1969) includes seven north-eastern states namely- Arunachal Pradesh, Assam, Maghalaya, Mizoram, Manipur, Nagaland and Tripura; Sikkim and Darjeeling district of West Bengal is a distinct phytogeographical region which has the highest floristic diversity in the Indian subcontinent. This region with higher precipitation is more humid and is far richer in species diversity and endemic elements than its Western Himalayan counter part. The region is dominated by broad-leaved elements like, oaks, rhododendrons, magnolias, laurels, tree ferns, orchids, etc. The warm humid climate, high rainfall and dense forests offer most favorable condition for the growth and development of a rich and diverse orchid flora and it is not surprising to note that about 900 orchid species find shelter in this region. *Bulbophyllum*, *Dendrobium*, *Eria*, *Habenaria*, *Coelogyne*, *Cymbidium*, *Oberonia*, *Liparis*, *Calanthe*, etc. are some of the most dominant genera and as many as 56 genera viz., *Acrochaene*, *India*, *Rhomboda*, *Risleya*, *Acriopsis*, etc. are restricted to Eastern Himalayan region. Eight of the nine species of lady's slipper orchid *Paphiopedilum* known from India are confined to this region except *P. druryi*, which is endemic to Western Ghats. Out of the 8 states falling under Eastern Himalaya, Arunachal Pradesh has the highest number of more than 630 orchid species followed by Sikkim and Meghalaya respectively.

b- North-Western Himalaya:

Western Himalayan region, which spreads over from Uttaranchal (Kumaon & Garhwal) up to Jammu & Kashmir characteristically differs from Eastern Himalaya in having cool dry climate and less rain fall which further decreases as one moves towards western side. This region abounds in coniferous forests not suitable for orchid growth. Based on the available data it is seen that about 300 species of orchids are found here of which the genus *Habenaria* is the most dominant followed by *Bulbophyllum*, *Dendrobium*, *Eulophia*, *Eria*, *Herminium*, *Liparis*, etc. Genera like *Archineottia*, *Coeloglossum*, *Hemipilia*, etc. are confined to this region only.

II- Peninsular Region:

This region is comprised of Eastern and Western Ghats, Madhya Pradesh, Andhra Pradesh, Gujrat, Gangetic plains, etc. Out of these the Western Ghats, recognized as one of the 18-mega diversity Hot-Spot area of the world, with high rain-fall and high humidity has dense moist and dry deciduous forests, tropical evergreen forests supporting a highly diverse and rich flora having a large number of

endemic species. The warm humid climate coupled with high degree of rain fall provided congenial conditions for the growth of orchids and more than 390 species of orchids are reported from the Peninsular region. Habenaria is reported to be the largest genus in order of dominance and is followed by *Oberonia*, *Dendrobium*, *Bulbophyllum*, *Liparis*, *Eria*, *Eulophia*, *Peristylus*, *Luisea*, etc. Genera like *Aenhenrya*, *Disperis*, *Diplocentrum*, *Sirhookera*, *Seidenfadeniella*, *Smithsonia*, *Taprobanea*, *Xenikophyton*, etc. are restricted only to this region.

III- Andaman & Nicobar Islands:

It is a group of 319 islands and islets in the Bay of Bengal. The climatic condition of these islands is mainly governed by the south- east monsoon. The heavy mist, high rainfall and the surrounding sea keeps the island forests moist round the year thus offering a favorable habitat for a luxuriant epiphytic flora including the orchids. So far nearly 120 species belonging to about 53 genera have been recorded from this region. The genus *Dendrobium* is the largest which is followed by *Eulophia*, *Bulbophyllum*, *Luisea*, *Peristylus*, *Eria*, *Aerides*, *Phalaenopsis*, *Malaxis*, etc. Genera like *Plocoglottis*, *Vrydagzynea*, *Grosourdyia* are confined only to these islands.

Phytogeography

The varied climatic conditions and habitat types prevailing in Indian region have provided an ideal and congenial niche for various floral elements migrating from the neighboring areas, as a result the present day Indian flora is an admixture of a number of taxa from Tibet, China, Myanmar, Indo- Malayan region, Central Asia, Russia, Japan, Europe, S. America, Africa, Australia, etc. Indian orchids too show close affinities with the orchid flora of neighboring countries like, Nepal, Bhutan, China, Myanmar, Bangladesh, Thailand, etc. while, a number of species have a much wider range of distribution extending up to North America, Africa, Japan, Australia, New Zealand, etc. It is interesting to note that the different Indian regions show similarity with other neighboring and far separated countries in floral composition. The Himalayan region is the meeting place of different floral elements of several neighboring countries. As a result the orchid flora of this region also has much higher number of genera and species as compared to other regions of the country. Due to this intermixing of floral elements from the neighboring countries, the percentage (%) of endemism in this region is fairly low. Studies so far conducted by various workers has shown that in the Himalayan region the tropical zone possess a large number of Malaysian elements, the subtropical zone has many elements common to China while its temperate zone has species common with European region. *Herminium monorchis* found in North Sikkim at an altitude of 4500 m

(the highest distributional limit of orchid in India) is also widely distributed throughout Europe. The monotypic genera like *Bulleyia*, *Risleya*, and *Didicia*, which occur in the Himalayan region have been found extended up to China.

Based on the higher percentage of endemic orchid species present it may be concluded that the true Indian flora exists only in the Peninsular region. This region has a number of genera like *Ipsea*, *Sirhookera*, *Diplocentrum*, *Cottonia*, *Seidenfadeniella*, *Taprobanea*, common with Sri-Lanka, while the presence of orchids like *Spiranthes sinensis*, *Satyrum nepalensis* relates the orchid flora of this region with that of Himalayas. Even truly African elements like *Disperis* and *Brachycorythis* are also known to occur in the Peninsular region. Andaman & Nicobar islands which lies close to Burma (Myanmar) and Sumatra respectively have many species common with Myanmar, Thailand, Malaysia, Sumatra and Java. These islands though share a number of species common with the main land (India) but the genera like- *Grosourdyia*, *Macropodanthus*, *Plocoglottis* and *Malleola* are restricted to the islands only.

Table-1. Distribution of orchids in India

S.No	States	Total Number of	
		Genera	Species
1	Andaman & Nicobar Islands	66	143
2	Andhra Pradesh	33	67
3	Arunachal Pradesh	128	624
4	Assam	81	191
5	Bihar (including Jharkhand)	36	100
6	Goa, Daman and Diu	18	29
7	Gujarat	10	25
8	Haryana	3	3
9	Himachal Pradesh	44	85
10	Jammu and Kashmir	27	51
11	Karnataka	52	177
12	Kerala	77	230
13	Madhya Pradesh (including Chattisgarh)	34	89
14	Maharashtra	34	111
15	Manipur	69	249
16	Meghalaya	98	352
17	Mizoram	75	249
18	Nagaland	63	241
19	Orissa	48	130
20	Punjab	12	21
21	Rajasthan	6	10
22	Sikkim	138	557
23	Tamil Nadu	67	199
24	Tripura	33	48
25	Uttanchal	72	243
26	Uttar Pradesh	19	30

Table 2. Ten dominant genera of orchids in India-

	115
<i>Bulbophyllum</i>	100
<i>Oberonia</i>	65
<i>Habenaria</i>	67
<i>Eria</i>	60
<i>Liparis</i>	51
<i>Coelogyne</i>	42
<i>Calanthe</i>	32
<i>Peristylus</i>	30
<i>Cymbidium</i>	23
<i>Eulophia</i>	23

Monotypic orchid genera in India

A number of genera are monotypic being represented by only one species (Table 3).

Table 3. Monotypic Orchid Genera in India

S. No.	Genus	Distribution in India
1	<i>Acrochaene</i> Lindl.	Eastern Himalaya
2	<i>Aenhenrya</i> Gopalan	Peninsular India
3	<i>Anthogonium</i> Wall. ex Lindl.	Himalayan region
4	<i>Arundina</i> Blume	Himalaya and Peninsular India
5	<i>Bulleyia</i> Schltr.	Eastern Himalaya
6	<i>Cottonia</i> Wight	Peninsular India
7	<i>Dickasonia</i> L.O. Williams	Eastern Himalaya
8	<i>Didicicia</i> King & Pantl.	Himalayas
9	<i>Eriodes</i> Rolfe	Eastern Himalaya
10	<i>Herpysma</i> Lindl.	Eastern Himalaya
11	<i>Hygrochilus</i> Pfitz.	Eastern Himalaya
12	India A.N. Rao	Eastern Himalaya 13
13	<i>Jejosephia</i> A.N. Rao & Mani	Eastern Himalaya
14	<i>Lusiopsis</i> Sath.Kumar & Suresh	Eastern Himalaya
15	<i>Neogyne</i> Rchb.f.	Eastern Himalaya
16	<i>Odisha</i> S.Misra	Peninsular India
17	<i>Ornithochilus</i> (Lindl.)Benth.	Himalayas
18	<i>Risleya</i> King & Pantl.	Eastern Himalaya
19	<i>Stereosandra</i> Blume	Eastern Himalaya
20	<i>Taprobanea</i> E. Christ.	Peninsular India
21	<i>Thecostele</i> Rchb.f.	Eastern Himalaya

The scrutiny of the available literature reveals that *Arundina graminifolia* popularly known as the Bamboo orchid is the most commonly occurring species distributed throughout the country. It is also noticed that the majority of monotypic species are confined to Eastern Himalaya, the genus *Didicicia* occurs both in Eastern and Western Himalaya while, the newly discovered genus *Xenikophyton* is confined only to the Peninsular region of India.

Saprophytic (mycoheterotrophic) orchids

Besides normal terrestrial species there are certain orchids, which lack chlorophyll and thus lead a saprophytic life (Table 4). The mycorrhizal fungi present in the orchid roots of these orchids help in digesting dead organic material in the absence of chlorophyll.

Table 4. Saprophytic (Mycoheterotrophic) Orchid Genera in India

S.No.	Genus	No. of Species
1	<i>Aphyllorchis</i> Blume	3
2	<i>Chamaegastrodia</i> Makino & Maekawa	2
3	<i>Corallorhiza</i> Rupp. ex Gagnep.	1
4	<i>Crepidium</i> Blume	2
5	<i>Cyrtosia</i> Blume	1
6	<i>Cymbidiopsis</i> H.J.Chowdhery	1
7	<i>Didymoplexis</i> Griffith	3
8	<i>Epipogium</i> Gmelin ex Borkhausen	6
9	<i>Erythrorchis</i> Blume	1
10	<i>Eulophia</i> R.Br. ex Lindl.	1
11	<i>Evrardianthe</i> Rauschert	1
12	<i>Galeola</i> Lour.	6
13	<i>Gastrodia</i> R. Br.	7
14	<i>Lecanorchis</i> Blume	1
15	<i>Neottia</i> Guettard	3
16	<i>Odontochilus</i> Blume	1
17	<i>Risleya</i> King & Pantl.	1
18	<i>Stereosandra</i> Blume	1
19	<i>Yuania</i> Maximowicz	2

Endemism

Studies conducted so far have revealed that 33.5% of the Indian flora is endemic. The three main centers of endemism in India are Eastern Himalaya, Western Ghats and Western Himalaya. The family Orchidaceae shows high degree of endemism and it is estimated that as many as 35% species of orchids are endemic (this includes newly described species also) and Peninsular India, Eastern Himalaya and North- Eastern region exhibit the highest degree of endemism in the family as compared to other parts of the country. A number of orchid genera like- *Cleisocentron* Bruh., *Diplomeris* D.Don, *Diplocentrum* Lindl., *Cryptochilus* Wall., *Aenhenrya* Gopalan, *India* A.N.Rao, *Jejosephia* A.N.Rao & Manilal, *Odisha* S. Misra, *Smithsonia* Saldanha, *Xenikophyton* Garay, etc. are endemic to India. A scrutiny of the available data and literature shows that the maximum number of endemic species are found in the Peninsular region specially the Western Ghats followed by Eastern Himalaya and Andaman & Nicobar islands. It is interesting to know that although the orchid species diversity in Peninsular region is much less than the Eastern Himalayan region, the % of endemism here is very high. This may be due to the unique location of Eastern Himalayan region, which is at the junction of the Paleoarctic, Indo- Chinese, and Indo- Malayan bio-geographic regions and as a result the biotic elements from all these regions are found here thus the % of endemic elements in this region is comparatively low though the species diversity is very high. The genus *Dendrobium* has the maximum number of endemic species, followed by *Habenaria*, *Bulbophyllum*, *Eria*, *Oberonia*, *Liparis*, *Smithsonia*.

Threatened species

The multi-pronged effect of various developmental activities, indiscriminate felling of forest trees, clearing of forested areas for urbanization, agriculture and the commercial exploitation of ornamental orchids from the wild have rendered a large number of orchid species rare, endangered and even threatened with extinction. As stated earlier, the majority of orchids (more than 60 %) grow perching on tree trunks / branches, etc. as epiphyte in the tropical humid regions of the country and in the absence of a suitable host tree as a result of indiscriminate felling of tropical forests, the survival of such epiphytic species is at stake, even a large number of terrestrial and saprophytic species growing on forest floors have also become threatened due to the degradation and destruction of their habitat. A number of species which were earlier considered to have vanished from Indian region viz., *Anoectochilus rotundifolius*, *Bulbophyllum rothschildianum*, *Bulbophyllum obrienianum*, *Brachycorthis wightii*, *Corybas himalaicus*, *Cymbidium gammieanum*, *Dendrobium jerdonianum*, *Hetaeria ovalifolia*, *Ipsea*

malabarica, *Paphiopedilum druryi*, *Phaius luridus*, *Pholidota wattii*, etc. have been rediscovered after a very very long time. Species like *Anoectochilus clarkei*, *Aphyllorchis gollani*, *Calanthe pachystalix*, *Coelogyne treutleri*, *Chrysoglossum hallbergii*, *Dendrobium aurantiacum*, *Bulbophyllum acutiflorum*, *Bulbophyllum aureum*, *Bulbophyllum elegantulum*, *Bulbophyllum nodosum*, *Dendrobium tenuicaule*, *Habenaria flabelliformis*, *Liparis biloba*, *Malaxis crenulata*, *Neottia inayatii*, *Oberonia angustifolia*, *Oberonia griffithiana*, *Oberonia clarkei*, *Oberonia anthropophora*, *Oberonia lobulata*, *Oberonia platycaulon*, *Paphiopedilum wardii*, *Pleione lagenaria*, *Vanda wightii*, *Zeuxine pulchra*, etc. are so far known only from single collection and all the efforts to collect these species from their original localities have failed. These are now considered possibly extinct from the Indian region unless these are rediscovered again.

Conservation Measures

Factors responsible for depletion of orchids:

Following are the major major threats to the orchid flora:

- Urbanization
- Loss of habitat- destruction of forests (epiphytic) and over grazing (terrestrial)
- Attractive flowers
- Exploitation as Medicinal plants
- Smuggling orchid species collected from the wild by the orchid traders
- Over enthusiastic collection by students and researchers
- Natural calamities
- Non-availability of pollinators

in situ Conservation: Through Protected Areas. Sanctuaries).

In addition several international organizations

IUCN -(International Union for Conservation of Nature & Natural Resources).

SSP -(Species Survival Commission)- formulated a strategic action plan to document orchid diversity & suggest conservation strategies.

OSG -(Orchid Specialist Group)

CITES -(Convention on International Trade of Endangered Species of Wild Fauna & Flora)- Prohibits the trade of such species.

*CITES: **Appendix-I:** Any trade of species listed in Appendix-I is completely banned. A number of orchid species are placed in Appendix-I.

*CITES: **Appendix-II:** Trade is allowed through export permit only. Entire Orchidaceae family is placed in Appendix-II.

ex situ Conservation: This can be achieved through-

National and regional Orchidaria are developed by Botanical Survey of India and other public or private organizations for ex-situ conservation.

Artificial propagation methods like seed and tissue culture are developed to conserve the germplasm.

Public Awareness:

Orchidaceae, despite being such a dominant and diversified group of flowering plant in India, is under severe threat and some of the species are at the verge of extinction. This is because of the lack of awareness among the common men, about our Orchid wealth and its immense economic potential.

It is the high time to prepare a comprehensive and complete illustrated manual of Indian Orchids, which can provide information on the diversity, distribution, identification, conservation and sustainable utilization of our orchid resources.

Sustainable utilization:

- Identification of medicinally and horticultural important orchid species and study of their biology.
- Identification of the therapeutically important ingredients and set up a pharmaceutical industry.
- Setting up of artificial propagation methods to fulfill the demand of commercially important species.
- Maintain the germplasm through in-situ conserving.

The Task Ahead:

Effective conservation strategies and sustainable utilization can be made only after comprehensive and systematic documenting the biology, including morphology, correct identity and nomenclature of all Indian orchids. The orchid taxonomy has undergone vast changes in the recent years. Orchid species, which do not occur in India and many synonyms still continue to be listed as distinct species in many of the published accounts. It is therefore essential to take up Taxonomic Revision of individual genera in order to have an accurate status of orchid species in India. Under the Flora of India Project in BSI, we have undertaken and completed the revisionary studies on certain selected genera

like *Eria* (57 species with 3 varieties), *Dendrobium* (100 sp), subtribe Goodyerinae (involving 83 species belonging to 13 genera viz., *Aenhenrya*, *Anoectochilus*, *Chamaegastrodia*, *Cheirostylis*, *Erythrodes*, *Goodyera*, *Herpysma*, *Hetaeria*, *Myrmechis*, *Odontochilus*, *Rhomboda*, *Vrydagzynea* and *Zeuxine*) and the genus *Habeneria* (67sp.), *Cymbidium* (19 sp./ 3 ssp./ 1 var.), *Eulophia* (23 sp.) and *Geodorum* (4 sp.).

This can be achieved through:

- 1- Preparation of a checklist of all the taxa (with correct name or synonyms) of Orchidaceae published in Indian context.
- 2- All the Indian herbaria and the herbaria abroad where Indian materials are deposited should be consulted for depiction of range of variation and distribution of taxa.
- 3- Live specimen should be studied for better understanding of the morphology, for making digital illustrations and propagating them for ex-situ conservation.
- 4- Problems related to Typification and nomenclature should be solved in accordance with the latest ICBN code and by referring type and authentic specimens.
- 5- By undertaking Taxonomic revisions at tribe, subtribe or genus levels.
- 6- Avoiding repetition of work i.e. work on same taxonomic group simultaneously being carried out by various Institutes and Organizations should be avoided.

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Abstract : Biological diversity has been among the most vital and important components for the survival and well being of mankind. However, due to phenomenal increase in human population, besides, several other factors, the natural resources are depleting very fast from this planet. Estimates of total number of eukaryotic species on earth vary between 2 million to 100 million but commonly considered between 5 – 30 million with a best working estimate of 8-9 million species. Of these under 1.8 million are estimated to have been recognized. Number of plant species in the world is ca. 4,10,800 including viruses, bacteria and fungi of which number of seed plants is 2,50,000 to 2,90,000. Indian subcontinent is one of the twelve “Megadiversity Centres” of the world with 47,513 plant species including 18,043 species of flowering plants. Based on IUCN sampled Red List Index for Plant, RBG, Kew and Natural History Museum, London, one in 5 of the world’s plant species is threatened with extinction. 22% of the plant species are classed as threatened. IUCN working in over 140 countries, has devised threat categories for assessment of various species in the world for their conservation. According to 2008 list, the number of assessed species is 44,838 of which 16,988 are threatened with extinction. Earlier Red Data Books were published by IUCN for threatened species of plants and animals but now Red Data Lists are prepared. Red Data Books for Indian Plants have been published by Nayar and Sastry (1987, 88, 90). CITES has kept threatened plants in Appendix-I, II and III depending on gravity of threat, for ban in international trade, which include 40 species of Indian plants. One third of Indian flora is endemic with Lauraceae having about 81% endemics.

Introduction

Biological Diversity has been among the most vital and important components for the survival and well being of mankind. The magnitude and distribution of species that exists today is a product of more than 3.5 billion years of evolution, involving speciation, radiation, extinction and more recently, the impacts of people. Estimates of total number of eukaryotic species existing on earth today vary greatly from 2 million to 100 million but commonly considered between 5 million and 30 million (May, 1992, Mace *et al.*, 2005), with a best working estimate of 8-9 million species (Chapman, 2006). Of these under 1.8 million are estimated to have been recognised (Groombridge and Jenkins, 2002; Chapman, 2006). Number of recognized plant species in the world is c. 410,800 including viruses, bacteria and fungi, of which estimates of seed plants vary from 250,000 to 290,000. In India, total number of plant species recognized, are 47,513 including 18,043 species of flowering plants (Paramjit Singh and Dash, 2014).

Threat

Global analysis of extinction risk for the world’s plants, conducted by Royal Botanic Gardens, Kew, together with Natural History Museum, London and IUCN revealed that one in five of the world’s plant species is threatened with extinction. They worked on IUCN Sampled Red List Index for Plants. c. 33% of the sampled species are insufficiently known to carry out a conservation assessment. Over 1/5 (22%) of the plant species assessed are classed as Threatened. Plants are more threatened than birds and as much as mammals. Gymnosperms are the most threatened

plant group with 52% cycads threatened. The most threatened habitat is tropical rain forest. Most threatened plant species belong to the tropics while the most threatening process is man-induced habitat-loss, mostly conversion of natural habitats for agriculture or livestock use.

Endemism

Confinement of a taxonomic unit, a species, a genus or other groups of plants in terms of distribution within a small geographic area, which is isolated by geographical or temporal barriers, is called endemism. Endemic species have been considered to be relics of the larger groups of organisms of the past (Ridley, 1922).

According to present concepts endemics are classified as:

Palaeoendemics: Which are taxonomically isolated, show no variation and occur in isolated refugia.

Schizoendemics: Which are produced by gradual speciation having common origin, but isolated in different ecological niches. They usually have identical chromosomes.

Patroendemics: Parent endemics, *i.e.*, diploids which give rise to polyploids.

Apoendemics: Which are polyploids, usually of hybrid origin, arising from widely distributed diploids.

In modern usage the terms *Palaeoendemics*, *Neoendemics* and *Holoendemics* are widely used:

Palaeoendemics: These are ancient endemics representing remnants of older floras and usually occurring in land masses of geological antiquity. A large number of endemics are supposed to be palaeoendemics or their derivatives. According to Bramwell (1972) they are characterized by (i) taxonomically isolated complements having no closely related species. (ii) Presence of woody life forms in isolated taxa occurring in islands and mountain summits (iii) low level of polyploidy (iv) major disjunction in the distribution and (v) possible fossil evidence.

Neoendemics: These are newly evolved endemic taxa of relatively recent origin possibly from an actively evolving genetic stock occurring in a particular ecotone. They have closely related taxa occurring in the same area. They also develop through speciation. Polyploidy is common and is stronger in herbaceous perennials (Stebbins, 1938). They generally have herbaceous and shrubby forms and occur in an area which is often subject to environmental or climatic stresses. They develop due to mutation, chromosomal re-arrangements, polyploidy, adaptive radiation, and variance in a new environment having climatic and edaphic stresses.

Holoendemics: This is an intermediate stage between neoendemics and palaeoendemics. All endemics

start as neoendemics and end as palaeoendemics. Under favourable conditions neoendemics stabilize and diversify. This is the stage of holoendemics. The pathway of neoendemics becoming palaeoendemics involves origin, expansion, stabilization, diversification, migration, fragmentation, contraction and extinction. There is no time scale for this pathway and taxa pass along the evolutionary pathway at different rates and a holoendemic could only be one step removed from the ancestor of the group, *i.e.*, have a few advance or 'derived' characters, while a contemporaneous role would be many steps removed, with numerous, such characters (Richardson, 1978).

Sometimes a term '*pseudoendemics*' is applied to a mutant species that fails to get naturally selected for speciation.

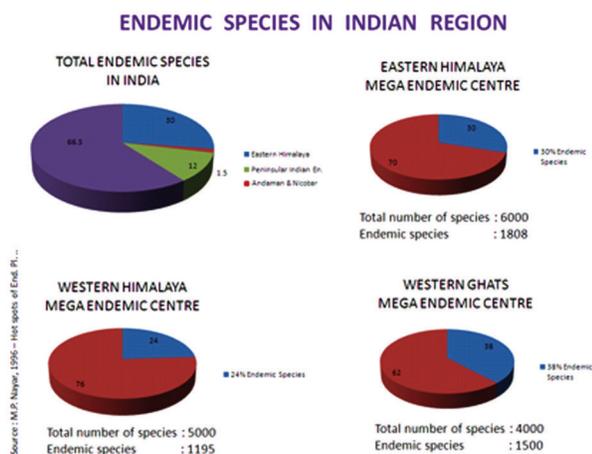
Endemics can also be, Point, Biotype, Biogeographic Region, Political Area or Regional depending upon the space occupied.

Endemic species being restricted to a limited area are sometimes also vulnerable to ecological threats caused by various reasons. Chatterjee (1940) pioneered the work on endemism in the Indian context. According to him "British India" had 133 endemic genera of flowering plants and approximately 61.5% of Indian flora is endemic.

Important Centers of Plant Endemism in India

Sl. No.	Name of the centre	State wise location
1	Trans-Himalayan Cold Desert and Western Himalayan region	Jammu & Kashmir, Himachal Pr.
2	Garhwal-Kumaon Himalaya	Uttarakhand
3	Eastern Himalaya	Sikkim, Arunachal Pradesh.
4	North-eastern region	Meghalaya, Assam, Nagaland, Manipur, Tripura, Mizoram.
5	Aravalli hills	Rajasthan.
6	Panchmarhi-Satpura-Bastar region	Madhya Pradesh.
7	Chotanagpur plateau	Bihar.
8	Simlipal Jeypore hills	Orissa.
9	Eastern Ghats	Andhra Pradesh, Tamil Nadu.
10	Western Ghats	Maharashtra, Karnataka, Kerala.
11	Saurashtra-Kutch region	Gujarat.
12	Andaman and Nicobar Islands	Andaman & Nicobar.

Endemic species in Indian Region (Nayar, 1996)



Number and Percentage of Endemic Plants of India (Singh *et al.*, 2013)

Taxon	No. of species	% Endemics
Bryophytes	2504	25.1
Pteridophytes	1265	3.7
Gymnosperms	741	0.8
Angiosperms	17926	22.5

Families with high degree of endemism in India (Nayar, 1996)

Family	Total No. of taxa	Total Endemic taxa	Percentage of Endemics
Poaceae	1205	376	31.2%
Fabaceae	1152	298	25.9%
Orchidaceae	1100	259	23.5%
Asteraceae	1052	390	37.0%
Rubiaceae	500	205	41.0%
Cyperaceae	446	108	24.2%
Labiatae	420	109	25.0%
Acanthaceae	380	224	58.9%
Scrophulariaceae	354	87	24.5%
Rosaceae	250	182	72.8%
Umbelliferae	209	165	78.8%

Liliaceae	203	114	55.6%
Ranunculaceae	180	135	75.0%
Balsaminaceae	180	123	68.3%
Ericaceae	168	80	47.6%
Primulaceae	165	80	48.4%
Lauraceae	163	133	80.9%

Families of Himalaya with high degree of Endemism

Family	Total taxa	Total endemic taxa	%
Berberidaceae	79	77	98.7%
Saxifragaceae	117	108	92.3%
Ranunculaceae	180	131	72.7%
Rosaceae	250	176	70.4%
Umbelliferae	209	144	68.8%
Caryophyllaceae	121	79	65.3%
Gentianaceae	147	84	57.1%
Primulaceae	165	80	48.4%
Lauraceae	163	78	47.9%

Families of Peninsular India with high degree of Endemism

Family	Total taxa	Total endemic taxa	%
Melastomataceae	81	46	56.7%
Balsaminaceae	80	80	44.4%
Acanthaceae	380	146	38.6%
Asclepiadaceae	209	67	32.4%
Rubiaceae	500	150	30.0%
Lauraceae	163	43	26.3%

Endemic Genera of the Himalaya

(Including those extending to N. E. India)

1. *Aechmanthera* Nees (Acanthaceae) 3 spp. of small shrubs; temp, Himalaya.
2. *Arcyosperma* Schulz (Cruciferae) 1 sp. of leafy herbs; W.Himalaya.
3. *Biswarea* Cogn. (Cucurbitaceae) 1 sp. of scandent herb; E. Himalaya

4. *Brachycaulos* Dixit et Panigrahi (Rosaceae) 1 sp. E. Himalaya
5. *Brachystemma* D. Don (Caryophyllaceae) 1 sp. of branching subscaudent herbs; C & E. Himalaya.
6. *Bryocarpum* Hook.f. & Thoms. (Primulaceae) 1 sp. of scapigerous herbs; E. Himalaya.
7. *Catamixis* Thoms. (Asteraceae) 1 sp. of erect undershrub; W. Himalaya.
8. *Cautleya* Royle (Zingiberaceae) 5 spp. of herbs; E. Himalaya
9. *Cavea* W. W Smith & Small (Asteraceae) 1 sp. of herbs; E. Himalaya.
10. *Chionocharis* I. M. Johnston (Boraginaceae) 1 sp. Of herbs; Alpine Himalaya.
11. *Cleisocentron* Bruhl (Orchidaceae) 1 sp. of epiphytic herbs; E. Himalaya & Assam.
12. *Cortia* Hook.f. (Umbelliferae) 1 sp of herbs; Himalaya.
13. *Craniotome* Reichb. (Labiatae) 1 sp. of herbs; temp, Himalaya.
14. *Cryptochilus* Wall. (Orchidaceae) 2 spp. of epiphytic herbs; temp, Himalaya.
15. *Cyathopus* Stapf (Poaceae) 1 sp. of herbs; E. Himalaya.
16. *Didicicia* King & Prain (Orchidaceae) 1. sp. of herbs; Himalaya.
17. *Diplomeris* D. .Don (Orchidaceae) 3spp.of herbs; Himalaya
18. *Drimycarpus* Hook.f.(Anacardiaceae) 1 sp. of trees; E. Himalaya.
19. *Edgaria* C.B. Clarke (Cucurbitaceae) 1 sp. of scandent herbs;E. Himalaya.
20. *Eskemukherjea* Malick & Sen Gupta (Polygonaceae) Monotypic.
21. *Eriophyton* Benth. (Labiatae) 1 sp. of herbs; Alpine Himalaya.
22. *Esmeralda* Reich. f. (Orchidaceae) 3. spp. of epiphytic herbs; E. Himalaya.
23. *Kashmiria* D. Y. Yong (Scrophulariaceae) 1 sp. of herbs; W. Himalaya
24. *Hemiphragma* Wall. (Scrophulariaceae) 1 sp. herbs; temp Himalaya & Assam.
25. *Indofevillea* Chatterjee 1 sp. of woody climbers; Assam.
26. *Ischnochloa* Hook.f. (Poaceae) 1 sp.of herbs; W. Himalaya.
27. *Kedarnatha* P. K. Mukh. & Const. 1 sp. of herbs; W. Himalaya
28. *Jejosephia* A.N. Rao & Mani. 1 sp.; N.E. India.
29. *Keraymonia* Cauwet- Mare & Farille (Umbelliferae) spp. NepalHimalaya.
30. *Jaeschkea* Kurz (Gentianaceae) 3 spp. of herbs; Himalaya.
31. *Lacaitaea*. Brand (Boraginaceae) 1 sp. of undershrub; E. Himalaya
32. *Lepidostemon* Hook.f. & Thoms. (Cruciferae) 1 sp. of herbs; E. Himalaya.
33. *Leptocodon* Lem. (Campanulaceae) 1 sp. of twining herbs; E. Himalaya.
34. *Listerobanthes* Bremek.: (Acanthaceae) 1 sp. of shrubs; E. Himalaya & Assam.
35. *Meeboldia* H. Wolff. (Umbelliferae) 1 sp; of herbs; W. Himalaya.
36. *Megacodon* (Hemsl.) H. Smith (Gentianaceae) 1 sp. of shrubs; Himalaya.
37. *Micholitzia* NE Br. (Asclepidaceae) 1sp. of climbers; Assam.
38. *Microschoenus* C. B. Clarke (Cyperaceae) 1 sp. of herbs; W. Himalaya.
39. *Milula* Prain (Alliaceae) 1 sp. of herbs; E. Himalaya.
40. *Neoluffa* Chakrav. 1 sp. of scandent herbs; E. Himalaya.
41. *Notochaete* Benth. (Labiatae) 1 sp. of herbs; E. Himalayas.
42. *Parajaeschkea* Burkill (Gentianaceae) 1 sp. of herbs; E. Himalaya.
43. *Parakaempferia* Rao & Verma (Zingiberaceae) 1 sp. of herbs; Assam.
44. *Paroxygraphis* W W Smith (Ranunculaceae) 1 sp. of herbs; E. Himalaya.
45. *Parrotiopsis* (Neid) Schmeid (Hamamelidaceae) 1 sp of small trees; W. Himalaya.
46. *Pauia* Deb & Dutta (Solanaceae) 1 sp. of herbs; E. Himalaya.
47. *Pedinogyne* Brand (Boraginaceae) 1 sp. of herbs; E. Himalaya.

48. *Pentabothra* Hook.f. (Asclepiadaceae) 1 sp. of herbs; Assam.
49. *Picrorhiza* Royle ex Benth. (Scrophulariaceae) 2 spp. of herbs; W. Himalayas.
50. *Platystemma* Wall. (Gesneriaceae) 1 sp. of herbs; temp. W. Himalaya.
51. *Pleuropermopsis* C. Norman (Umbelliferae)
52. *Polysolenia* Hook.f. (Rubiaceae) 1 sp. of undershrubs; E. Himalaya.
53. *Polyura* Hook.f. (Rubiaceae) 1 sp. of herb; E. Himalaya.
54. *Pottingeria* Prain (Escalloniaceae) 1 sp. of undershrub; N. E. Himalaya (Nagaland)
55. *Pseudaechmanthera* Bremek. (Acanthaceae) 1 sp. of shrubs; Himalaya
56. *Pseudodanthonia* Bor & C.E. Hubbard (Poaceae) 1 sp. W. Himalaya.
57. *Pseudostachyum* Munro (Poaceae) 1 sp. of shrubby plants; E. Himalaya.
58. *Pteracanthus* (Nees) Bremek (Acanthaceae) 20 spp of shrubs; Himalaya
59. *Pycnoplithus* O. E. Schulz (Cruciferae) 1 sp. of herb; Himalaya.
60. *Roylea* Wall. (Labiatae) 1 sp. of undershrub; Himalaya.
61. *Sempervivella* Dunn (Crassulaceae) 4 sp. of herbs; W. Himalaya.
62. *Smithiella* Dunn. (Urticaceae) 1 sp. of herbs; E. Himalaya.
63. *Stilbanthus* Hook.f. (Amaranthaceae) 1 sp. of woody climbers; E. Himalaya.
64. *Stiptanthus* (Benth.) Briq. (Labiatae) 1 sp. of herbs; E. Himalaya.
65. *Sympagis* (Nees) Bremek. (Acanthaceae) 5 spp. of shrubs; E. Himalaya.
66. *Tarphochlamys* Bremek. (Acanthaceae) 1 sp. of undershrub; E. Himalaya & Assam
67. *Theropogon* Maxim. (Liliaceae) 1 sp. of herbs; temp. Himalaya.
68. *Thomsonia* Wall. (Araceae) 2 sp. of herbs; Himalaya.
69. *Treutlera* Hook.f. (Asclepiadaceae) 1 sp. of herbs; E. Himalaya.
70. *Triaenacanthus* Nees (Acanthaceae) 1 sp. of shrubs; E. Himalayas & Assam.
71. *Staintoniella* Hara (Cruciferae) 1 sp. Nepal Himalaya.

Endemic Genera of Peninsular India

1. *Aenhenrya* Gopalan (Orchidaceae) 1 sp.
2. *Anaphyllum* Schott. (Araceae) 2 spp. of tall herbs; S. W. Ghats.
3. *Ascopholis* Fisch. (Cyperaceae) 1 sp.
4. *Baeolepis* Decne ex Moq. (Periplocaceae) 1 sp. of climbing undershrubs; South W. Ghats (Nilgiri)
5. *Bhidea* Stapf. (Poaceae) 2 sp. of herbs; Northern and Southern W. Ghats
6. *Blepharistemma* Wt. ex DC. (Rhizophoraceae) 1 sp. of trees; W. Ghats, Coorg to Travancore.
7. *Bonnayodes* Blatt. & Hallb. (Scrophulariaceae) 1 sp. of herbs; north W. Ghats.
8. *Carvia* Bremek. (Acanthaceae) 1 sp. of shrubs; North W. Ghats.
9. *Chandrasekharania*, V. J. Nair et al. (Poaceae) 1 sp.
10. *Danthonidium* C. E. Hubb. (Poaceae)
11. *Decalepis* Wt. & Arn. (periplocaceae) 1 sp. of climbing shrubs; Peninsular India.
12. *Dicoelospermum* Clarke (Cucurbitaceae) 1 sp. of climbing herbs; W. Peninsular India.
13. *Diplocentrum* Lindl. (Orchidaceae) 2 spp. of epiphytic herbs; Southern W. Ghats.
14. *Erinocarpus* Nimmo ex J. Grah. (Tieliaceae) 1 sp. of trees; Central & North W. Ghats.
15. *Frerea* Dalz. (Asclepiadaceae) 1 sp. of herbs; northern W. Ghats.
16. *Gantelbua* Bremek (Acanthaceae) 1 sp. of herbs; Peninsular India.
17. *Glyphochloa* W. D. Clayton (Poaceae) 8 sp. of herbs; W. Ghats extending to Bundelkhand.
18. *Griffithella* (Tul.) Warm. (Podostemaceae) 1 sp. of herbs; w. Ghats.
19. *Haplothismia* Airy Shaw (Burmanniaceae) 1 sp. of herbs; south W. Ghats (Parambikulam hills).
20. *Helicanthes* Danser (Loranthaceae) 1 sp. of parasitic shrub; W. peninsular India (W. Ghats).

21. *Hubbardia* Bor (Poaceae) 1 sp. of delicate herbs; central W. Ghats.
22. *Hyalisma* Champ. (Triuridaceae) 1 sp. of saprophytic herbs; southern W. Ghats.
23. *Hydrobryopsis* Engl. (Podostemaceae) 1 sp. of herbs; W. & E Ghats.
24. *Indobanalia* Henry & Roy (Amaranthaceae) 1 sp. of undershrubs; southern W. Ghats.
25. *Indopoa* Bor (Poaceae) 1 sp. of herbs; W. Ghats.
26. *Indotristicha* van Royen (Podostemaceae) 1 sp. of herbs; southern W. Ghats.
27. *Janakia* Joseph & Chandrasekaran (Periplocaceae) 1 sp. of herbs ; southern W. Ghats.
28. *Jerdonia* Wt. (Gesneriaceae) 1 sp. of scapigerous herbs; southern W. Ghats.
29. *Karnataka* Mukh. et Constance (Umbelliferae) 1 sp.
30. *Kanjarum* Ramam. (Acanthaceae) 1 sp. of under shrub; southern W. Ghats.
31. *Lamprachaenium* Benth. (Asteraceae) 1 sp. of herbs; Peninsular India.
32. *Limnopoia* C. E. Hubb. (Poaceae) 1 sp. of aquatic herbs; Southern W. Ghats.
33. *Meteoromyrtus* Gamble (Myrtaceae) 1 sp. of small trees; southern W. Ghats.
34. *Moullava* (Rheede) Adanson (Caesalpinaceae) 1 sp. of scandent shrub; W. Ghats.
35. *Nanothamnus* Thoms. (Asteraceae) 1 sp. of herbs; W. Ghats.
36. *Nilgirianthus* Bremek. (Acanthaceae) 20 sp. of shrubs; W. Ghats.
37. *Normanboria* Butzin (Poaceae) 1 sp. of herbs; Tamil Nadu
38. *Ochreinauclea* Ridsd. & Bakh. f. (Rubiaceae) 1 sp. of small trees; central & south W. Ghats.
39. *Oianthus* Benth. (Asclepiadaceae) 4 spp. of twining un-dershrub; W. Ghats extending E. Ghats (*O. disciflora*).
40. *Otonephelium* Radlk. (Sapindaceae) 1 sp. of trees; southern W. Ghats.
41. *Paracautleya* R. M. Smith (Zingiberaceae) 1 sp. of herbs; Central W. Ghats.
42. *Phlebophyllum* Nees (Acanthaceae) 8 spp. of shrubs; W. Ghats & E. Ghats.
43. *Pleocaulus* Bremek. (Acanthaceae) 3 spp. of small undershrub; W. Ghats.
44. *Poeciloneuron* Bedd. (Bonnetiaceae) 2 spp. of large trees; central & southern W. Ghats.
45. *Pogonachne* Bor (Poaceae) 1 sp. of herbs; coast of Maharashtra.
46. *Polyzygus* Dalz. (Umbelliferae) 1 sp. of herbs; central & northern W. Ghats.
47. *Proteroceras* Joseph & Vajravelu (Orchidaceae) 1 sp. of herbs; southern W. Ghats.
48. *Pseudodichanthium* Bor (Poaceae) 1 sp. of herbs; north W. Ghats.
49. *Pseudoglochidion* Gamble (Euphorbiaceae) 1 spp. of trees; south W. Ghats (Anamalais).
50. *Santupaua* Balakr. & Subram. (Acanthaceae) 1 sp. of herbs; Alagar hills.
51. *Seshagiria* Ansari & Hemadri (Asclepiadaceae) 1 sp. of climbing undershrub; northern W. Ghats.
52. *Silentvalleya* V. J. Nair et. al (Poaceae) 1 sp. of herbs; southern W. Ghats. (Silent valley in Palghat)
53. *Supushpam* Suryan. (Acanthaceae) 1 sp.
54. *Taeniandra* Bremek. (Acanthaceae) 1 of undershrub, southern W. Ghats.
55. *Trilobachne* Schnek ex Henr. (Poaceae) 1 sp. of herbs; W. peninsular region.
56. *Triplopogon* Bor (Poaceae) 1 sp. of herbs; W. peninsular India.
57. *Utleria* Bedd ex Benth. (Periplocaceae) 1 sp. of shrub; southern W. Ghats.
58. *Vanasushava* Mukherjee & Constance (Umbelliferae) 1 sp of herbs; southern W. Ghats.
59. *Willisia* Warm. (Podostemaceae) 1 sp. of herb; southern W. Ghats.
60. *Xenacanthus* Bremek. (Acanthaceae) 3 spp. of shrub; southern W. Ghats.

Threatened Plants of India (Nayar, 1996)

Order/Family	Genera	Species
Lycopodiopsida		
Isoetaceae	1	3
Selaginellaceae	1	2
Pteridopsida		
Adiantaceae	1	1
Cyatheaceae	1	2
Dennstaedtiaceae	1	2
Dryopteridaceae	3	3
Gleicheniaceae	1	1
Lomariopsidaceae	1	3
Marattiaceae	1	1
Polypodiaceae	3	3
Thelypteridaceae	7	9
Woodsiaceae	2	3
Pinopsida		
Cephalotaxaceae	1	2
Pinaceae	2	3
Taxaceae	1	1
Cycadopsida		
Cycadaceae	1	1
Magnoliopsida		
Acanthaceae	18	29
Aceraceae	1	4
Order/Family	Genera	Species
Actinidiaceae	1	1
Amaranthaceae	2	2
Anacardiaceae	4	8
Annonaceae	14	26
Apocynaceae	2	2
Aquifoliaceae	1	4
Araliaceae	2	2

Aristolochiaceae	2	2
Asclepiadaceae	13	46
Balsaminaceae	1	37
Begoniaceae	1	18
Berberidaceae	2	12
Bombacaceae	1	1
Boraginaceae	5	6
Burseraceae	1	1
Campanulaceae	4	5
Capparaceae	2	8
Caryophyllaceae	6	12
Celastraceae	5	13
Chrysobalanaceae	2	3
Combretaceae	1	1
Compositae	21	52
Connaraceae	2	3
Order/Family	Genera	Species
Convolvulaceae	3	6
Crassulaceae	2	3
Cruciferae	6	7
Cucurbitaceae	5	7
Dichapetalaceae	1	1
Dipterocarpaceae	4	7
Elaeagnaceae	1	1
Elaeocarpaceae	1	5
Ericaceae	2	10
Euphorbiaceae	23	31
Flacourtiaceae	2	2
Gentianaceae	3	8
Geraniaceae	1	1
Gesneriaceae	3	7
Gittiferae	4	10
Hydrangeaceae	1	1
Icacinaceae	3	3

Ixonanthaceae	1	1
Labiatae	10	25
Lauraceae	7	21
Leeaceae	1	3
Leguminosae	32	78
Lentibulariaceae	1	1
Linaceae	1	1
Loganiaceae	1	2
Lythraceae	2	7
Magnoliaceae	3	4
Malpighiaceae	1	3
Malvaceae	3	7
Melastomataceae	4	15
Meliaceae	1	2

Order/Family	Genera	Species
Menispermaceae	5	7
Moraceae	1	2
Myristicaceae	3	3
Myrsinaceae	4	8
Myrtaceae	5	25
Nepenthaceae	1	1
Olacaceae	2	2
Oleaceae	3	5
Oliniaceae	1	2
Onagraceae	1	1
Papaveraceae	3	4
Piperaceae	1	3
Pittosporaceae	1	1
Podostemaceae	4	4
Polygalaceae	1	1
Primulaceae	2	5
Proteaceae	1	2
Ranunculaceae	9	18

Rhamnaceae	1	2
Rosaceae	5	9
Rubiaceae	29	100
Rutaceae	3	3
Sabiaceae	1	1
Sapindaceae	1	1
Sapotaceae	3	7
Saxifragaceae	1	1
Schisandraceae	1	2
Scrophulariaceae	7	10
Solanaceae	2	2
Sterculiaceae	5	7
Symplocaceae	1	3

Order/Family	Genera	Species
Theaceae	3	3
Tiliaceae	1	1
Ulmaceae	1	1
Umbelliferae	12	18
Urticaceae	1	1
Valerianaceae	1	1
Verbenaceae	3	3
Violaceae	2	3
Viscaceae	2	2
Vitaceae	4	6
Liliopsida		
Alismataceae	1	1
Alliaceae	1	4
Amaryllidaceae	2	3
Anthericaceae	1	3
Aponogetonaceae	1	2
Araceae	10	33
Asparagaceae	1	4
Burmanniaceae	1	1

Order/Family	Genera	Species
Colchicaceae	1	3
Commelinaceae	7	16
Convallariaceae	4	4
Cyperaceae	7	23
Dioscoreaceae	1	6
Eriocaulaceae	1	13
Gramineae	40	69
Hyacinthaceae	4	9
Hydrocharitaceae	1	1
Iridaceae	1	2
Juncaceae	2	2
Lemnaceae	1	2
Liliaceae	2	4
Marantaceae	2	3
Orchidaceae	46	105
Palmae	11	22
Pandanaceae	1	1
Smilacaceae	1	1
Zingiberaceae	9	19
Total	573	1255

International Union for Conservation of Nature (IUCN)

IUCN was conceptualized in the congress sponsored by Sir Julian Huxley, first Director General of UNESCO, to establish a new environmental institution. It was organized in Fontainebleau, France on 5th October 1948, in which 18 governments, 7 international organizations and 107 national nature conservation organizations signed an act to create International Union for the Protection of Nature (Christofferson, 1994).

IUCN is an international organization dedicated to finding “pragmatic solutions to our most pressing environment and development challenges” (iucn.org.). It supports scientific research, manages field projects worldwide and brings governments, NGOs, United Nations agencies, companies and local communities together to develop and implement policy. IUCN is the oldest and largest global environmental network with more than 1,000 government and NGO member organizations and almost 11,000 volunteer scientists in over 160 countries. Its work is

supported by more than 1,000 professionals in 60 offices and hundreds of partners in public, NGO and private sectors globally. The IUCN headquarter is in Gland, Switzerland. The stated vision of IUCN is “a just world that values and conserves nature”. Its mission is to “influence, encourage and assist societies throughout the world to conserve nature and to ensure that any use of natural resources is equitable and ecologically sustainable”. The organization publishes the **IUCN Red List of Threatened Species** of plants and animal species which assesses their conservation status.

IUCN Red Lists and Red Data Books

International Red Data Books of the IUCN were conceived by Peter Scott in 1963, to focus the attention of all concerned on the species of plants and animals that are under threat of extinction. It is “a register of threatened wildlife that includes definitions of degrees of threat” (Fisher *et al.*, 1969). The concept was enthusiastically accepted and resulted in the production of many national and regional Red Data Books and Red Lists for a wide range of plants and animals.

IUCN Red List of Threatened Species (Red Data List)

Founded in 1964 it is the world’s most comprehensive inventory of the global surveys and conservation status of biological species. The IUCN Red List is set upon precise criteria to evaluate the extinction risk of thousands of species and subspecies. The aim is to convey the urgency of conservation issues to the publishers and policy makers and help the world community to try to reduce species extinction. The *Red Data List* for the first time published by IUCN and the Council of Europe (COE) in 1977, has been the list of rare, threatened and endemic plants of Europe which included 12,000 vascular plants falling in various threatened categories designated by IUCN Threatened Plant Committee. It was united in 1982 by COE and reassessed in 1984 during Species Survival Commission (SSC) symposium ‘**The Road to Extinction**’ (Fitter and Fitter, 1987).

The IUCN aims to have the category of every species re-evaluated every five years if possible or at least every ten years. It is done in a peer reviewed manner through Species Survival Commission Specialist Groups. IUCN Red List has been revised periodically since 1964. Its latest available version was released at Rio + 20 Earth Summit on 19th July, 2012.

The IUCN assessed a total of 63,837 species which revealed 19,817 as threatened with extinction, 3,947 “critically endangered” 5,766 as “endangered” and more than 10,000 species are listed as “vulnerable”. It has 132 species of plants and animals from India as “Critically Endangered”.

Most of earlier Red Data Books were pertaining to

animals, but Vol. 5 was concerning *Angiosperms*. In 1978 came **The IUCN Plant Red Data Book** followed by several volumes on animals. In 1998 came “1997 IUCN Red List of Threatened Plants” and in 1998 was published “*The World List of Threatened Trees*”.

Red Data Books of Indian Plants

Jain and Sastry (1984) first published The Indian Plant Red Data Book. Later, Nayar and Sastry (1987, 1988, 1990) published Red Data Books of Indian Plants in 3 volumes. Evaluation and categorization of taxa in them was done following the criteria of IUCN Plant Red Data Book (1978). Based on 1997 IUCN Red List of Threatened Plants of the World (based on 1994 criteria), Environment Information System (ENVIS) Centre of Botanical Survey of India published a ‘Red List of Threatened Vascular Plant Species in India (2003) compiled by Kameshwara Rao *et al.* According to it 7.7 percent of Indian Vascular Plants are under threat. A total of 1,236 species are listed under threat and 19 species extinct.

IUCN Red List Categories

(A) EXTINCT (EX): A taxon is Extinct when there is no reasonable doubt that the last individual has died. A taxon is presumed extinct when exhaustive surveys in known and/or expected habitat, at appropriate times (diurnal, seasonal, annual), throughout its historic range have failed to record an individual. Surveys should be over a time frame appropriate to the taxon’s life cycle and life form.

(B) EXTINCT IN THE WILD (EW): A taxon is Extinct in the Wild when it is known only to survive in cultivation, in captivity or as a naturalized population (or populations) well outside the past range. A taxon is presumed Extinct in the Wild when exhaustive surveys in known and/or expected habitat, at appropriate times (diurnal, seasonal, annual), throughout its historic range have failed to record an individual. Surveys should be over a time frame appropriate to the taxon’s life cycle and life form.

(C) CRITICALLY ENDANGERED (CR): A taxon is Critically Endangered when the best available evidence indicates that it meets any of the criteria A to E for Critically Endangered, and it is, therefore, considered to be facing an extremely high risk of extinction in the wild.

(D) ENDANGERED (EN): A taxon is endangered when the best available evidence indicates that it meets any of the criteria A to E for Endangered and it is, therefore, considered to be facing a very high risk of extinction in the wild.

(E) VULNERABLE (VU): A taxon is Vulnerable when the best available evidence indicates that it meets any of the criteria A to E for Vulnerable and it is, therefore, considered to be facing a high risk of extinction in the wild.

(F) NEAR THREATENED (NT): A taxon is Near Threatened when it has been evaluated against the criteria but does not qualify for Critically Endangered, Endangered or Vulnerable now, but is close to qualifying for or is likely to qualify for a threatened category in the near future.

(G) LEAST CONCERN (LC): A taxon is Least Concern when it has been evaluated against the criteria and does not qualify for Critically Endangered, Endangered, Vulnerable or Near Threatened. Widespread and abundant taxa are included in this category.

(H) DATA DEFICIENT (DD): A taxon is Data Deficient when there is inadequate information to make a direct, or indirect assessment of its risk of extinction based on its distribution and/or population status. A taxon in this category may be well studied, and its biology well known, but appropriate data on abundance and/or distribution are lacking. Data Deficient is, therefore, not a category of threat. Listing of taxa in this category indicates that more information is required and acknowledges the possibility that future research will show that threatened classification is appropriate. It is important to make positive use of whatever data are available. In many cases great care should be exercised in choosing between DD and a threatened status. If the range of a taxon is suspected to be relatively circumscribed, and a considerable period of time has elapsed since the last record of the taxon, threatened status may well be justified.

(I) NOTEVALUATED (NE): A taxon is Not Evaluated when it has not yet been evaluated against the criteria.

Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) – Trade of Endangered Species

The ‘Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES)’ was set up on the basic principles to control and regulate international trade of endangered species of fauna and flora which came in force during 1975. It allows the trade of species (including plants) which can withstand current rate of exploitation, but prevents illegal trade of those taxa which are facing threats to extinction. This treaty was first signed during 1973 and the Convention entered into full force on July 1, 1975. Presently it has been ratified by 145 nations who have agreed under its terms and conditions to forbid the export or import of those plant species which have been listed as endangered and also to restrict trade of those that are at the risk of endangerment. The Convention has 25 articles for easy operation to act as an effective vehicle and a tool for the member countries towards communication and implementation within and outside their territories. The Convention establishes the legal basis towards co-operation

among the member countries for the sustainable use of bio-resources (Sandison and McGough, 1994).

A CITES Plant Committee was constituted during 1988 to increase the efficiency and monitor the trade of plants within the frame work of its system. Trade of plants and animals under this Convention refers to their movement across international borders and is regulated by a permit system. Plant groups of which the exports and imports are strictly regulated under the CITES are : Orchids, Cacti, Succulents, Euphorbias, *Cyclamen*, *Galanthus*, Cycads, *Sternbergia*, most of “Tree Ferns” and many carnivorous plant species including rare taxa of medicinal and biological importance (Lange, 1998). India has also been a signatory of this convention since July, 1976. The CITES secretariat is based in Geneva, Switzerland which co-ordinates and assists the parties for implementation of convention in close collaboration with WWF, IUCN and BGCI. The CITES Plant Committee has following important roles to play for ascertaining the fundamental significance of plants in all conservation activities and ensure that it does not endanger the survival of wild populations (Simpson, 1993).

- *To increase awareness for the need to conserve the germplasm of endangered plant species.*

- *To manage the CITES regulatory machinery in order to enhance the number of endangered plant species on national lists of endangered taxa.*

- *To increase the awareness of the need for conservation of plants by educating the officials and the general public.*

- *To organize the training sessions for the officials at various levels such as custom officers directly involved to regulate such trade at national/international ports and airports all over the world.*

Presently there are about 30,000 plant species which CITES controls.

Appendix – I: Includes plant species threatened with extinction and affected by international trade (mostly including Orchids & Cacti). Trade of plants collected from wild sources for the commercial purpose is strictly prohibited. Over 300 taxa are included in this Appendix.

Appendix – II: Is a list of plants, which may not be threatened with extinction but may become so if their trade is not regulated and properly monitored (all Orchids and Cacti not included in Appendix –I). This also includes taxa similar in appearance in order to secure better control. But the trade in both collected from wild and artificially propagated plants is allowed through regulation. More than 24,500 species are included in this appendix.

Appendix-III: includes plant subject to regulation within the territory of a CITES Party and for which the co-operation of other parties is required to prevent or restrict their over exploitation from nature. International trade for such material requires an export permit from the native country that listed the species or a certificate of origin. Only six plant species so far are included in this Appendix.

Biodiversity Conservation in India

Tradition	Age-old conservation Practices	
	Conservation principles laid down by Gautama Buddha	500 B.C.
	Conservation principles outlined in Arthasastra	321-297 B.C.
Colonial	System of Reserved Forests, Indian Forest Act	1927
	Protected Areas Act	1935
Post Independence	Conservation principles in First Five Year Plan	1950
	National Forest Policy	1952
	Prevention of Cruelty to Animals Act	1960
	Wildlife (Protection) Act	1972
	Stockholm Conference on Environment and Development	1972
	National Wildlife Action plan	1973
	42nd Amendment of the Constitution of India	1976
	Ratification of CITES	1976
	Department of Environment Forest (Conservation) Act	1980
	Ratification of Ramsar Convention	1981
All India Co-ordinated Project on Ethnobiology	1982	
Ministry of Environment and Forests	1985	
Amendment of Forest (Conservation) Act	1988	
Amendment of National Forest Policy	1988	
National Cons. Str. & Pol. Stat. Env. & Dev.	1992	

Organizations and Conventions for Conservation

- ❖ World Commission on Environment & Development (WCED)
- ❖ Ramsar Convention (for Wetland Protection)
- ❖ Earth Summit (Rio de Janeiro)
- ❖ United Nations Conference on Environment & Development (UNCED)
- ❖ Convention on Biological Diversity (CBD)
- ❖ Convention on International Trade in
- ❖ Endangered Species of Wild Fauna and Flora (CITES)
- ❖ World Conservation Monitoring Centre (WCMC)
- ❖ Trade Record Analysis of Flora & Fauna in Commerce (TRAFFIC)
- ❖ WWF
- ❖ IBPGR
- ❖ Indian National Gene Bank
- ❖ TRAFFIC –India

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Keynote Address

Bioinformatics: Advancing Biotechnology for Novel Bioprocess Development

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Abstract : Environmental samples were chosen to screen industrially important bacteria. The work was focused on identification of a bacterium that has commercial potentials. The identification based on 16S rRNA gene sequencing has a higher accuracy than conventional colony based biochemical identification methods. The phylogenetic position of our isolate was explored using Neighbour-Joining analyses and distance matrix. Construction of phylogenetic tree using the Neighbour-Joining method indicated that strains are *Pseudomonas clemancea* and *Exiguobacterium* sp. PR 10.6. They have the potential to produce biosurfactant (Sekhon and Rahman, 2014) and nanoparticles (Padman *et al.*, 2014) for commercial applications.

Keywords: *Pseudomonas*, Rhamnolipid, Biosurfactant, 16S rRNA, *Exiguobacterium*, nanomaterial synthesis

Introduction

With the rapid development of computer processing power over the latter part of the 20th century emerged a new field of study: bioinformatics. Vast databases may now be searched by a computer in a fraction of the time that it would take to manually search for information. Bioinformatics is defined as “the field of science in which biology, computer science and information technology merge into a single discipline” (NCBI, 2014). This field deals with an array of activities; however Genomics (analysis of genetic data) and Proteomics (analysis of proteins) are arguably the most commonly used. The activity undertaken in the bioinformatics sessions was based on genomic analysis. Genomes of many organisms have now been sequenced. These sequences are uploaded to databases such as the NCBI and EBI. By using software such as ClustalW to compare gene sequences from two organisms, the degree of similarity can be discerned. The 16S rRNA gene is commonly used when determining evolutionary relationships between organisms. This is because it is a highly conserved region of DNA. If two organisms have a large degree of variation in their 16S rRNA sequence, more mutations can be said to have happened since the two shared a last common ancestor (LCA). This indicates that a longer time has passed since the two species diverged in evolution. A very similar 16S rRNA region suggests the LCA of two species was more recent. This information can be analysed and represented visually in a phylogenetic tree.

Materials and Methods

2.1 Phylogenetic tree for *Pseudomonas clemancea*

The bacterial sequence (16S rRNA) was analysed using BLAST software on the EBI website (EBI, 2014). To

understand the procedures to identify a microorganism from their obtained accession numbers and nucleotide sequences using the definite tools such as ENA on EBI or Blast on NCBI database. Individual identified microorganisms' FASTA sequences were downloaded and a multiple sequence alignment will be prepared to construct a phylogenetic tree that will help to understand the degree of relatedness between them. Clustal Omega on EBI was used as a tool and obtained cladogram.

2.2 Phylogenetic tree for *Exiguobacterium* sp.

The sequence assigned shown in fig. 1 was inputted on the nucleotide blast database on the NCBI website, this allowed the identification of the species, which had 100% similarity to the sequence. This strain was *Exiguobacterium* sp. PR 10.6. Also, from this search, nine further bacterial species within this genus were identified. The remainder of the species were identified using PubMed, which gave the accession numbers of species, which were noted. The 19 species chosen were all members of the *Exiguobacterium* genus; however, two of the 19 species were not individual species, but strains, within the *Exiguobacterium* genus, due to being unable to identify any more separate species. The out-group chosen was *Propionibacterium acidifaciens*, which was chosen as it is a member of a different phylum to *Exiguobacterium*. These accession numbers were then searched using the EBI website, and the 16S rRNA gene sequences were identified for the 20 species were identified. These sequences were then edited to the correct format for input into Clustal Omega, a multiple sequence alignment programme, to create a phylogenetic tree. The phylogenetic tree was then formatted to include the genus, species and strain, as well as the accession numbers, of all 20 bacteria chosen.

Results and Discussion

3.1. Phylogenetic tree for *Pseudomonas clemancea*

The sequence was identified as *Pseudomonas clemancea*'s 16S rRNA gene with 100% similarity. 20 other species from the *Pseudomonas* family were selected at random from the EBI database. The 16S rRNA genes were found using EBI's gene database and each was sequenced using ClustalW multi-sequence alignment software. A phylogenetic tree was produced to illustrate the relationships between the species (Fig. 1). *P. clemancea* is a Gamma-Proteobacteria of class Pseudomonadales. It was first referred to in literature by Rahman *et al* (2009) and was said to be a "novel biosurfactant-producing strain from Northeast England". From the phylogenetic tree (Fig. 1) it can be seen that *P. clemancea* is closely related to *Pseudomonas pavonaceae*. Upon further investigation it was discovered that *P. pavonaceae* was reclassified in 1986 to the *Acinetobacter* family due to rRNA and $T_{m(e)}$ similarities (Van Landschoot *et al*, 1986). *P. clemancea* is also shown to be closely related to *Pseudomonas jessenii*, a bacterium found in sponges with antimicrobial properties (Keller-Costa *et al*, 2014). It is possible that these antimicrobial properties may stem from biosurfactant synthesis by *P. jessenii*; due to its relation to *P. clemancea*, a known biosurfactant producer, it may share genes related in the synthesis of this product.

3.2. Phylogenetic tree for *Exiguobacterium* sp.

Phylogenetically speaking we can see the evolutionary

relationships between the taxa, through the common ancestor; in the clade we can see the relationship of the organisms. Some of the taxa have rapid separation between them which can be seen with *Exiguobacterium aurantiacum* M-4 (HM030747.1) and *Exiguobacterium acidifaciens* (AB565481.1), this can be due to quick separation of species resulting in several phylogenetic polytomies (Page, 2003). This means that several mutations have occurred between species causing a large separation of taxa. There are however, distinct groups which shows that the species linked are more closely related. More distantly related species may have an impact on the efficacy of utilising *Exiguobacterium* sp. for bioremediation purposes such as the bioremediation of heavy metals as organisms on the same clade as *Exiguobacterium* sp. PR 10.6; this is because they may be so distantly related that they no longer share certain genes pertaining to bioremediation. The species of the *Exiguobacterium* genus are short, irregular coryneform bacilli (Koneman, 2006). *Exiguobacterium* sp. have been found in a vast range of conditions and exhibit highly specialised adaptations; for example, certain species within the genus have been found to have the ability to significantly reduce concentrations of heavy metals, in particular Cr(VI). Therefore, species within this genus may have a potential application in the bioremediation of heavy metals (Zaidi *et al.*, 2012). The phylogenetic tree generated can be seen below:

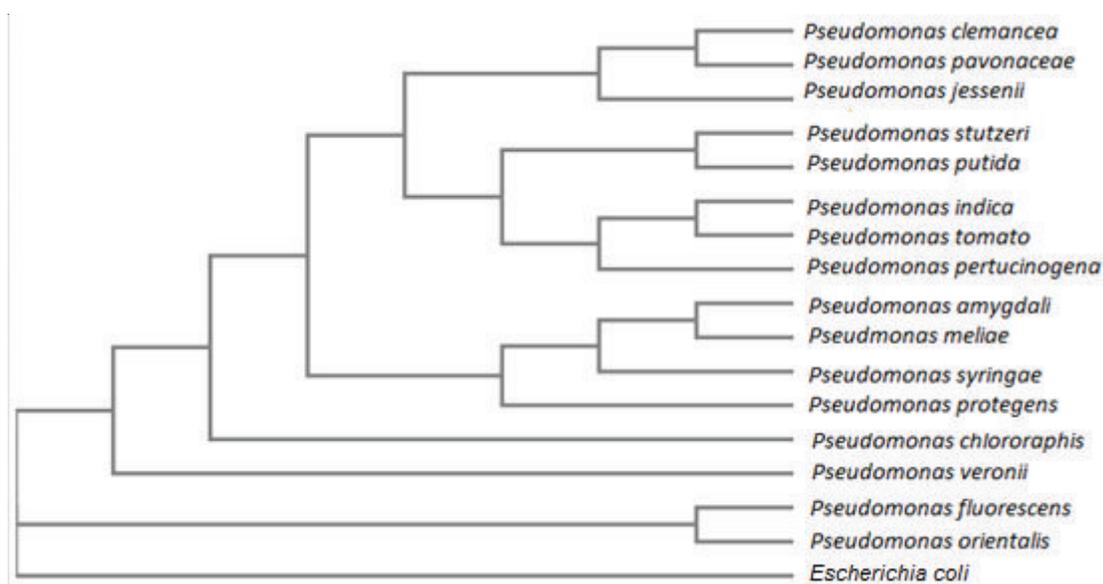


Figure 1: Phylogenetic tree comparing 16 species of *Pseudomonas* bacteria. *Escherichia coli* was used as an out group for comparison

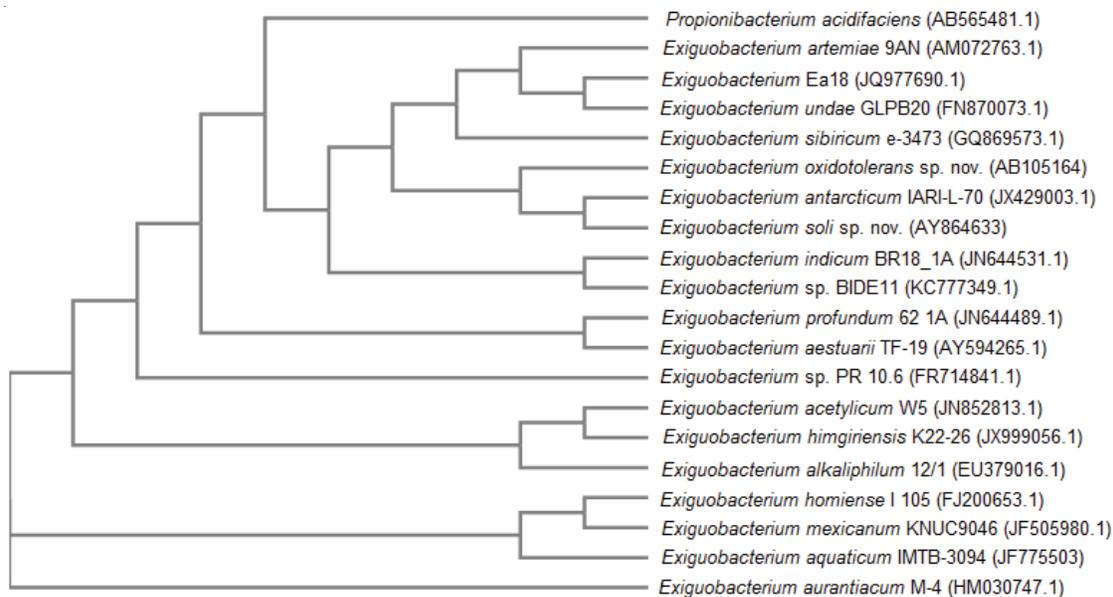


Figure 2: Phylogenetic tree comparing of *Exiguobacterium* species

Conclusion

In conclusion, bacterial sequences analysed through bioinformatics tools show relationships between species by visually showing the “Last Common Ancestor” (LCA). Species that share an LCA from long ago will be less related than those who share a more recent LCA. Mutations in the highly conserved 16S rRNA gene give clues to the time passed since the LCA. Bioinformatics can be used in this way to bioprospect for species and strains with desirable properties or products which are similar to a known microorganism. In our study, natural environmental samples were chosen to screen industrially important bacteria. The work was focused on identification of a bacterium that has commercial potentials. Construction of phylogenetic tree indicated that the two strains are *Pseudomonas clemancea* and *Exiguobacterium* sp. PR 10.6. They have the potential to produce biosurfactant and nanoparticles for commercial applications

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CSIR-NBRI Botanic Garden: A Repository of Plant Diversity Ideal for Systematic Studies

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Introduction

Present day botanic gardens have their origins from medicinal plant gardens established during the middle of the 16th century meant for cultivation of medicinal plants. Therefore, roots of botany are traced from the medicine. These botanic gardens are considered as an ordered collection of plants, assembled primarily for scientific and educative purposes. They serve as the living repositories and offer excellent opportunities for *ex-situ* conservation, taxonomy and studies on various other botanical aspects as mentioned below:

- Serve as a living herbarium and unique facility as one stop destination to study the wide range of plant groups for systematic studies and commercial exploitation.
- Live specimens of little known species may offer opportunities for providing the taxonomic description and updating the incomplete descriptors.
- For making the comparative studies of fresh and dried plant specimens (preserved in a herbarium) for better and complete understanding of a plant species.
- Many species which have taxonomic complexes may be grown in the iso-climatic regions, studied and solved taxonomically by applying cytogenetic, molecular, chemical and other parameters.
- Revisionary studies of wild relatives of diverse taxa and ornamental crops may provide significant clues and better understanding of the affinities, close and distant relationships at inter and intra-specific and varietal levels.
- Provide better support and opportunities to learn taxonomic and floristic studies with the help of living fresh material which can reveal several unknown mysteries of the life cycle of a taxon.
- To understand the phenotypic plasticity of the indigenous, introduced as well as ornamental and economically significant taxa.

- They serve as one of the best centres for the systematic studies on the ornamental crops having larger collections.

Besides, the botanic gardens play a very important role in generating public awareness and imparting environmental education for the masses. CSIR-NBRI Botanic Garden offers the scope for the systematic studies by fulfilling above requirements

CSIR-NBRI Botanic Garden

Botanic Garden of CSIR-National Botanical Research Institute, Lucknow is well known all over the world. It is the third largest and one of the oldest Botanic Gardens in India. Spread over in 65 acres of area, it is located in the heart of Lucknow city, the capital of Uttar Pradesh. It has four main functions *viz.*, conservation, education, scientific research and display of plant diversity in plant houses and arboreta. Botanic Garden is reputed for organised display of plant wealth in a well-designed landscape (Goel, 2002). Botanical strength of this Botanic Garden can be gauged due to the conservation of diverse living collections of various groups of plants comprising 5000 taxa/cvs. distributed under 212 families. Considering the rich plant genetic diversity in the Botanic Garden, the Institute has been designated as a **Living National Repository** under the Govt. of India notification during 2007 by **National Biodiversity Authority**, Chennai under the *Biological Diversity Act - 2002*. Besides, it has also been recognized as a **Lead Botanic Garden** by the Ministry of Environment & Forests, New Delhi for enhancing *ex-situ* conservation activities. Moreover, it has also been designated as a **'DUS Test Centre'** for three ornamental crops *viz.*: *Bougainvillea*, *Canna* and *Gladiolus* by the **Protection of Plant Variety & Farmer's Rights Authority**, Ministry of Agriculture, Government of India, New Delhi during 2012 (Roy, 2006a,b).

Botanic Garden covers within its limits, historical 'Sikander Bagh' laid out around 1800 AD as a royal garden by 'nawabs' of Oudh region. It was named by Wajid Ali Shah, last 'nawab' of Lucknow, after the name of Begum Sikander Mahal, one of his favourite queens. After 1857 war, it was taken over by the state of Oudh as a Horticultural Garden in 1869. Later on after independence, it was taken

over by Government of Uttar Pradesh in 1948 as **National Botanic Garden** and finally by Council of Scientific & Industrial Research (CSIR), New Delhi in 1953 (Goel and Sharga 2001).

Germplasm Collections

Plant wealth in this Botanic Garden has been displayed in Arboretum, Bonsai House, Conservatory, Cacti and Succulents House, Cycad House, Fern House, Moss House, and Palm House besides the mandate ornamental crops for the cross section of the society.

Arboretum

It covers 7 hectares of area representing nearly 300 species of trees, shrubs and climbers and located on the left side of main entrance where trees are systematically planted and labelled, providing botanical/common name, family and nativity. Some of the notable indigenous and exotic tree species in arboretum are: *Adansonia digitata*, *A. rubrostipa*, *A. za*, *Alstonia macrophylla*, *Aphanamixis polystachya*, *Bauhinia variegata*, *Bligha sapida*, *Boswellia serrata*, *Butea superba*, *Castanospermum australe*, *Chorisia* × *insigniosa* (NBRI Cultivar), *Cinnamomum camphora*, *Coccoloba uvifera*, *Crateva nurvula*, *Dalbergia lanceolaria*, *Diospyros kaki*, *D. malabarica*, *Ficus benghalensis* var. 'Krishnae', *Jacaranda mimosaeifolia*, *Khaya senegalensis*, *Koelreuteria apiculata*, *Mitragyna parviflora*, *Oroxylum indicum*, *Parmenteira cerifera*, *Protium serratum*, *Santalum album*, *Saraca declinata*, *Strychnos potatorum*, *Tabebuia palmeri*, *Tecomella undulata*, *Tectona grandis*, *Terminalia muelleri*, *Triplaris surinamensis*, *Vitex pinnata* and *Wrightia tinctoria*. Plant resources of gymnospermous taxa like: *Agathis*, *Biota*, *Ephedra*, *Ginkgo*, *Pinus* and *Podocarpus* are also conserved here (Roy *et al.*, 2013).

Display of Plant Diversity in Conservatories

Bonsai House

'Bonsai' is a unique technique and art of growing plants in dwarf form in a shallow container with the help of pruning and training. Bonsai House acquires 450 sq m area and equipped with automated misting system and shading net. A collection of 350 bonsai specimens, trained in different styles, has been exhibited. Plants are well labelled. Few important species worth mentioning are: *Acacia gotezei*, *Achras sapota*, *Adansonia digitata*, *A. za*, *Bambusa ventricosa*, *Callistemon lanceolatus*, *Citrus microcarpa*, *Cycas revoluta*, *Drypetes roxburghii*, *Ficus benjamina* var. 'Nuda', *F. indica*, *F. infectoria*, *Ficus* 'Long Island', *F. tesiela*, *Portulacaria afra*, *Psidium guajava* and *Punica granatum*, besides a large number of *Bougainvillea* cultivars in wide range of flower colours.

Cacti and Succulents House

This house is a pagoda shaped glass house meant for conservation of germplasm collection of cacti and succulents. It is centrally located covering 284 sq m area and shelters about 300 species/varieties. Some of the interesting species displayed are: *Adenium obesum*, *Agave parviflora*, *A. stricta*, *Cereus grandiflorus*, *C. peruvianus*, *Cotyledon orbiculata*, *Dudleya virens*, *Dyckia remotifolia*, *Echinocactus grusonii*, *Euphorbia tirucalii*, *Gasteria maculata*, *Gymnocalycium mihanovichii*, *Haworthia fasciata*, *Hesperaloe parviflora*, *Mammillaria echinata*, *Notonia grandiflora*, *Opuntia argentina*, *O. microdasys* 'Albida', *O. vulgaris* 'Variegata', *Pereskia aculeata*, *P. bleo*, *Senecio pendula*, *Stapelia gigantean*, *Yucca aloifolia* and *Y. filamentosa*.

Welwitschia mirabilis, a unique gymnosperm, known as "Tree Tumbo" has been introduced from NBG, Kirstenbosch, Republic of South Africa. This species has only two leaves throughout its life-span (over 500 years) which elongate continuously in opposite direction. It is very important from educational and evolutionary point of view and considered as a bizarre in plant kingdom. It grows wild in Namib desert of South Africa along the coastal line. Among the SAARC nations, only CSIR-NBRI Botanic Garden possesses this extremely rare plant (Sharma and Goel 2003).

Conservatory

An arch-shaped plant house, spread in 1370 sq m area, is meant for the conservation of house plants from tropical and subtropical climates. There are nearly 350 species/cultivars of house plants in the conservatory. Some of the novel and interesting plants are: *Alocasia* × *amazonica*, *Bambusa ventricosa*, *Dracaena marginata* 'Tricolor', *Encephalartos transvenosus*, *E. villosus*, *Fatsia papyrifera*, *Ficus* 'Long Island', *Ginkgo biloba*, *Heliconia rostrata*, *Hoya carnososa* and *H. wightii*. Besides, a large collection of *Aglaonema*, *Alocasia*, *Anthurium*, *Asparagus*, *Calathea*, *Chlorophytum*, *Codiaeum*, *Dieffenbachia*, *Dracaena*, *Maranta*, *Peperomia*, *Philodendron*, *Pandanus* and *Syngonium* is being conserved. Besides, *Microcycas calocoma* is an extremely rare cycad, introduced from Florida. It is designated as the **National Plant of Cuba**. Besides, some economic plant species viz., *Cinnamomum camphora*, *Coffea arabica* and *Piper betel* have also been showcased here.

Cycad House

Nearly 50 species of cycads belonging to 8 genera viz., *Cycas*, *Dioon*, *Encephalartos*, *Lepidozamia*, *Macrozamia*, *Microcycas*, *Stangeria* and *Zamia*, hailing from various phyto-geographical regions of Australia, India, South Africa and South America are being conserved in

Cycad House covering 300 sq m area for the educative and aesthetic display. This is a maiden effort and first of its kind in India, that *ex-situ* conservation and creating awareness about cycads have been taken-up (Kumar *et al.*, 2006, Roy and Goel 2006).

Fern House

Ferns and fern allies are widely used as ornamentals for interior plantscaping. This fernery is pyramidal in shape and occupies 400 sq m area. It is covered with shade net to cut-off excessive sun light and heat and is kept humid by sprinklers, mist irrigation and water-filled channels all around. A germplasm collection of 60 species of ferns and fern allies is maintained in fern house. Few notable ferns are: *Adiantum capillus-veneris*, *A. hispidulum*, *Blechnum occidentale*, *Bolbitis heteroclita*, *Diplazium esculentum*, *Drynaria quercifolia*, *Equisetum debile*, *Lygodium flexuosum*, *Microsorium alternifolium*, *Nephrolepis cordifolia*, *N. cordifolia* cv. 'Duffii', *N. tuberosa*, *Ophioglossum reticulatum*, *Psilotum nudum*, *Pteris cretica* cv. 'Albolineata', *P. vittata*, and *Selaginella bryopteris*.

Moss House

A moss house is established in 270 sq m area, which is covered with netlon and fitted with water sprinklers, misting system and water filled channels around to simulate the microclimatic conditions. It is first of its kind in India which conserves bryophytes under local tropical conditions. A collection of nearly 20 species of liverworts and mosses is being maintained here. Some of the noteworthy species conserved are: *Cyathodium cavernarum*, *Marchantia linearis*, *Marchantia paleacea*, *Plagiochasma appendiculatum*, *Riccia billardieri* and *Targionia hypophylla* and mosses like *Barbula indica*, *Semibarbula ranuui* and *Vesicularia montagnei* are conserved here. It facilitates demonstration of variety of bryophytes for educative purpose and general awareness for the public.

Palm House

Palm House with an area of 285 sq m, is meant for conserving and showcasing the palm collections. The germplasm comprises over 60 species displayed in pots and in ground. It includes some fine specimens of: *Areca catechu*, *Arenga pinnata*, *Bentinkia nicobarica*, *Caryota mitis*, *C. urens*, *Chamaedorea elegans*, *C. stolonifera*, *Chrysalidocarpus lutescens*, *Cocos nucifera*, *Daemonorops kunstleri*, *Elaeis guineensis*, *Licuala grandis*, *L. spinosa*, *Livistona chinensis*, *L. cochinchinensis*, *Phoenix reclinata*, *P. robelinii*, *P. rupicola*, *Ptychosperma macarthurii*, *Sabal palmetto*, *Thrinax barbadensis*, *T. Excelsa*, *Trachycarpus takil* and *Washingtonia filifera*. Several palm species can be grown in pots are useful as house plants for interior decoration.

Ornamental Crops and their hortotaxonomICAL

Bougainvillea Germplasm

Bougainvillea (Nyctaginaceae) and has wider adaptability and grown as shrubs, climbers, hedges, topiary, ground covers, standards, hanging baskets and bonsai. A rich collection of 200 cultivars is maintained in Bougainvillea garden and as potted plants. Institute has developed 24 new varieties like: 'Arjuna', 'Aruna', 'Begum Sikander', 'Chitra', 'Hawain Beauty', 'Los Banos Variegata', 'Mahara Variegata', 'Mary Palmer Special', 'Pallavi', 'Shubhra' and 'Wajid Ali Shah' which are highly popular in the horticultural trade. *Bougainvillea* cv. 'Dr. P.V. Sane' was developed during 2011 as Gamma ray mutant. Two new varieties viz.: 'Los Banos Variegata – Jayanthi' and 'Pixie Variegata' have been developed by using the chemical mutagen (Ethyl Methane Sulphonate). Some of these newly developed cultivars, have been registered with International Bougainvillea Registration Authority, IARI, New Delhi. The existing germplasm collection is also enriched by introducing Bougainvillea varieties like: 'Royal Daupline', 'Himani', and 'B.T. Red' from botanic gardens outside the country. (Roy *et al.*, 2007, Sharma and Goel 2006).

Canna Germplasm

Canna (Cannaceae) is native to tropical America and Asia, and represented by nearly 12-15 species. Its magnificent flowers in different colour combinations (bicoloured, spotted, blotched, margined) are quite attractive and remain in bloom throughout year in tropical and sub-tropical regions. Germplasm collection of 50 varieties is conserved here which has been planted in formal beds in accordance with height and flower colour for educative and aesthetic display. Few notable varieties are: 'Assault', 'Black Knight', 'Butter Cup', 'King Alfred', 'King Humbert', 'Lucifer', 'President', 'Striatum', 'New Red', 'Orange King' and 'Trinacria variegata'. Recently three new *Canna* varieties have been developed at CSIR-NBRI viz.: *Canna generalis* 'Kanchan', 'Agnisikha' and 'Raktima' under ongoing improvement programme.

Chrysanthemum Germplasm

A rich collection of Chrysanthemum with 200 varieties is being showcased and conserved. A large number of 'Dwarf No Pinch No Stake' type cultivars have been selected which are suitable for mini-pot culture. Some of the varieties, viz., 'Himanshu', 'Jwala', 'Jyoti' and 'Phuhar' bloom profusely during summer and rainy seasons. A mini chrysanthemum cv. 'Mother Teresa', evolved by NBRI, got US Patent (Patent No. PP-13678) in 2003. Recently, Institute developed new cultivars of Chrysanthemum viz., Vijay Kiran (Bud sport of Vijay), NBRI Little Hemant, NBRI Little Pink, NBRI Little Orange, NBRI Little Kusum (Seedling selection), NBRI

Himanshu (Seedling selection); NBRI Kaul, NBRI Khoshoo (Hybrid) and NBRI-Pushpangadan.

Gerbera Germplasm

For the diversification of floricultural crops for commercial purpose, a 'Pilot facility' demonstrating agrotechnology for cut-flower production of *Gerbera* (Asteraceae) in a Poly-house covering 560 sq m area has been established. Initially seven *Gerbera* cultivars viz.: 'Danaellen', 'Goliath', 'Rosalin', 'Salvadore', 'Silvester', 'Sunway' and 'Zingaro' in various colours are cultivated. Techno-economics is worked out by taking into account the cost of Poly House construction and total income generated during a span of three years. The estimated net profit comes to Rs.7 - 10 lakhs in 3 years if properly marketed at a sale price of Rs.5-6 per flower.

Gladiolus Germplasm

Gladiolus (Iridaceae) is native to South Africa and an important floricultural crop grown throughout the world. Institute initiated R&D work for developing new and novel Glad varieties. Botanic Garden has developed agrotechnology for commercial cultivation in north Indian plains besides identification of suitable cultivars viz.: 'Aldebaran', 'American Beauty', 'Big Time Supreme', 'Deciso', 'Friendship Pink', 'Oscar', 'Red Beauty', 'Tropic Sea', 'White Prosperity' and 'Yellow Stone'. Germplasm collection of 100 varieties has been conserved and maintained, besides development of new and novel varieties. Notable ones are: 'Rashmi', 'Surekha', 'Classic White', 'Neelima', 'Roshni', 'Jamuni' ('Amethyst'), Suverna, 'Sydney Percy Lancaster' and 'Urvashi'. Recently a new Glad variety 'Acharya Jagadish Chandra Bose' was released during Annual Rose & Gladiolus Show held on 19 Jan., 2013.

Hippeastrum Germplasm

Hippeastrum (Amaryllidaceae), native to tropical and subtropical America, is important genus among the bulbous ornamentals. A germplasm collection of 10 varieties is conserved. Several new hybrids in attractive colour combinations and forms, adaptable to North Indian plains, have been developed through hybridization, involving Royal Dutch hybrids and local strains. Notable ones are: 'Garima', 'Man-Mayura', 'Kiran Rekha', 'Smriti', 'Jwala', 'Niharika', 'Prakash', 'Dhruva', 'Agni' and 'NBRI Kiran'.

(Lotus) *Nelumbo nucifera* collections

Genus *Nelumbo* (Nelumbonaceae) is represented by two species namely: *N. lutea* 'Yellow Lotus', indigenous to eastern North America and *N. nucifera* 'Kamal', native to tropical and subtropical Asia. *Nelumbo nucifera* Gaertn., is an elegant creation of nature. Besides, it is an important ornamental in floriculture and landscaping. Germplasm

collection of Indian and exotic races in different shades of pink and white is being maintained in the aquatic bodies in Botanic Garden (Goel et al. 2003, Sharma and Goel 2001). Besides, the germplasm collection of *Nymphaea* cultivars and *Euryale ferox* (Makhana) is also conserved in aquatic bodies.

Rose Germplasm

Rose is an important floricultural crop all over the world and ranks first in top ten cut-flowers in the international floricultural trade. In India, roses are used in various forms viz., cut and loose flowers and in the extraction of essential oils. Besides, there is a good demand of roses in horticultural trade. Considering its commercial importance, germplasm collection of 225 rose varieties both Indian and exotic) is being maintained, comprising all groups viz., hybrid tea, polyantha, floribunda, miniature and climbing roses. Some important varieties are: 'City of Lucknow' (a thornless variety), 'Viridiflora' (clusters of green flowers), 'Coctail', 'Shyamblata' (climbing type) and *Rosa clinophylla*.

Other Important R&D Activities for Empowerment of Plant Taxonomy

Plant Introduction Studies

It is the most paramount activity in for enrichment of germplasm collection and creating wider genetic base for further use by researchers and plant lovers (Roy 2009, Roy et al. 2013). Seeds and plant materials are procured from over 50 Botanic Gardens from within and outside the country on exchange. It also provides authentic plant material to other sister organizations in India and abroad, specifically for R&D work under MTA. Some of the important species, recently introduced are: *Adansonia za*, *A. rubrostipa*, *Adenantha microsperma*, *Billbergia alfonsi-joannis*, *Caesalpinia cacalaco*, *C. mexicana*, *Clerodendrum speciosissimum*, *Crescentia mirabilis*, *Cycas media*, *Dasilirion glucophyllum*, *Dracaena draco*, *Hesperaloe parviflora*, *Jacaranda cuspidifolia*, *Khaya senegalensis*, *Livistona carnavron*, *Pavetta revoluta*, *Phoenix canarensis*, and *Triplaris surinamensis* (Roy 2011, Roy and Datta 2005).

Ex-situ Conservation Studies

Botanic Garden plays an important role for conservation of plant diversity and acts as a centre of excellence for the conservation of wild and introduced plant species. The germplasm under conservation includes *Adhatoda beddomei*, *Alectra chitrakutensis*, *Allium hookerii*, *Anogeissus sericea* var. *nummularia*, *Commiphora wightii*, *Curcuma pseudo-monatana*, *Cycas beddomei*, *Dischidia benghalensis*, *Ephedra foliata* var. *ciliata*, *Erythrina resupinata*, *Frerea indica*, *Hoya lanceolata*, *H. wightii*, *Hyphaene dichotoma*, *Isonandra*

villosa, *Indopiptadenia oudhensis*, *Phoenix rupicola*, *Sophora mollis*, *Tecomella undulata*, *Trachycarpus takil* and *Vanilla walkeri* (Goel and Mamgain 2001, Goel 2002, 2003, Goel and Kulshreshtra 2005, Goel and Sharma 2005, Goel *et al.*, 2007, Roy 2000, 2003).

Touch-‘n’-Smell Garden for differently abled

Visually impaired people are totally deprived of enjoyment associated with natural resources. Institute has created a unique garden meant for visually impaired and disabled persons enabling them to learn about the diversity plants by touch and smell. The garden is first of its kind in Indian subcontinent and seventh in the world (Pushpangadan *et al.*, 2002). It is spread in 1000 sq m area. Plant labels and legends are written in Braille on the aluminium sheets mounted on stands which provide botanical and common name, family, origin and other relevant information in English and Hindi. Pre-recorded information through audio system has been provided. The plant species either having fragrant flowers, aromatic / coarse leaves have been planted. The notable ones are: *Buddelia madagascariensis*, *Cestrum diurnum*, *C. nocturnum*, *Cinnamomum camphora*, *Crinum* spp., *Cymbopogon martinii*, *Ficus krishnae*, *Ixora parviflora*, *Jasminum* spp., *Lantana camara* ‘Flava’, *Nyctanthes arbortristis*, *Ocimum* spp., *Polianthes tuberosa* and *Rosa* cv. ‘City of Lucknow’ (Roy 1999, 2005). (Fig. 29)

Annual Flower Shows

Institute organizes every year two Annual Flower Shows viz. **Rose & Gladiolus Show** in January and **Chrysanthemum & Coleus Show** in December for the last 45 years. The purpose of organizing these flower shows is to create aesthetic sense and to develop awareness among the masses for keeping their surroundings and environment clean/healthy and green besides generating self-employment. They also provide a common platform and an ideal opportunity to the scientists, researchers, horticulturists, gardeners and general public, for interaction on problems of mutual interest, well identified ornamental varieties of the ornamental crops and the quality planting material.

Botanic Gardens as a facility for taxonomic studies

With such diversified germplasm resources in this Botanic Garden, it offers a great scope of conducting the taxonomic studies on wild plant species as well as the cultivated ornamental crops. The available fresh materials can be used for dissection purpose and making the detailed taxonomic descriptions. Many new plant species are described every year from various Botanic Gardens world over thus providing a unique opportunity and scope to discover and describe them. Even the complex taxa can be

grown under *ex-situ* and their correct identities may be established at the later stages. Identification of introduced species has been found to be quite interesting and cumbersome task and requires well trained taxonomic eyes as well as expertise.

The students at junior and senior levels can be trained in plant identification properly and more precisely with the help of fresh plant material. The phenotypic plasticity can be well explained to the students and the researches at one place. Studies with the live plant material makes plant taxonomy more lively and interesting. Even the floristic studies of a district may not reveal such a wide phenotypic as well as the genotypic diversity as available in the Botanic Gardens.

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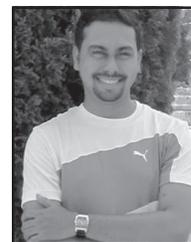
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DNA Barcoding: from Theory to Applications in Taxonomy and Molecular Phylogenetics

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Species identification and classification has traditionally been the specialist domain of taxonomists, providing a nomenclatural backbone and a key prerequisite for numerous biological studies. The identification of species depends on the knowledge held by taxonomists whose work cannot cover all taxon identification requested by non-specialists. To deal with these difficulties, the ‘Consortium for the Barcode of Life (CBOL, <http://barcoding.si.edu>)’ was established with the aim to develop a standardized, rapid and inexpensive species identification method accessible to non-specialists.

By definition, the DNA barcoding is a technique for characterizing species of organisms using a short DNA sequence from a standard and agreed-upon position in the genome. DNA barcode sequences are very short relative to the entire genome and they can be obtained reasonably quickly and cheaply. Species identification through barcoding is usually achieved by the retrieval of a short DNA sequence – the ‘barcode’ – from a standard part of the genome (i.e. a specific gene region) from the specimen under investigation. The barcode sequence from each unknown specimen is then compared with a library of reference barcode sequences derived from individuals of known identity. A specimen is identified if its sequence closely matches one in the barcode library. Otherwise, the new record can lead to a novel barcode sequence for a given species, or it can suggest the existence of a newly encountered species. I shall be discussing the properties of the DNA barcodes in detail during the talk.

The most common DNA barcode used in animals is a fragment of the cytochrome c oxidase (COI) mitochondrial

gene, while for plants, two chloroplast gene fragments from the RuBisCo large subunit (rbcL) and maturase K (matK) genes are widely used. As far as the DNA barcodes for fungi is concerned, The Fungal Barcoding Database, managed by the International Fungal Working Group (<http://www.fungalbarcoding.org>) identified the ITS region and the D1/D2 region of the nuclear large subunit (LSU), as fungal DNA barcodes.

DNA barcoding can have significant impact on taxonomy. It may provide more rapid progress than the traditional taxonomic work. DNA barcoding allows taxonomists to rapidly sort specimens by highlighting divergent taxa that may represent new species. DNA barcoding may offer taxonomists the opportunity to greatly expand, and eventually complete, a global inventory of life’s diversity. Once fully developed, DNA barcoding will have the potential to completely revolutionize our knowledge of diversity of living organisms and our relationship to nature. In addition to taxonomy, the DNA barcoding can complement current phylogenetics research by providing background information that will be helpful in the selection of taxa for further analysis. I will share our experience of DNA barcoding of fungi, being regularly done as a part of fungal identification services provided by NFCCI.

An increasing use of DNA barcodes in conservation biology, ecological studies, medicine, pharmaceuticals and systems biology has been predicted by many researchers from all over the world. However, we need to be cautious while developing or applying DNA barcoding, as there have been a few limitations associated with it. I shall be discussing those limitations during the talk.

Lead Lecture

Advances in Arbuscular Mycorrhizal (AM) Biotechnology

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Introduction

Arbuscular mycorrhizal (AM) fungi from the phylum Glomeromycota are ubiquitous soil borne microbial symbionts forming mutualistic associations with a majority of terrestrial plants. They facilitate uptake of nutrients (mostly immobile P) through their extra-radical mycelial network and provide other benefits to their host plants. These benefits can be physiological, nutritional and ecological and therefore exploiting and managing AM fungi has important consequences for both agricultural and natural ecosystems. Nowadays, they are increasingly considered in agriculture, horticulture, and forestry programs, as well as for environmental reclamation, to increase crop yield and health and to limit the application of agrochemicals (Gianinazzi *et al.*, 2002; Johansson *et al.*, 2004). However, the obligate biotrophic nature of AM fungi has complicated the development of cost-efficient large-scale production methods to obtain high-quality AM fungal inoculum. This is one of the reasons why their commercial exploitation is still in its infancy (Ijdo *et al.*, 2011).

The inoculum production systems for AM fungi are classified into *viz.*, the classical sand/soil or more advanced substrate-based production systems and the *in vitro* cultivation systems, which are based either on excised roots i.e. root organ cultures (ROC) or on whole autotrophic plants (Ijdo *et al.*, 2011).

Am Fungal Inoculum Production and Multiplication:

2.1: Inoculum Production

AM fungal inoculum has been utilized in agriculture, horticulture, landscape restoration, and site remediation for almost two decades (Hamel, 1996). In the early 1990s, researchers described multiple ways in which AM species management would be useful for sustainable systems, including agro-systems and restoration (Bethlenfalvay and Linderman, 1992; Pflieger and Linderman, 1994). In a long-term study comparing organic and conventional agriculture, Maeder *et al.* (2002) found that AM were stimulated in organic treatments, which was correlated to enhanced system health (faunal diversity, soil stability, and microbial activity) and to increased crop efficiency.

2.2: Sources of AM inoculum

AM fungi are obligate symbionts, growing only in association with a host plant. Current production systems therefore rely on soil-based systems (plots or pots), which are not sterile and are often contaminated with other AM species, and other microbes, including pathogens (Gianninazzi and Bosatka, 2004). Non-soil based approaches include *in vitro* systems involving the use of Ri T-DNA transformed plant root organs (genetically modified with *Agrobacterium rhizogenes*) to grow on media under sterile conditions. These are much cleaner, but have a limited production capacity (Declerk *et al.*, 2005).

2.2.1: Soil based systems or pot cultures

Soil from the root zone of a plant hosting AM can be used as inoculum. Such inoculum is composed of dried root fragments or colonized root fragments, AM spores, sporocarps, and fragments of hyphae. Soil may not be a reliable inoculum unless one has some idea of the abundance, diversity, and activity of the indigenous AM species. Spores can be extracted from the soil and used as in-oculum but such spores tend to have very low viability or may be dead or parasitized. In such a case, soil sample can be taken to set up a 'trap culture' using a suitable host plant to boost the number of viable spore propagules for isolation, further multiplication and also to produce pure or monospecific cultures.

Pure cultures or monospecific cultures are obtained after a known isolate of AM and a suitable host are grown together in a me-dium (sterilized soil/sand) optimized for development of AM association and spore for-mation. It consists of spores, colonized root fragments, and AM hyphae.

2.2.2: Host plant species

The plant grown to host AM fungi in the inoculum production medium should be carefully selected. It should grow fast, be adapted to the prevailing grow-ing conditions, be readily colonized by AM, and pro-duce a large quantity of roots within a relatively short time (45–60 days). It should be resistant to any pests and diseases common in the inocula production environment.

Gilmore (1968) recommended strawberry (*Fragaria* sp.) for open pot culture propagation of AM fungi. The range of plant species used since then are too numerous to list. Some common temperate host plants included *Zea mays* (corn), *Allium cepa* (onion), and *Arachis hypogaea* (peanut). Widely-used tropical hosts included *Stylosanthes* spp., *Paspalum notatum* (bahia grass) and *Pueraria phaseoloides* (kudzu) (<http://invam.wvu.edu/methods/cultures/host-plant-choices>).

The host plant should also be fertilized by periodic additions of a nutrient solution such as Hoagland's solution (especially -P) so as to manage the chemical composition of the medium and to regulate the formation of AM association. To ensure that most of the spores in the inoculum are mature, it is essential to grow the host plant for 12–14 weeks. The medium is then allowed to dry slowly by reducing the frequency of watering over a week and then withdrawing water completely. The inoculum can then be further multiplied.

2.2.3: Advantages and disadvantages

Soil-based systems for cultivation of AM fungi (pots, bags, or beds) are the most widely adopted technique for AM fungal inoculum production. Soil-based production systems are the least artificial and support the production of a large set of AM fungal species (single or monospecific cultures). In general, they are considered as a convenient system for large-scale production that is able to reach inoculum densities set for mass production of 80–100 propagules per cubic centimeter (Feldmann and Grotkass, 2002). In soil-based production systems, the nutrient supplies to the AM fungus and plant can be monitored and regulated (Lee and George, 2005). More controlled culture conditions are an advantage as this can lead to insights on factors to optimize propagule production (Ijdo *et al.*, 2011).

A disadvantage of soil-based cultivations systems is that, in most cases, they cannot guarantee the absence of unwanted contaminants. Besides, these systems are often space consuming. The AM fungal propagules are isolated through wet sieving and decanting technique, which can be followed by sucrose density centrifugation. In addition to soil or sand as a substrate, technical adaptations such as the addition of glass beads, river sand, or vermiculite have been developed facilitating harvest of relatively clean AM fungal spores and colonized roots that can be chopped into pieces. The presence of a substrate, however, provides an inoculum which is not directly suitable for mechanical application, as is the case for soil-free production methods (Mohammad *et al.*, 2004).

2.3.1: *In vitro* systems or root organ cultures

Ri-plasmid transformed root cultures were pioneered by Mugnier and Mosse (1987). A natural genetic transformation of plants by the ubiquitous soil bacterium *Agrobacterium rhizogenes* Conn. (Riker *et al.*, 1930) produces a condition known as hairy roots. This stable transformation (Tepfer, 1989) produces Ri T-DNA transformed plant tissues that are morphogenetically programmed to develop as roots. Their modified hormonal balance makes them particularly vigorous and allows profuse growth on artificial media (Tepfer 1989). *Daucus carota* L. (carrot) and *Convolvulus sepium* L. (bindweed) were among the earliest species to be transformed using *A. rhizogenes* Conn. (Tepfer and Tempé, 1981). For *in vitro* culture of AM fungi using Ri T-DNA roots, the disinfected AM fungal propagules (spores and colonized root fragments) are plated on to Modified Strullu Romand (MSR) media for germination after which the germinated propagules are associated with actively growing Ri T-DNA transformed roots for establishment of AM symbiosis (Bécard and Fortin, 1988).

2.3.2: Advantages and disadvantages

The most obvious advantage of *in vitro* cultivation systems is the absence of undesirable contaminants or microorganisms, which makes them more suitable for large-scale production of high-quality AM fungal inoculum. While cross-contaminations by other AM fungi are evidently excluded (if the starter inoculum is monospecific), the contamination by other microorganisms (endophytes, bacteria) may occur either at the establishment of the cultivation process or at later stages of culture. Therefore, it may be useful to control the cultures visually, by standard plate-counting techniques and by molecular techniques. The cultures may be placed in a growth chamber requiring minimal space for incubation with no light required. The possibility to follow sporulation dynamics during cultivation also provides a means to control the level of spore production and to determine the optimal harvesting time. Factors that influence optimal production (e.g., nutrient availability, presence of contaminants) can be more easily detected and controlled in (liquid) *in vitro* cultures. As a disadvantage, the diversity (in terms of genera) of AM fungi that have been grown *in vitro* is lower than under pot cultivation systems. Another disadvantage of *in vitro* production is the costs associated with the production systems, requiring skilled technicians and laboratory equipments such as sterile work flows, controlled incubators for ROC, and growth chambers for plant systems. Other advantages of the ROC systems are the low requirements in the follow-up of the cultures. Once successfully initiated, the cultures may be maintained for periods exceeding 6 to 12 months without intervention (Ijdo *et al.*, 2011). For harvesting of the *in vitro* produced AM fungal propagules, solubilization of the culture

medium is carried out using citrate buffer. The application of sterile produced inoculum can be of great value for *in vitro* propagation of high-value crops and ornamental plants (Kapoor *et al.*, 2008). In addition, *in vitro* propagation in association with AM fungi could reduce mortality rates and the transplantation shock of reintroduced endangered plant species. It could also be used to enhance the production of secondary metabolites used in the pharmaceutical industry (Kapoor *et al.*, 2008). Although *in vitro* cultivation methods are currently still costly, it seems likely that the criteria for quality control of AM fungal inoculum will result in the utilization of techniques that are able to reduce contamination risks. Cultivation by *in vitro* methods may then become an important method to meet future quality standards for commercial mass production (Ijdo *et al.*, 2011).

Conclusion

Large-scale production of AM fungal bio-inoculum is not possible in the absence of a suitable host due to their obligate biotrophic nature, and it is not possible to identify AM species in their active live stages (growing mycelium). As a consequence, quality control is often a problem, and tracing the organisms into the field to strictly relate positive effects to the inoculated AM fungus is nearly impossible. In addition, no clear criteria have been set for the quality control of commercial inoculum, but most likely, the legislation dealing with the application of beneficial microorganisms will become more drastic in the coming decades (Ijdo *et al.*, 2011). The production of AM fungi on plants under *in vitro* conditions has been recently proposed (Voets *et al.*, 2005) and extended to hydroponic systems (Declerck *et al.*, 2009, WO/2009/090220). Following the pre-inoculation of a suitable autotrophic host plant in the system of Voets *et al.* (2009), a culture is transferred in a hydroponic cultivation system favoring the production of large quantities of propagules. Other *in vitro* methods might come up, which could involve spore production on callus or sporulation in sterile alginate beads or fully closed hydroponic plant cultivation suitable for the production of AM fungi (up-scaling the system of Dupré de Boulois *et al.* 2006). However, other relatively clean methods (e.g., in aeroponics) also have a strong developmental potential and could be further developed in the future. Biermann and Linderman (1983) already discussed that techniques such as sonication and gradient flotation as well as enzymatic methods could be developed to separate intra-radical spores and vesicles from roots. With an AM fungus as the only endophyte, such intra-radical propagules can serve as a high-quality inoculum.

The search for and the utilization of beneficial microbes for sustainable agro-ecosystems has created a potential for the exploitation of AM fungi and as such there is a necessity

to accelerate their incorporation as biofertilizers in agricultural production systems. Therefore, continuous development of high-quality and low-cost AM fungal inoculum production methods is expected, which could lead to establishment of more advanced methods for large-scale production of AM bio-inoculum.

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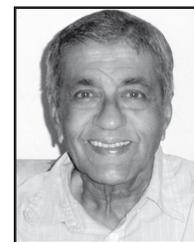
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Lead Lecture

Relevance of Taxonomy in an Era of Industrial Biotechnology with special Reference to Fungal Systems

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“Biodiversity is one of earth’s most important and least utilized resource “

EDWARD O. WILSON (*The Scientist*, February 9, 1987, p.11)

“As long as people think that genetic engineers can cure everything, the world will think that it does not need taxonomists anymore. But there is no biological diversity without the taxonomist to tell the stuff apart”.

MARK PLOTKIN, Director of Plant Conservation, World Wildlife Fund, Washington, USA

The quotes above underscore the importance of natural biodiversity in developing technologies beneficial to mankind and the enormous impact the science of taxonomy and classification has on a fuller understanding of biodiversity. The term “Biodiversity” became a buzz-word to reckon with after the Earth summit in Rio-de-Janiero in 1992 when global attention was focused on the need to conserve the different life forms on this planet. Mutual interrelationships among the living components for the sustainable well-being of the biosphere were also emphasised.

Conservation of endangered plant and animal species became a matter of importance globally and this helped in preventing several species from going into extinction. However scant attention was given initially towards microbial biodiversity which cannot be easily enumerated and requires skilled scientific inputs even for a preliminary evaluation and understanding. Recent years have witnessed considerable attention being paid to enumerate and conserve microbial biodiversity from diverse ecosystems.

Taxonomy has been the backbone to progress in the understanding and classification of living systems. Conventionally Latin names are given while describing new taxa. Prof. C.V. Subramanian, renowned Mycologist and Founder Member of the Mycological Society of India described new genera and species discovered by him from the Indian subcontinent giving Sanskrit binomials. Genera such as *Anthasthoopa*, *Tharoopama*, *Vakrabeeja* and several others have received international acceptance and been listed in international mycological literature.

Morphology and ecosystem- based taxonomy has been richly supplemented with biochemical and molecular data, offering newer insights and at the same time throwing challenges to conventionally accepted concepts.

The relevance of taxonomy to progress in biology is undisputed and in this presentation, I will attempt to discuss taxonomy as applied to fungal systems, especially in relation to their technological applications.

Progress in mycology owes a great deal to botanists who studied the morphology and life cycles of diverse fungi and also described and classified them scientifically. Phylogenetically fungi are not related to plants, while sharing some traits with the animal kingdom. The term “Mycota” to designate fungi as a unique and distinct group has gained global support. The reason for major contributions to mycology coming from botanists is the major damage caused to plants and agriculture by plant pathogenic fungi and led to advances in both phytopathology and basic mycology. Rules pertaining to nomenclature and classification of fungi have largely been discussed over the years in International Botanical Congresses and in the deliberations of the International Code of Botanical Nomenclature (ICBN).

Recent advances in molecular techniques have brought new knowledge and also resulted in conceptual changes in the way fungi are classified. For example, the earlier concept of grouping all the zoosporic fungi under Phycmycetes having monophyletic descent from algae has now been abandoned. The Chytridiomycetes are now placed under Eumycota along with the Zygomycetes, Ascomycetes and Basidiomycetes by virtue of presence of chitin in their cell walls, alpha-amino adipic acid pathway for lysine biosynthesis and phylogenetics of the ribosomal RNA genes. Other zoosporic fungi such as the Saprolegniales and Blastocladales with glucans which are cellulose-like, in their cell walls are placed under Oomycota (Chorismata) and are considered directly originated from the algae. Polyphyletic origin of fungi has gained increased recognition and acceptance with mycologists regarding them as a heterogeneous aggregation of forms characterised by heterotrophic nutrition and widely distributed in nature as saprophytic forms or pathogenic members.

Fungi reproduce by formation of spores and the taxonomy based on the morphology of spore forms has provided the strong foundation necessary for recognition and classification of different biotypes. Fungi form asexual spores (conidia) as well as sexual spores (ascospores, basidiospores) in their life cycles. The conidial stages of many fungi are linked with the sexual (“perfect”) state in ascomycetes and basidiomycetes. The terms “Anamorph” and “Teleomorph” were applied to denote the asexual and sexual spore types. Historically **Article 59 of International Code of Botanical Nomenclature** permitted mycologists to give separate Latin names for the anamorph and teleomorph states of the same fungus. This dual nomenclature has been in practice for long and conventionally accepted without question all through. For example, the gibberellic acid producing ascomycetous fungus has the anamorph *Fusarium moniliforme* and teleomorph *Gibberella fujikuroi*.

A large population of fungi known only from the anamorphic state were grouped together in an artificial assemblage variously termed as “Fungi Imperfecti”, “Deuteromycetes”, “Hyphomycetes and Coelomycetes” etc. The Dual Nomenclature was an irritating one and the desirability of a single name for each fungus was gaining momentum. It was also becoming apparent that through molecular phylogenetics, analysing hereditary molecular differences mainly in DNA sequences, a reasonable molecular systematic can be achieved even in the absence of sexual spore forms. A landmark decision to implement the “**one fungus – one name**” concept was taken during the International Botanical Congress in Melbourne, Australia in July 2011 in the deliberations of the International Code of Nomenclature on Algae, Fungi and Plants. Accordingly, after January 1, 2013 one fungus can have only one name. The system of permitting separate names to be used for anamorphs ended. When both anamorph and teleomorph names of the same fungus were available, the teleomorph name was accepted. All legitimate names proposed for a species regardless of what state they are typified by can serve as the correct name of that species. All names now compete on an equal footing for priority regardless of the stage represented by the name bearing type.

Implementing these guidelines to arrive at an acceptable nomenclature profile is a Herculean task and presently experts in fungal taxonomy are cataloguing validly published names of various taxa before subjecting them for critical evaluation to decide on the final accepted name for each fungus. By the next meeting of the ICBN scheduled to be held in 2017, the one fungus-one name concept will be hopefully in place and under use.

Relevance of Taxonomy to Industrial Biotechnology

Industrial Biotechnology based on fungal fermentations has been in the forefront in providing technologies for the manufacture of diverse valuable products such as Taka Diastase (*Aspergillus oryzae*), Citric acid (*Aspergillus niger*), Penicillin (*Penicillium chrysogenum*), Gibberellic acid (*Gibberella fujikuroi*), Lovastatin (*Aspergillus terreus*) and Cyclosporin (*Tolypocladium inflatum*). Exploration of natural fungal biodiversity to isolate in pure culture fungal taxa relatively unexplored for biotechnology applications is a topic of immense scientific interest with academic as well as technological spin-offs. Mycologists have an opportunity to apply their specialist knowledge in the basic biology, ecology, physiology and biochemistry of diverse fungal groups to culture and conserve them in germplasm banks for innovative exploration for useful metabolites. Competence in taxonomic identification based on the morphology of spore forms is a vital requirement since any patent application for Intellectual Property Rights Protection of bioprocesses developed would necessitate correct and authentic identification of the production strain. For patent purposes, it is obligatory that the strain has to be deposited in a recognized patent depository under the Budapest treaty where the identification will be verified by experts before accessioning it and giving a number which has to be quoted in the patent application. An incorrect identification or nomenclature would nullify the patent claims. The importance of high level expertise for correct identification and naming of fungal strains for industrial biotechnology would be obvious and I believe needs no further elaboration.

Taxonomy is also of vital importance in differentiating morphologically similar strains having different biotechnology profiles. For example, *Aspergillus flavus* and *Aspergillus oryzae* are morphologically very similar and while *A. flavus* produces the highly carcinogenic Aflatoxin; *A. oryzae* is widely used for the production of food grade amylase and the fermentation of *Sake*, *Miso* and Soy sauce. It is obligatory that the strain used in the food industry is a non-aflatoxin producer.

Molecular techniques are being devised to classify these strains with morphological similarity. For example, **Chao-Zong-Lee et al (Bot.Bull.Acad.Sin.45:61-68, 2004)** used Amplified Fragment Length Polymorphism (AFLP) to differentiate these two species. DNA fragment profiles amplified with each of three selective primer pairs displayed similar patterns for all *A. flavus* strains tested whereas different patterns were observed with these primer pairs for *A. oryzae* strains. This is an example of utilising sophisticated molecular techniques to resolve a problem not amenable to be solved by classical taxonomic procedures.

Invasive fungal infection of human patients immune-compromised following organ transplantation or AIDS therapy is a serious development in which several species of fungi widely distributed and regarded as non-pathogenic saprobes are becoming the agents of infection. Among zygomycetous fungi, *Rhizopus*, *Mucor* and *Rhizomucor* are particularly lethal among patients with diabetes mellitus and account for almost 75% of Mucoromycosis cases. These isolates are morphologically similar to strains employed in industrial fermentations and do not cause infection if inoculated in normal laboratory animals to verify Koch's postulates. The invasive fungal invasion syndrome is a complex one involving various factors, notably virulence of the strain and the level of immunity of the human host. There is an urgent need to study at molecular level clinical isolates to identify gene sequences associated with potential virulence and such knowledge could go a long way in future to determine the "bio-safety" of fungal strains used in fermentation industries and industrial biotechnology.

Conclusion

"The only proper reasons for changing a name are either a more profound knowledge of the facts resulting from adequate taxonomic study or the necessity of giving up a nomenclature that is contrary to the rules"

KEITH SEIFERT, Canadian Mycologist and Chairman,
International Commission on Taxonomy of Fungi

Taxonomy is a progressive science and it is obvious that fungal taxonomy has undergone considerable modifications as a result of acquiring newer knowledge from the application of advanced techniques. Future years will witness newer dimensions to this dynamic field and will lead to a better perspective in the understanding of fungi and their multifaceted activities both in nature and under domestication for the production of valuable metabolites. The need for trained personnel to meaningfully explore, identify and conserve natural biodiversity for biotechnological inventions requires greater emphasis from academia as well as industrial circles. The 21st century is considered as the golden era of biotechnology and given the right inputs fungi and mycologists can be expected to make significant contributions.

Microbial Genome Mining in Drug Discovery

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Microbes are prolific producers of secondary metabolites (SMs) that show a variety of biological activities. Recent advances in genome sequencing have shown that microbial genomes harbour far more SM gene clusters than are expressed under conventional laboratory conditions. Activation of these “silent” gene clusters is a major challenge, and many approaches have been taken to attempt to activate them and, thus, unlock the vast treasure chest of microbial SMs. In the last few years, several computational tools have been developed to facilitate this process by identifying genes involved in secondary metabolite biosynthesis in bacterial and fungal genomes like the software programs that are available for this purpose, are *antibiotics & Secondary Metabolite Analysis SHEll*

(*antiSMASH*) and *Secondary Metabolite Unknown Regions Finder (SMURF)* and five related software packages like *CLUsterSEquenceANalyzer (CLUSEAN)*, *ClustScan*, *Structure Based Sequence Analysis of Polyketide Synthases (SBSPKS)*, *NRPS Predictor* and *Natural Product searcher (NP.searcher)*. With the advent of genome sequencing, new drugs are being found by the techniques of genome mining, offering hope for the future.

This presentation will cover what is genome mining, what are the present trends in natural product drug discovery, their limitation and our idea of genome mining in brief with some examples. This will also include various platform and bioinformatics tools and application.

Lead Lecture

Computational Analysis of Proteins for Functional Residue Prediction

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Proteins are involved in most cellular functions and hence are one of the most important macromolecules in any given organism. They are made up of amino acids and exist in the form of three dimensional structures. Experimental biologists are interested in uncovering functional residues in proteins in order to understand the mechanism of their function. In this talk, I will present our recent approach for functional residue prediction in a given three dimensional structure by collective inference. We represent the structure as a weighted, undirected residue interaction network (RIN). Amino acid residues are nodes of a RIN and two interacting residues are connected by an edge. The weight of the edge represents the correlation between the labels of interacting residues. The functional residues are identified by minimizing

the combined cost of residue-wise label misclassification and violation of label correlation constraints. We solve this optimization problem in two stages - the first stage minimizes residue-wise label misclassification cost followed by an iterative collective inference stage that adjusts labels predicted in the first stage so as to minimize violations of label correlations. Our approach significantly outperforms state of the art methods on the standard benchmark dataset. This work was jointly carried out with Prof. B. Ravindran, Saradindu Kar and V. Deepak of IIT Madras and was published in ACM conference on Bioinformatics, Computational Biology and Biomedical Informatics (ACM-BCB) in 2012.

Opening Address (First Pre-conference workshop)**The Legacy of Scientific Nomenclature****Moses Kolet**Dept. of Botany, B.N.Bandodkar College of Science, Chendani, Thane 400601, Maharashtra
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The Bible mentions that one of the first tasks undertaken by God, after creation of the earth and all its living beings, was to name each and every living creature; a record which certainly can be called as the earliest. The same text, a few pages later mentions the creation of different languages; thus initiating different names for different living entities. . . . The Banyan tree became Aalada, Ala, Ala Maram, Bargad, Bodha, Bot, Doda Alata, Mara, East Indian Fig, Kalpabata, Peddamari, Peral, Vad, Vata, in various parts of India and the same was referred to as Balete, Baniarviikuna, Curtain fig, Fiquier pleureur etc. elsewhere in the world. These multiple referings in different languages were quite OK till times when the majority of civilizations and populations were rooted in their respective areas. The development of modern science as a specialized concept changed the scenario drastically, with new and fast modes of transport and communications, enhanced opportunities, movement of populace and new technology available. With these came the urge to explore new horizons, exploiting latest technologies. Biological Sciences, being nearest to mankind, were the foremost in the initial scientific researches and it did not take long for the biologists to realize that multiple names in various languages were causing confusions and havoc in their respective researches in different parts of the world. The very subjects of their research were held in ambiguity by research workers in other parts of the globe, severely hampering developments in science. The need for common scientific language and naming began to be felt, resulting in several earlier attempts, some of which rather complicated the entire issue. Trinomial nomenclature also entered the scenario with names such as *Physalis annua ramosissima doing rounds in scientific circles*. Such tongue twisting names were clearly not for the common man and lay students.

Carl Linnaeus, the Swedish botanist, hence resorted to simplification of matters and, in the process, building upon a similar binomial system, envisioned by Gaspard and Johann Bauhin nearly two centuries before Linnaeus; came

out with the brilliant binomial system of nomenclature as we know it today. With this system, similar entities were grouped into genera and differences between the same genera could be easily addressed to, thus cataloguing biology and considerably simplifying things for biologists. The rest is history. The system was extensively built upon, biological entities were described, classified, synonymised and reclassified by taxonomists. The list of taxonomists who spent their lives classifying living organisms, spending months and years together at remote locations, with the barest of minimum requirements, is endless. Present day taxonomists still bank on the contributions of these workers from the 'golden era' of taxonomy. New discoveries still progress, adding to biodiversity, while pre mature extinctions close the chapter for many. With the current pace of development, many species, especially the microbes are vanishing even before they could be discovered.

Modern laboratory based techniques and methodologies are now contesting and challenging classical taxonomy, the outcomes of which, only time will tell. An attempt has been made in the National Conference on New and Emerging Trends in Bioinformatics and Taxonomy (14-15 January 2015; B.N. Bandodkar College of Science, Thane, Maharashtra, India), to bring revered taxonomists following the classical system of taxonomy and followers of usage of modern techniques and hi-tech gadgets and instruments in taxonomy, on a common platform to highlight their respective views on the common subject of cataloguing something not created by them.

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Invited Talk (pre-conference workshop)

Advances in Microbial Taxonomy

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As microbes are diverse in nature, it is imperative to classify and group them. The three components of microbial taxonomy include classification, nomenclature and identification. Those organisms which share common traits with respect to the criteria used are placed in the same category. The properties which are useful in classification of bacteria are the shape of the cell and its arrangement, the colony characteristics, the Gram nature of a cell, whether aerobic or anaerobic, type of carbon and energy source it can utilize, the special structures it possess viz: flagella, capsule, endospore, the structure of its cell wall and the special physiological, metabolic and biochemical characteristics it possess. These can be listed as the phenotypic features and form the basis of numerical taxonomy. Highly specific serological tests also offer an important tool in classification of organisms. The antiserum contains antibodies that react with the antigens on the unknown organisms. Binomial system is applied for naming the microbes.

The advent of polymerase chain reaction gave fillip to the approach of molecular microbial taxonomy. In this technique, the cells are lysed and processed to yield DNA. The genetic material can subsequently be amplified to measurable quantities.

The use of the chain reaction has produced a so-called bacterial Phylogenetic tree.

Determining the G + C content of DNA is a valuable tool in taxonomy.

$$\text{Mol \% (G + C)} = \frac{(G+C)}{G+C+A+T} \times 100 \%$$

It is estimated by determining T_m , i.e. the melting temperature of DNA. Higher melting temperature implies higher G + C content. Also, it is an indirect evidence of the nucleotide base sequence,

DNA or RNA sequences can be compared by the technique of Nucleic acid hybridization. This can be achieved by mixing single stranded DNA (ssDNA) from two

different species and thereby determine the percentage of the DNA that can form double stranded DNA (dsDNA) hybrid. If the species are closely related, the percentage of nucleic acid hybridization is greater. Thus nucleic acid hybridization can resolve the genetic relatedness between the organisms.

The genomes can be compared by the technique of nucleic acid sequencing. Sequencing of conserved genes like rRNA is reliable because generally it remains stable and also any change may occur over a long period of time. The sequences of SSU rRNA are employed in Phylogenetic studies of microorganisms. The nucleic acid sequence for the complete genome of a number of species is now available. Subunit 5S and 16S ribosomal RNA (rRNA) sequences can be compared and this comparison becomes a useful tool in establishing the phylogenetic relationships of microbial groups. At times, there is a huge diversity in terms of its metabolic and ecological parameters among the members of the group. This may perhaps reflect the parallel evolution of certain aspects such as fermentation pathways, photosynthetic pathways etc. The 16S rRNA gene is a part of prokaryote DNA which is found in all bacteria and Archeobacteria. This gene codes for an rRNA molecule which in turn makes up the part of the ribosome. The ribosome is composed of the large subunit (LSU) and small subunit (SSU). The mRNA molecule is sandwiched between these two subunits. Thus 16S rRNA gene is the most powerful and effective tool for identifying the bacteria. The traditional characterization included phenotypic traits like morphology and Gram nature. But today, taxonomists consider DNA analysis more reliable than the phenotypic traits. If one wishes to classify only the bacteria in a particular ecological niche, then 16S rRNA gene is a promising tool for extracting and identifying bacteria as it is separate and distinct from 18S rRNA gene Eukaryote. Also the 16S rRNA gene is comparatively shorter at 1.5Kb. All these features justifies making 16S rRNA faster and cheaper to sequence than many other bacterial genes.

Microbial phylogeny can be determined by genomic

finger printing techniques. These include multilocus sequence analysis (MLSA), multilocus sequence typing (MLST), restriction fragment length polymorphism analysis (RFLP), the study of repetitive sequences and single nucleotide polymorphism analysis.

At times, sequencing the amino acids of some proteins can serve as a vital tool in establishing the taxonomy and phylogeny. In order to evaluate the phylogeny of microbes, molecular methods which involves molecular chronometers, Phylogenetic trees, signature sequence and polyphasic approach are used. Molecular chronometers postulate that the changes in the conserved genes have occurred over time. However, the function of the molecule has not changed. Phylogenetic trees compare molecular sequence of a conserved gene between organisms. These differences are depicted in the form of a branched 'tree'. Signature

sequence incorporates the criteria that the particular groups of microbes will possess unique nucleotides at specific locations in 16S rRNA molecules. Polyphasic taxonomy employs a wide range of stable phenotypic information. Phylogenetic classification incorporates evolutionary relationships instead of similarity of properties .It is inevitable for a microbial taxonomist to utilize Phylogenetic trees constructed from rRNA analysis. Bergey's Manual of Systematic Bacteriology provides the taxonomy of prokaryotes.

Invited Talk (pre-conference workshop)

Taxonomy of Arbuscular Mycorrhizal Fungi - Past and Present

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Abstract : Taxonomy is an essential subdivision of the biological sciences. VAM fungal taxonomy has advanced greatly during the last 30 years. Today, the basic taxonomic categories of genus and species are well-defined and a reasonably stable nomenclature is available for accurate identification of taxa. During the last three decades systematics of VAM fungi (now AMF) has gained significance because of their role in soil fertility, nutrient uptake and bio control of plant diseases. Many of the fungi have not yet been cultured axenically which also includes VAM fungi. Therefore, their identification depends on specimens directly isolated from soil on the maximum observable characters. Arbuscular mycorrhizal fungi (AMF) are grouped in a monophyletic group, the phylum Glomeromycota. The taxonomy and systematics of these obligate biotrophs is addressed by recognizing four periods. The initial discovery period (1845-1974) is characterized by description mainly of sporocarp-forming species and the proposal of a classification for these fungi. The alpha taxonomy period (1975-1989) that followed, established a solid morphological basis for species identification and classification, resulting in a profuse description of new species and a need to standardize the nomenclature of spore subcellular structures. The cladistics period (1990-2000) saw the first cladistic classification of AMF based on phenotypic characters only. At the end of this period, genetic characters played a role in defining taxa and elucidating evolutionary relationships within the group. The most recent phylogenetic synthesis period (2001 to present) started with the proposal of a new classification based on genetic characters using sequences of the multicopy *rRNA* genes.

Keywords: Arbuscular Mycorrhizal Fungi, Glomeromycota

Introduction

Arbuscular Mycorrhizal Fungi: VAM fungi belong to the Glomeromycota. They are primitive fungi at the base of the tree for higher fungi (basidiomycetes). They associated with first land plants and appear to have evolved very slowly since then. They have no known sexual state. They produce microscopic structures, or relatively small sporocarps (truffle-like). Just over 200 species of these fungi are described, yet they are capable of forming mycorrhizal associations with a vast majority of plants.

Taxonomy

Traditionally, Glomeromycotan taxonomy of arbuscular mycorrhizal (AM) fungal group has been based on the morphology of the spores. The way the spore is formed on the hypha ("mode of spore formation") has been important to circumscribe genera and families, and the layered structure of the spore wall is used to distinguish species (Morton, 1988).

The accumulation of data on identification of VAM fungi has been scientifically done by Schenck and Perez (1990). In the members of the family Glomaceae viz. *Glomus* and *Sclerocystis* the spores are formed on cylindrical sporogenous hyphae. In *Sclerocystis* individual spores are *Glomus* like, formed in sporocarps, spores arising in an orderly manner from sterile central plexus (Gerdemann and Trappe, 1974). Almeida and Schenck (1990) recognize only

Sclerocystis coremioides as valid species of genus *Sclerocystis*. The remaining species have been considered as synonyms of existing species of *Glomus*.

In *Acaulospora* and *Entrophospora* belonging to family Acaulosporaceae, a saccule is formed terminally on a sporogenous hyphae, after which the spores are formed laterally or in between. The spores in *Gigaspora* and *Scutellospora* of family Gigasporaceae are expanded from and borne on a bulbous sporogenous cell and have much large spores than in the other four genera. (Spain *et. al.*, 1990).

Most members of sub-order Glomineae develop Vesicular Arbuscular Mycorrhiza (VAM) and members of Gigasporineae form Arbuscular Mycorrhiza (AM). Before 1974, most AM fungi were in the genus *Endogone*, until Gerdemann and Trappe (1974) (Table 1) placed them in four different genera in the order Endogonales (*Glomus*, *Acaulospora*, *Sclerocystis* and *Gigaspora*).

Morton and Benny (1990) (Table 2) established a new order Glomales in Zygomycota, but then evidences started accumulating based on rDNA phylogenetic studies and it was proved that it was the sister group of Ascomycota and Basidiomycota.

Table 1. Classification of VAM fungi by Gerdemann and Trappe (1974), Benjamin (1979)

Phylum	Order	Family	Genera
			<i>Endogone</i>
			<i>Sclerogone</i>
Zygomycotina	Endogonales	Endogonaceae	<i>Glomus</i>
			<i>Sclerocystis</i>
			<i>Acaulospora</i>
			<i>Entrophospora</i>
			<i>Gigaspora</i>
			<i>Scutellospora</i>

Table 2. Classification of VAM- fungi by Morton and Benny (1990)

No.	Order	Sub-order	Family	Genera
1	Endogonales	--	Endogonaceae	<i>Endogone Sclerogone</i>
2	Glomales	Glomineae	i)Glomaceae	<i>Glomus</i>
				<i>Sclerocystis</i>
			ii)Acaulosporaceae	<i>Acaulospora</i>
				<i>Entrophospora</i>
		Gigasporineae	Gigasporaceae	<i>Gigaspora</i>
				<i>Scutellospora</i>

The taxonomy of AM Fungi with examples of the large spores produced by different genera in the soil by Dodd (2000) is as shown in Table 3.

Table 3. Classification of AM- fungi by Dodd (2000)

Order	Class	Genera
Glomales	Glomaceae	<i>Glomus</i> , <i>Sclerocystis</i>
	Acaulosporaceae	<i>Acaulospora</i> , <i>Entrophospora</i>
	Gigasporaceae	<i>Gigaspora</i> , <i>Scutellospora</i>

Based on molecular, morphological and biochemical data, Morton and Redecker (2001) erected two new families viz. Archaeosporaceae and Paraglomaceae (now paraglomeraceae) in the order Glomales (now Glomerales). The family Archaeosporaceae consists of a single genus, *Archaeospora*, with three species forming *Acaulospora*-like spores from the neck of a sporiferous saccule. Two of these species viz., *Ar. gerdemannii* and *Ar. leptotica* were considered dimorphic, and also formed *Glomus* like spores. The genus *Paraglomus* consisted of two species producing spores different from *Glomus* species. The latest classification is given by Schubler *et al.*, (2001) (Table 4)

with amendments of Oehl *et al.*, (2006), Spain *et al.*, (2006), Walker *et al.*, (2007), Oehl *et al.*, (2008) and Palenzuela *et al.*, (2008).

Table 4. Classification of AM- Fungi by Schubler *et al.*, (2001)

Phylum - Glomeromycota

Class - Glomeromycetes

Order	Family	Genera	
Archaeosporales	Ambisporaceae	<i>Ambispor</i>	
	Archaeosporaceae	<i>Archaeospora</i> <i>Intraspora</i> <i>Geosiphon</i>	
	Geosiphonaceae		
	Diversisporales	Acaulosporaceae	<i>Acaulospora</i> <i>Kuklospora</i>
		Diversisporaceae	<i>Diversispora</i> <i>Otospora</i>
		Entrophosporaceae	<i>Entrophospora</i>
	Gigasporaceae	<i>Gigaspora</i>	
	Scutellosporaceae	<i>Scutellospora</i>	
	Racocetraceae	<i>Racocetra</i> <i>Cetraspora</i>	
	Dentiscutataceae		<i>Dentiscutata</i> <i>Fuscutata</i> <i>Quatunica</i>
		Pacisporaceae	<i>Pacispora</i>
	Glomerales	Glomeraceae	<i>Glomus</i>
Paraglomerales	Paraglomeraceae	<i>Paraglomus</i>	

In this system of classification, all the AM fungal species are placed in four orders viz. Archaeosporales, Diversisporales, Glomerales and Paraglomerales which comprise 13 families and 19 genera that belong to class Glomeromycetes of the phylum Glomeromycota. The family Geosiphonaceae with a single species viz., *Geosiphon pyriformis* is placed under the order Archaeosporales and does not form arbuscular mycorrhizae. It forms endocytosymbiosis with cyanobacteria (*Nostoc* sps.) and is placed under the phylum Glomeromycota due to its molecular relationship.

Conclusion

Currently there are 228 described AMF species (Schüßler and Walker, 2010), but only for about 50% of these, sequence data are available and only ~81 sps. are available in the form of cultures from culture collections (e.g. International Culture Collection of VA Mycorrhizal Fungi, INVAM; The International Bank for the Glomeromycota, BEG; Glomeromycota in Vitro Collection, GINCO; cf. Morton, 1993; Declerck *et al.*, 2005). Until 2001 it was discussed whether

AMF are a non-monophyletic group of fungi, but based on phylogenetic analyses of the small subunit (SSU) rRNA gene, it was shown that the AMF are a monophyletic and well separated clade of fungi (Schüßler *et al.*, 2001). Thus, the AMF were placed in their own fungal phylum, the Glomeromycota (Schüßler *et al.*, *loc.cit.*), as weakly supported sister group of Asco- and Basidiomycota.

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Invited Talk (pre-conference workshop)

Chemotaxonomy of Plants

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Mother Earth is blessed by a number of diverse life forms. In order to carry out systematic study of these, it is essential to assign different organisms in suitable groups. Thus taxonomy is a highly important branch of biology which involves appropriate methods to classify the life forms on the basis of similar or dissimilar characteristics. The traditional classification system of plants greatly relies on morphological characters such as nature of leaf, number of floral members, aestivation of petals, etc. The knowledge of phytochemicals and their utility in plant classification is also age-old. Its application started in mid period of 17th century and resulted in the development of chemotaxonomy - a unique approach of classifying the plants on the basis of their phytochemicals. Chemotaxonomy is applicable at all levels of hierarchy of classification from the rank of species to the rank of class.

A simple principle is involved in chemotaxonomy. Using knowledge of distribution of key phytochemical/s, the closeness or distantness among the plants is determined. The degree of resemblance in plants is mainly dependent on sharing of common alleles. These common alleles direct the resembling metabolic pathways which lead to production of related metabolites in plants. Therefore, while applying chemotaxonomy, the crucial factor is selection of appropriate individual phytochemical or group of related phytochemicals. Each plant produces diverse types of phytoconstituents which include primary and secondary metabolites. Generally

any phytochemical which is widely distributed, physiologically stable and easily identifiable is preferred in this approach of plant classification.

The pioneer chemotaxonomists used to group the plants mainly on the basis of presence or absence of different secondary metabolites such as flavonoids, alkaloids and aromatic compounds. Many chemical analyses of members of certain orders or families revealed the presence of characteristic compounds; e.g. plants belonging to the order centrospermae produce betalains, members of the plant family lamiaceae are characterized by presence of terpenoids whereas solanaceae members contain tropane alkaloids.

The modern era of chemotaxonomy involves use of molecular markers of nucleic acids and proteins. Coupling of molecular techniques of electrophoresis and sequencing with tools of bioinformatics proved to be highly applicable especially in phylogenetic studies, e.g. comparison of DNA sequences in wheat, rye and barley of Triticeae showed many similarities between wheat and rye. Analyses of pattern of peroxidases, esterases and phosphatases between *Vicia* and *Lathyrus* indicated close phylogenetic relationship.

Thus one can say that chemotaxonomy is an enhancement over the traditional approach. Unique blending of traditional and chemical taxonomy can become useful for resolving shortcomings of traditional method as well as establishing evolutionary relationships.

Invited Talk (pre-conference workshop)

Isolation, Taxonomic Study and Conservation of Some Rare Fungi from Unusual Habitats: Fungi from Forest Floor

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Galaxy of fungi and their natural beauty occupy prime place in the biological world. Fungal species are especially important components of biodiversity in tropical forests. As major contributors to the maintenance of the earth's ecosystem, biosphere and biogeochemical cycles, fungi perform unique and indispensable activities on which larger organisms including humans depend. It is hard to imagine terrestrial life without fungi. However, current knowledge regarding the successive changes in fungal communities and their role during litter decomposition and colonization of various substrates are limited. The isolation of uncommon fungi from various substrates like leaf litter, fallen fruits, wood logs etc. from forest floor needs selective isolation techniques on selective nutritional media. For example, isolation procedure for fungi from fallen fruits on forest floor showing visible fungal growth on their surface is to pick a small portion from the selected visible spot which is then placed on fresh medium; isolation of litter fungi by hanging bag method, incubation of substrate in humid chamber and isolation etc. Taxonomic study of isolates is essential for proper identification. It includes morphological characterization such as growth pattern, colour, texture on various medium, measurement of reproductive parts viz., conidia, conidiophores etc.

In India there are several microbial (culture) collections which are serving the entire nation but only such centres cannot cater to the need of mycologists. They all are specialized in their approach with one major objective in mind i.e. conservation and preservation of indigenous biodiversity. Thus there is need to explore unusual habitats as well as substrates by university/ college professors and researchers to isolate the fungi in pure form and preserve them in suitable forms at their center and submit the pure cultures to recognized repository, so that the novel organisms and potent fungal cultures would be easily available to workers concentrating their research on fungi.

The exploration and conservation of biodiversity completely is not possible by few specialized people. India is mega biodiversity country. There is need to take part in exploration of fungal diversity, particularly the roles of under graduate and post graduate students are more important in the conservation of fungi.

Invited Talk (Second pre-conference Workshop)**Herbarium and Herbarium Technology****Ujwala C. Bapat**

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**Introduction:**

Herbarium is a store-house of preserved and identified plant specimens that are identified and stored in cupboards for future use. The herbarium specimens are often used as reference material for the study of plant taxonomy, geographic distributions of plants and for stabilizing nomenclature and for cataloguing or identifying the flora of an area.

There are many herbaria established in the world (e.g. Royal Botanic Garden-Kew at London, UK, Missouri Botanic Garden at St. Louis, USA, Royal Botanic Garden at Edinburgh, UK, National herbarium at Melbourne, Australia, Central National Herbarium at Howrah, India, National Botanic Garden herbarium at Lucknow, India, Blatter Herbarium, Mumbai, India and several others).

Technique of preparing the herbarium specimens:

1. Collection of plant material:

Plant samples should be collected from the natural environment (wild).

A good herbarium specimen is an entire plant along with roots in case of annual herbs and grasses and a twig with flowers and fruits in case of shrubs and trees.

Only a small set of plant samples should be collected

Important thing to remember is rare plants, isolated plants or plants with diseases or spoiled should not be collected.

2. The collected specimen is arranged (e.g. lower side of at least one or 2 leaves is displayed) between sheets of news paper/blotting papers. A plant press may be used to apply sufficient pressure and the paper sheets may be changed as required.
3. After drying the specimen is treated with a solution of mercuric chloride prepared in absolute alcohol and is mounted on a hard paper (standard size 16.5 in X 11.5 in) either by stitching or by sticking with glue.

4. Small envelopes may be used to keep small seeds/ fruits or fallen parts of the specimen. The envelope may be stuck on the herbarium sheet along with the specimen.

5. Labeling:

A small label with the information such as plant family, scientific names i.e. generic and species, location, habitat, collector's name and collection number, date of collection and descriptive information such as local name, color of the flowers, medicinal uses (if any) etc., is stuck on the lower right corner of the herbarium sheet.

In the herbarium, the specimens of a plant species are kept in one folder. The different species of the same genus are alphabetically arranged in a genus folder (bigger size). The genera folders of a family are also arranged in alphabetical order in the pigeon holes of the cupboards (wooden or steel). The families are arranged as per the classification system followed in that region (in most of the Indian herbaria, they are arranged according to Bentham and Hooker's system of classification).

Blatter Herbarium:

It is situated in Mumbai at the Department of Botany, St. Xavier's college. It is listed in the *Index Herbariorum*, published by the International Association for Plant Taxonomy. It was initially known as the 'Collegii St. Francisci Xavierii Herbarium' and was established by Rev. Fr. Ethelbert Blatter S.J., in 1906 as a teaching aid for the undergraduate students. It was renamed under the present title, 'The Blatter Herbarium' in 1941 by Rev. Fr. Santapau S.J. The Herbarium has a collection of more than 150,000 plant specimens mainly from western Maharashtra. There is a separate unit of 460 type specimens (the species is named and described based on the characters observed in that particular specimen). It also stores the specimens of Gymnosperm, Pteridophytes, Fungi and Algae. Other collections include germplasm (seeds) of many wild and economically and medicinally important plant species from Maharashtra (in the Santapau carpology Center) and dry wood samples of timber trees of Maharashtra, gums, resins,

medicinally and economically important plant products, fruits and seeds (in the museum).

There is a rich library having diversified collections of original literature on plant taxonomy, Forestry, Agriculture, Medicinal Botany, Ethnobotany, Silviculture, Drugs, Economic botany, Gardening, Algae, Fungi, Lichens, Mosses, etc. beginning from 16th Century to the present time. More than 2,600 books are housed in this library. Some of the books viz. 'Coloquios dos simples e drogas e cousas medicinais da India' by Garcia d'Orta (1563) and 'Hortus Indicus Malbaricus' by Van Rheedee are worth mentioning here. The library also holds national and international floras and journals. Following are the recent publications from Blatter Herbarium.

Almeida, S. M. 1990. The Flora of Sawantwadi, Vol. I- II

Almeida, M. R. 1996 -2009. Flora of Maharashtra, Vol. I - VI

Almeida, M. R. and Almeida S. 2005. Dictionary of Generic Names of Flowering Plants and Ferns in Maharashtra

Almeida, M.. R. 2007. Konkani Names of Plants (With comments on Hortus Malabaricus)

Almeida, S. M. and Almeida, M. 2010. Hand-Book of Diseases and Their Herbal Remedies in Maharashtra

Services offered:

Authentication of plant samples

Referral services

Organization of field trips

e-mail: blat@xaviers.edu

Phone 022-22620665 extn. 345

Invited Talk (pre-conference workshop)

Floral Biodiversity of the Western Ghats

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Biodiversity is the result of 3.5 billion years of changes that continuously occurred throughout the formation of the earth. Biodiversity is defined as the degree of variation of life. It is a measure of the organismic variety present in diverse ecosystems. Under the directive of IUCN, in the year 1982, B. A. Wilcox defined, "Biological diversity is the variety of life forms at all levels of biological systems (i.e., molecular, organismic, population, species and ecosystem)". Terrestrial biodiversity tends to be highest near the equator. The biodiversity is not evenly distributed on this planet earth. Biodiversity is found to be richest in tropical regions and it tends to cluster in hotspots. Biodiversity of an area is assessed by International Union for Conservation of Nature (IUCN), World Wildlife Fund for Nature (WWF) and United Nations Environment Program (UNEP). The authorities for biodiversity in India are National Biodiversity Authority (NBA), Botanical Survey of India (BSI) and Maharashtra State Biodiversity Board (MSBB).

The term hotspot was introduced in the year 1988 by Dr. Sabina Virk. A biodiversity hotspot is a region with high level of numerous species that is under threat by humans. According to Myers et al. (2000), biodiversity hotspots must contain at least 0.5% or 1,500 species of vascular plants as endemics, and it has to have lost at least 70% of its primary

vegetation. Around the world, there are 25 areas which can be considered as biodiversity hotspots, with nine other possible regions. These sites support nearly 60% of the world's plant, bird, mammal, reptile, and amphibian species, with a very high share of endemic species.

The Western Ghats are also known as Sahyadri Hills. It is well known for its rich and exclusive collection of flora and fauna. Norman Myers included the Western Ghats amongst the 25 biodiversity hotspots identified in the world. The Western Ghats is home to several serene hill stations like Munnar, Ponmudi and Waynad. The Silent Valley National Park in Kerala is among one of the last tracts of virgin forest in India. The forest in the Western Ghats has been severely fragmented due to human activities, mainly from 1860 to 1950. Species that are rare, endemic and restricted to the habitat are more adversely affected and tend to be lost faster than other species.

From the total area of Western Ghats, only 9% is protected with 20 National parks and 68 sanctuaries. In Western Ghats 39 sites are declared as world heritage sites in the year 2012. There are 7,402 species of flowering plants of which 1,273 are endemic. Twenty six percent of flowering plants of India are found in this region. Since 1980 more than 300 new species have been discovered.

Invited Talk (Second pre-conference Workshop)

The Evolutionary Basis of Bioinformatics: An Introduction to Phylogenetic trees

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Abstract: Evolution helps us to understand the history of life. Phylogenetic is the science of creating the evolutionary trees which has become prevalent in the study of evolutionary biology. Charles Darwin sketched his first evolutionary tree in 1837, which to present remains the central representation in evolutionary biology. He however never called his diagram of common descent as a tree. A phylogenetic trees, is a hypothesis about the relationships among organisms. This paper attempts to provide basic information on phylogenetic trees.

Introduction

Biological evolution is descent with modification. Evolutionary changes and relationships are represented as family trees. Life has a history which has changed over time however different species share common ancestors. Based on fossil records and studying the evolutionary patterns and relationship among the different life forms on earth, both living (extant) and dead (extinct), scientists build hypotheses of life's history or the phylogenetic trees. Phylogenetics thus describes the pattern of relationships among taxa and presents evolutionary relationships through illustrations called phylogenetic trees.

Jean-Baptiste Lamarck (1744-1829), a French Naturalist propounded the first scientific theory of evolution (inheritance of acquired traits). He advocated that species were not created in their current form but have changed over time. Since the time of the ancient Greeks, the prevailing guide to thinking about nature, was the so-called "*ladder of life* or *Great Chain of Being*" also known as *scala naturae*. Lamarck's assumption was the continuum between physical and biological world. He explained there is a ladder of life with superior forms (humans) near the top and lower forms on lower rungs. He did not think of evolution in a tree-like form. However, living organisms are not ancestors of one another and the ladder implies progress thus Charles Lyell (1797-1875) English Geologist summarized and opposed Lamarck's views. Evolution is not linear but branching. He noted that evolution implies a tree-like form. Charles Darwin (1809 -1882), proposed a mechanism of natural selection and he accepted Lyell's view that evolution implies a "tree of life". Darwin considered the "tree of life" important in understanding evolution (descent with modification) and he included a tree like diagram in his book "On the origin of species" (Darwin, 1859). If a mutation occurs, one species is not turning into another, but there is a split, and both lineages continue to evolve. So, evolution is not progressive and phylogenetic trees reflect the hierarchical structuring of relationships. In the years following Darwin's work,

biologists formally rejected the ladder of life in favour of the tree concept.

The Foundation of Phylogenetics: Taxonomy is the science of naming, classifying and describing organisms. From the beginning scientists such as Carolus Linnaeus have used nomenclature, i.e. the naming of organisms and classification, i.e. the assignment of taxa to groups of organisms, in order to figure out their origins. These classifications were initially based on morphology and anatomy, later however computational and molecular methods became available. Molecular phylogenetics and its applications are popular and useful tools for making comparative investigations in genetics: however estimating phylogenetic trees is not always straightforward (Bos and Posada, 2005). Molecular phylogeny based on nucleotide or amino acid sequence comparison has become a widespread tool for general taxonomy and evolutionary analyses (Moreira and Philippe, 2000). German botanist Walter Zimmerman (1931) and later German entomologist Willi Hennig (1950) developed formal methods for reconstructing phylogenies. Scientists looked at how closely different species were related to one another and when they seemingly went towards different evolutionary directions. Systematics is the study of taxonomy and phylogenetics and phylogenetics was developed to answer these questions and study the evolutionary patterns and relationship. The species phylogenies are generally inferred based on the paleontological/geological information or morphological traits (Nei, 2003). Phylogenetic trees are used to analyse and visualize evolution. However, trees can be imperfect data types when summarizing multiple trees. This is especially problematic when accommodating for biological phenomena such as horizontal gene transfer, incomplete lineage sorting, and hybridization, as well as topological conflict between datasets (Smith *et. al.*, 2013). Evolutionists dream of tree-reconstruction method that is efficient (fast), powerful, consistent, robust and falsifiable (Penny, *et. al.*, 1992). Molecular phylogeny has been regarded as the ultimate tool

for the reconstruction of relationships among eukaryotes - especially the different protist groups-given the difficulty in interpreting morphological data from an evolutionary point of view. In fact, the use of ribosomal RNA as a marker has provided the first well resolved eukaryotic phylogenies, leading to several important evolutionary hypotheses (Philippe et.al., 2000).

Phylogenetic Trees and Relatedness (genetic similarity): Phylogenetic trees are the graphical representation of the evolutionary relationship between the taxa/genes in question. A dendrogram is a broad term for the diagrammatic representation of a phylogenetic tree. Different terminologies are used to describe the characteristics of a phylogenetic tree. The cladogram is a dendrogram which explains only genealogy of the taxa but says nothing about the branch lengths or time periods of divergence (Procter et al., 2010). Similarity is a result of descent from a common ancestor. Species evolved over a time. Relatedness is defined in terms of closeness to a common ancestor. As a result, the question "Is species 'A' more closely related to species 'B' or to species 'C'?" can be answered by asking whether species 'A' shares a more recent common ancestor with species 'B' or with species 'C' (Baum, 2008). Relationship is evolutionary kinship (closely related organisms share a recent common ancestor). Phylogenetic relatedness should be the sole basis of classifications. Characters that vary among organisms contain information on the phylogeny.

Basic elements of a phylogenetic tree: A phylogenetic trees, is a hypothesis about the relationships among organisms. Different organisms located at the top of the tree diagram. Scientists hypothesized that all species on Earth have evolved from the same common ancestor. The more closely two species are related, the more recent their last common ancestor. The tip of the tree represents the taxa in the study. It may be at any taxonomic level i.e. order, species, population etc. They are called OUT (operational taxonomic unit). The lines within the trees are called branches. The points at which the branches connect are the internal nodes and the tips of the branches are the external nodes which represents the taxa. Branch connects two nodes of the tree. The length of each branch from one node to another node represents the changes that occurred until the next speciation event. Some trees have a basal node called root. The different traits or characteristics located along the tree diagram (Fig. 1). Evolutionary trees depict clades. A clade is a group of organisms that includes an ancestor and all descendants of that ancestor (Fig. 1).

A phylogenetic tree estimates the historical connections between species and genes that they carry. The root of the tree represents the ancestral lineage (Fig. 2). The tip of the branches represents the descendants of that ancestor (Fig. 2). As we move from the root to the tip we are moving forward in time (Fig. 2). In a phylogenetic tree each node represents a speciation event in evolution. When a lineage splits (speciation), it is represented as branching on a phylogeny. When a speciation event occurs, a single ancestral lineage gives rise to two or more daughter lineages (Fig. 3). Phylogenetic analysis provides a powerful tool for comparative genomics (Pagel, 2000). Trees may be rooted or un-rooted. A phylogenetic tree is rooted when it has a basal ancestor (the root). There exists a basal root node (Fig. 4). The path from the root to the nodes corresponds to evolutionary time. In un-rooted phylogenetic tree, all the objects on it are related descendants but there is insufficient information to specify a common ancestor (the root). Un-rooted trees thus do not have an ancestral root (Fig. 5). Phylogenies trace patterns of shared ancestry between lineages. Each lineage has a part of its history that is unique to it alone and part that are shared with other lineages. Similarly lineage has ancestors that are shared with other lineages called common ancestors (Fig. 6). Phylogeny represents the evolutionary relationships among a set of organisms or groups of organisms, called taxa. The tips of the tree represent groups of descendent taxa and the nodes on the tree represent the common ancestor of those descendants. Two descendants that split from the same node are called sister group. Sister group are each other's closest relatives (Fig. 8). Many phylogenies also include an out group which stems from the base of the tree. All the members of the group of interest are more closely related to each other than they are to the outgroup (Fig. 8). Outgroup is useful in constructing evolutionary trees. A Phylogenetic tree represented with branches of different length shows scaled branches and it is based on the number of evolutionary changes or distance (Fig. 9). A Phylogenetic tree represented with branches of same length shows un-scaled branches (Fig. 10).

With the increased availability of whole genome sequences, the field of phylogenomics (i.e. use of either whole genome or a large number of genes for phylogenetics analysis) is becoming popular among the evolutionary biologists (Korbel, et. al., 2002; Thornton and DeSalle, 2000). Sequence-based phylogenetic reconstruction is analysing the molecular sequences of different species by methods like (a) distance-based methods, such as (NJ) Neighbor Joining (Saitou and Nei, 1987), which has very fast practical performance; (b) heuristics for either (ML) Maximum-Likelihood (Felsenstein, 1981) or Maximum-Parsimony (MP) (Fitch, 1971), which are two NP hard optimization problems; and (c) the Bayesian Markov Chain Monte Carlo (MCMC)

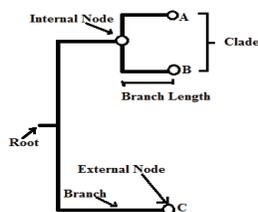


Fig. 1: Basic elements of a phylogenetic tree.

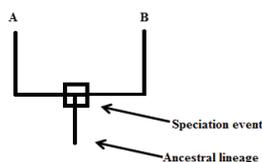


Fig. 3: Speciation event in Phylogenetic tree

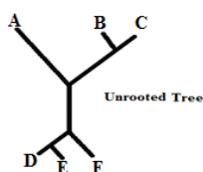


Fig. 5: An unrooted Phylogenetic tree

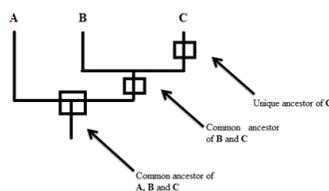


Fig. 7: Phylogenetic tree depicting clades

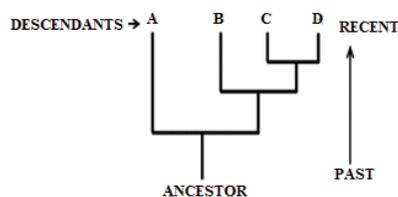


Fig. 2: A phylogenetic tree showing ancestor – descendent relationships among taxa

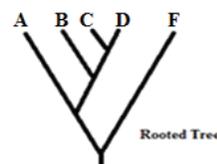


Fig. 4: A rooted Phylogenetic tree

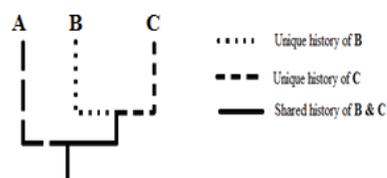


Fig. 6: Phylogenetic tree showing lineages

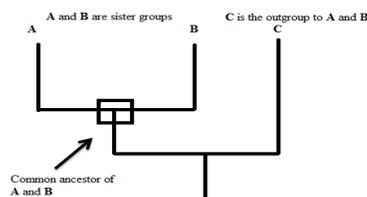


Fig. 8: Phylogenetic tree depicting outgroups

method, which, instead of a single tree, produces a probability distribution of the trees or aspects of the evolutionary history. Current practice dictates that trees be constructed using different methods and that the resulting trees then be compared for consensus (Farach and Thorup, 1995). Molecular phylogenetics is a broad, diverse field with diverse applications, supported by multiple computational and statistical methods. The field of molecular phylogenetics has grown, both in size and in importance, since its inception in the early 1990s.

Conclusion:

Constructing evolutionary trees for species sets is a fundamental problem in biology. The importance of phylogenetics has been greatly enhanced by the successful application of tree reconstruction. There has been advancement of other phylogenetic techniques, to resolve more diverse and perplexing issues in biology. Phylogenies are used essentially by drawing inferences from the structure of the tree or from the way the character states map onto the tree. Broadly speaking, the relationships established by

phylogenetic trees often describe a species' evolutionary history and, hence, its phylogeny, the historical relationships among lineage's or organisms or their parts, such as their genes. A phylogenetic tree of a group of species (taxa) describes the evolutionary relationship among the species. The study of phylogeny not only helps to identify the historical relationships among a group of organisms, but also supports some other biological research such as drug and vaccine design, protein structure prediction, multiple sequence alignment and so on (Linder and Warnow, 2005). Sequence-based methods are generally highly accurate. However, these methods are computationally intensive.

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Section 2 :
Research Papers

Ethnobotany of Orchids: A Review

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Abstract: Orchids are most beautiful, splendid flowers among angiosperms and the family Orchidaceae is represented by more than 30,000 species worldwide across a wide range of habitats. They are one of the most admirable creations of nature which characteristically stand apart from other plant groups. They are widely known for their economic importance but less for their ethnobotanical value. Over the centuries orchids have been a symbol of love, luxury and beauty. They have a broad range of ethnobotanical applications and have been extensively used in indigenous systems of medicines since Vedic period. They have had a long and important relationship with humans for a very long time. The article reviews ethnobotanical aspects of orchids along with their different tribal uses.

Key words: Orchids, Orchidaceae, Ethnobotany.

Introduction

Plants have played a significant role in maintaining human health and improving the quality of human life for thousands of years. Despite the availability of different approaches for the discovery of therapeutics, plant products, veterinary products, handicrafts still remain as one of the best reservoirs of new structural types. Also there is a growing interest among pharmacologists and researchers from modern medical science investigating the vast and original knowledge through the indigenous discipline known as Ethnobotany.

1. Ethnobotany in religion, superstition and magic:

Orchids have long been associated with religion, superstition and magic; usually in connection with their supposed medicinal effects on humans and animals. In Mexico, the pre-Conquest tribal chiefs placed great value on the possession of brilliant orchid flowers. After the Spaniards settled in the region, many orchids were incorporated in the religious rituals and in expression of devotion to God and saints. Some illustrious examples are mentioned below:

Infusion of *Corycium nigrescens* Sond is used in southern parts of Africa to ward off evil (Rayner, 1977).

The root of *Cypripedium humile* Salisb. Syn. *C. acaule* Ait. was an ingredient of a love charm used by the Meskawi Indians of North America (Smith, 1928).

In Western India, the dried roots of *Eulophia virens* Spreng. placed in small bags were said to drive away snakes (Dalgado, 1896).

In Indochina, the flowers of *Dendrobium pilchellum* Roxb. Syn. *D. dalhousieanum* Paxt resembling the head of a

dog, were fed to dogs to make them skillful hunters (Dournes, 1955).

The Thompson Indians of British Columbia prayed to *Habenaria leucostachys* S. Wats. in the belief that it would bring wealth and possessions. A preparation from this plant was used to wash guns to ensure good hunting, and to make the young men lucky (Steedman, 1930).

Ancient Sanskrit writings mention the use of *Eria muscicola* Lindl. to ward off calamities, avert ill fortune and promote prosperity (Hoernle, 1893- 1912).

In parts of Germany, the cuckoo's call was thought to disclose the location of ore bodies; consequently a luxuriant growth of *Orchis mascula* L., commonly known as cuckoo flower, was believed to indicate rich metal deposits beneath (Friend, 1884; Beals, 1917).

Ancient Sanskrit writings record *Vanda roxburghii* R. Br. as an ingredient of a preparation that was taken to avert calamities and in another that was eaten with food by women who wanted sons (Hoernle, 1893- 1912).

Dendrobium moniliforme Sw. was used in Japan as a beautiful ornament to decorate temples (Kaempfer, 1712; Morren, 1847; Puydt, 1880; Dakkus, 1935).

2. Ethnobotany in food:

Tubers of orchids are listed as emergency foods in eastern North America (Fernald and Kinsey, 1943).

In northeastern India, the local tribes use *Cymbidium* species for food.

In Malawi, the tubers of *Disa* sps. are sold in the form of a prepared jelly, which is boiled in salted water and served with peanuts as a side dish (Williamson, 1955).

Joret (1904) reported that the bulbs of *Eulophia campestris* Wall. constitute part of the diet of the Indian people from time immemorial.

In the western Himalayas, the tuberous roots of *Habenaria commelinifolia* Wall.ex Lindl. were reportedly used to make a gruel (Usher, 1974).

Several species of *Satyrium*, roots of *Habenaria acuminata* Thw.ex Trim. and stems of *Pholidota articulata* Lindl. have been used as food in India (Duggal, 1972).

The dried root of *Orchis coriophora* L. was cooked and eaten in the Levant (Hedrick, 1919).

3. Ethnobotany in animal and veterinary uses:

Lactagogical properties were ascribed to orchids with palmate tubers. Brondegaard (1971) surveyed the uses of orchids as aphrodisiacs in veterinary practice. Orchids also form useful food for domestic animals in northeastern India.

In Malaysia the roots of *Cymbidium finlaysonianum* Lindl. were an ingredient of a medicinal mixture given to sick elephants (Maxwell, 1906; Ridley, 1906; Burkill, 1966).

The leaves of *Habenaria hookenaria* Torr.ex A. Gray have been used in Vermont as a poultice to treat lameness in horses (Bergen, 1899).

Bulbs of *Orchis mascula* L. are prized as an aphrodisiac for animals (Levy, 1963).

Retzius (1806) reported that *Ophrys* spp. were eaten by cattle in Sweden.

The Himalayan squirrel relishes the inflorescence of *Pholidota pallida* Lindl. (Pradhan, 1977).

Sheep are reported to be fond of several species of *Diuris* in the Mudgee district of New South Wales (Hamilton, 1886).

Tubers of *Habenaria susannae* R.Br. are eaten by wild pigs in India (Wealth of India, 1959; Chopra *et al.*, 1969).

4. Ethnobotany of Traditional Herbal Medicines:

In the Middle Ages, orchids were used as a remedy for a number of illnesses. They have also been considered an aphrodisiac. In India the knowledge and use of medicinal properties of orchids dates back to the Vedic period. They have been extensively used in the indigenous systems of medicines and also find reference in Atharvaveda. There are some 20 or more medicinal value orchids that are widely employed in the indigenous systems of medicine either alone or in combinations. *Ashtawarga* is a group of 8 drugs in Ayurvedic system which are used for the preparation of tonics, such as

'Chyavanprash', consisting of four orchid species, viz. *Malaxis muscifera* (Lindl.) Kuntze, *M. acuminata* D.Don, *Habenaria intermedia* D.Don and *H. edgeworthii* Hook. f.

Conservation

It is essentially important to document tribal botanical knowledge to preserve it for future reference. Further, there is also a need for awareness among local tribes for conservational efforts to protect the rich biodiversity of the area. Biological evaluation of orchids could provide scientific rationale for their continuing use among the tribal people and could lead to the discovery of biologically active novel compounds, which may be helpful for several pharmaceutical industries.

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Review Article

***Saraca Asoca* Roxb. De Wilde: Bridging Mythology, Taxonomy and Modern Research- A Brief Review**

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Abstract : The legendary Ashoka tree (*Saraca asoca* Roxb. de Wilde) is one of the most respected sacred trees of India. In the last few years, this tree has become exceedingly rare in its natural habitats; and is more commonly seen as an ornamental in urban locations; suggesting an urgent need for conservation efforts. The taxonomical aspect and vernacular names, signifying specific characteristics of the tree, are discussed. The tree has a lot of mythological importance, ancient literary references, religious significance; being sacred to Buddhists, Jains and Hindus alike; historical importance and medicinal applications attached with it, all of which are discussed in the paper along with modern research on the plant.

Introduction

Trees are one amongst nature's most generous gifts to the planet. The direct and indirect contributions of trees towards human welfare has been well documented; so is their aspect of sociability (Datta, 2000) and, calculated in monetary terms, the value of a single tree would run into several lakhs of rupees (Gopaldaswamiengar, 1991; Sagreiya, 2000). While some trees and plants are respected and revered for a multitude of reasons since time immemorial; finding honourable references in various ancient mythological, literary and religious texts, others have earned sacred stature through their inevitable requirement as offerings to Gods, goddesses and various deities in various religious rituals. While specific plants are associated with gods, goddesses and heavenly bodies (Mehra, 1996), others find associations with *naxatras* (Ghanekar, 2010); yet others are linked with features such as happiness, health, good luck, prosperity, well being and averting of calamities (Sadhale, 1996, Bansal, 2001) and some with concrete gains such as improvement in power of concentration or enhancement of agricultural produce (Sadhale, 1999).

The Ashoka (*Saraca asoca* Roxb. de Wilde) one of the most respected and legendary trees of India; is widely revered as a sacred tree. A native of the eastern parts of the Indian subcontinent, this tree can be found up to altitudes of 750 m above MSL, in its natural habitats encompassing foothills of central and eastern Himalayan ranges, western parts of peninsular India and also the Andaman islands. Apparently more common in southern parts of India, specimens can be frequently located along woodland streams and in the shaded under storey of evergreen forest habitats (Shah, 1988). In the last few decades though, this tree has increasingly become scarce in its natural habitats (Ninan and Geethamma, 1988) and is rather more commonly seen as ornamental specimens, in cities, gardens and parks (Arora, 1990; Gopaldaswamiengar, 1991).

Botanical Nomenclature

Botanical Name: *Saraca asoca* Roxb. de Wilde

Synonyms: *Jonesia asoca* Roxb.

Saraca asoca Roxb. Dewilde.

Saraca asoca (Roxb.) W.J.de Wilde

Saraca indica Linn.

Family: Leguminosae; Sub Family:
Caesalpinaceae

Select vernacular names

Ashok Tree, True Asoka, Asoka Tree (English); *Asok*, *Ashok*, *Sita Ashok* (Hindi); *Ashoka*, *Sita Ashok*, *Jasundi* (Marathi); *Anganapriya*, *Apashaka*, *Ashoka*, *Asupala*, *Gandapushpa*, *Hemapushpa*, *Kankeli*, *Madhupushpa*, *Pindipushpa*, *Sokanasa*, *Vanjula*, *Vichitra*, *Visoka* (Sanskrit).

Commentary

The name '*Ashoka*', when split up into '*a*' and '*shoka*' indicates freedom from grief i.e. eternal joy and happiness. The same has also been translated as 'remover of ailments', supposedly referring to the medicinal and spiritual values attached to this tree. Similar connotations are indicated in the name '*Sokanasa*'. The word '*Ashoka*' literally translates into 'the sorrowless one', giving a unique benevolent significance to this tree. The similar also holds true for *Visoka*, apparently a colloquial variation. Ancient literature quotes the very touch of this tree to remove anxieties and worries, indicative of stress buster potential and anti depressant properties (Verma *et al.*, 2010) in current times. *Gandhapushpa*, *Hemapushpa*, *Madhupushpa*, *Pindipushpa* and *Vichitra* apparently bear reference to specific characters of its blooms. *Anganapriya* refers to the connotation 'favourite of the court yard' indicating it's

auspicious and valued status in front of the house. The name ‘*Vanjula*’, is apparently non-specific and refers to ‘yielder of plenty’, hinting at the benevolent nature of this tree. This tree is unique in the sense that, apart from its medicinal value, it is associated with several literary, mythological, philosophical and religious references.

Literary and Mythological Importance and Significance

There are plenty of references to this tree in the Puranas, ancient Ardhmagadhi texts and works of Kalidasa (Sarangdhar, 2007). The tree has mythological legacies in Buddhism, Jainism, Hinduism, as well as in local folklore. While Lord Gautama Buddha is widely and debatably believed to have been born under the ashoka tree, Lord Vardhamana Mahavira is believed to have renounced worldly pleasures under the same. The Ashoka tree finds reference in Valmiki Ramayana, wherein Devi Sita was confined for several months in Ashok-vatika; and where Lord Hanumana located her. The Ashoka tree, dedicated to *Kama Deva* or *Madana*, the God of love; its flowers said to constitute one among the five arrows in his quiver (Shree Malu Kavi, 1819), has several mythological legends spun around it and the ashoka tree in Sri Lanka, grown from a seedling of the original tree that witnessed the birth of Gautama Buddha, is considered the oldest surviving tree of historical importance in the world (Gandhi and Singh, 1989). This tree is valued since ancient times as a symbol of love and is believed to avert calamities, relieve grief and bestow health and longevity. The tree is also associated with beliefs related to fertility.

Religious significance

The tree is related to lord *Vishnu* and *Shiva* and Goddess *Durga*; Hinduism, Buddhism and Jainism all hold the ashoka tree in deep reverence (Biswas and Debnath, 1972). Rituals such as *asokasasthi* and *asoka tri-ratri* for auspicious benefits indicate the respectable status of the tree. Temple and Stupa art and sculptures have featured the ashoka tree in great details, as described in the respective commentaries. The trees were a common feature of Buddhist and Hindu gardens especially palace, monastery and temple gardens and court yards, possibly explaining their long association with religious sculptures and statues.

Historical Significance

Apart from legends associated with Buddhism, Jainism and Ramayana, the great emperor Ashoka is said to have patronized large scale plantations of this tree along major avenues to provide shade to travellers. The medicinal attributes of *Saraca asoca* find mention in the *Charaka Samhita* (1000 B.C.), works of *Susruta* (500 B.C.), *Vagbhata* (6th century A.D.), *Dhanvantari Nighantu* (9th century), *Raj Nighantu* (14th century), *Kayadeva Nighantu* (15th century),

Bhavaprakasa (16th century) and *Saligram Nighantu* (19th century) (Dwivedi, 1924; Sharma, 1925a, b; Surendra Mohan, 1927; Sengupta and Sengupta, 1931; Shaligram, 1956; Biswas and Debnath, 1972). Its multiple benefits are appropriately listed in the ancient treatise *Surapala's Vrikshayurveda* (Sadhale, 1996). The tree has featured in Indian art since ancient times.

Medicinal Applications and Modern Research

The pharmacognosical characteristics, pharmacological activities and phytochemical aspects of *Saraca asoca* are well documented (Pradhan *et al.*, 2009; Mukhopadhyay and Nath, 2011). The tree is known for its medicinal values (Chopra *et al.*, 1956). All parts of this tree are attributed with various medicinal properties (Kolet *et al.*, 2012) such as antimicrobial, anti-cancer, anti-diabetic, anti-inflammatory, anti-menorrhagic, anti-oxytocic, anti-progestational, anti-ulcer, analgesic, central nervous system depressant, memory enhancement, uterine toning and larvicidal properties, to name a few (CSIR, 1972; Mathew *et al.*, 2009; Bhowmick *et al.*, 2010; Lall *et al.*, 2013; Mishra *et al.*, 2013); its parts and phytochemicals finding applications in allopathy and modern drug research (Raghavan, 2011; Singh *et al.*, 2012; Shirolkar *et al.*, 2013; Asokan and Thangavel, 2014), ayurveda (Krishnan, 1966; Jadhav and Bhutani, 2005; Khatoon *et al.*, 2009), homoeopathy (Nayak *et al.*, 2009), traditional herbal medicine (Kamboj, 2000; Dubey *et al.*, 2004), folk medicine (Yadav *et al.*, 2006) and regional indigenous medicines used locally (Kingston *et al.*, 2009).

The outcomes of multi-faceted usages of this legendary tree in modern drug research encompassing its uterine stimulating (Dutt, 2008), anti-pyretic (Sasmal *et al.*, 2012), nitrogen assimilative (Prabhakar *et al.*, 2012), cardioprotective (Viswanatha *et al.*, 2013), antioxidant (Katiyar *et al.*, 2013) analgesic (Mohod *et al.*, 2014), anti-inflammatory (Gupta *et al.*, 2014) anti-platelet aggregation (Kalakotla *et al.*, 2014) anxiolytic (Manohar *et al.*, 2014) and several other major and minor properties (Verma *et al.*, 2014) are very encouraging.

Current status

Despite the best of intentions, *Saraca asoca* currently figures in the list of endangered plants (Reddy and Reddy, 2008; RPRC 2014). Apart from measures undertaken (Kala and Sajwan, 2007), there is urgent need to conserve this heritage plant and create awareness regarding its legacy and importance in Indian culture. The tree can be easily propagated from seeds and by air layering. Educational and research institutions, government offices and dedicated forest lands would be the best places to initiate conservation efforts for this unique, handsome and legendary tree.

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Research Article

Study of Phytoplankton Diversity from Ponds at Navi Mumbai, Maharashtra

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Abstract : The present study is based on diversity of phytoplankton from three freshwater bodies at Navi Mumbai. These ponds showed presence of seventeen genera representing six algal groups. Chlorophyceae was recorded as the dominant group. *Scenedesmus sp.* exhibited prominent occurrence in these ponds indicating probable pollution.

Keywords: *phytoplankton, Navi Mumbai, Scenedesmus sp.*

Introduction

Phytoplankton constitutes important primary producers in natural fresh water lentic habitats such as ponds and lakes. Phytoplankton forms the vital source of energy in the fresh water environment. (Babu *et al.*, 2014). Phytoplanktons are the autotrophic component of the plankton community. (Kulkarni *et al.*, 2012). Acting as food source for zooplankton, fish and other organisms, they form basis of aquatic food chains. Abundance of phytoplankton is related to physico-chemical environment of the water body and grazing activity of consumers. Their diversity indicates the trophic status of the habitat. The present investigation includes observations with respect to phytoplankton community of some fresh water ponds situated in Navi Mumbai region.

Navi Mumbai (19°012'N 73°012'E) is a planned city in the state of Maharashtra, India. This urban area shows high rate of developmental activities including constructions. The city has many freshwater ponds. Local authorities have undertaken beautification activities to clean and maintain some of these ponds. Three freshwater bodies from Navi Mumbai region were selected to record diversity of phytoplankton. These include Shree Amruteshwar pond at Belapur village, which is a temple pond; Gunani pond and Chatrapati Shivaji pond, situated at Ghansoli Village. The ponds are closely situated to residential areas and have influence of various anthropogenic activities including idol immersions, washing clothes, vehicle washing, bathing, and dumping of household solid waste such as plastic bottles, plastic bags, papers etc. such as plastic bottles, plastic bags, papers etc.

Materials and Methods

The study was carried out at the locations mentioned above viz. Shree Amruteshwar pond (Belapur village), Gunani pond and Chatrapati Shivaji pond (both at Ghansoli village) in Navi Mumbai. Surface water samples for

phytoplankton study were collected from the three selected fresh water bodies during periodic visits in summer (March, April, May 2014). The samples were collected in early morning hours. Fixed volume of water sample was immediately fixed with Lugol's iodine solution and later 4% formaldehyde was used for long term preservation.

The phytoplankton samples were concentrated and identified up to genera level using standard literature (Bellinger, 1992). Density count was done by Haemocytometer method (Trivedi and Goel, 1984).

Results and Discussion

During this study, a total of seventeen genera belonging to six groups of phytoplankton were recorded from the three fresh water bodies (Table 1). Fourteen genera were recorded from Amruteshwar pond, whereas Gunani pond and Chatrapati Shivaji pond showed nine and ten genera respectively.

Amruteshwar pond exhibited higher abundance of phytoplankton as compared with Gunani pond and Chatrapati Shivaji pond. The phytoplankton community of the three water bodies showed higher density of green algal members. Higher temperature recorded during summer period (27°C -29°C) appears to be favourable for growth of green algae. Abundance of green algae during the summer is in accordance with observations recorded by Bhoyar and Tamloorkar (2012).

Percentage contribution of Chlorophyceae was higher in Gunani pond. (Fig.2). Similar observations are recorded at Masunda lake, Thane (Somani, *et al.*, 2007) and lakes at Panvel in Navi Mumbai Region (Prajapati *et al.*, 2014). Among green algae, *Scenedesmus sp.* was recorded with higher abundance in all three water bodies. This was recorded as one of the most tolerant genera among fresh water phytoplankton (Palmer, 1969). *Monoraphidium sp.* was the second member in terms of abundance of green algae, especially in Amruteshwar pond.

Fig.1. Phytoplankton distribution in Shree Amruteshwar Pond

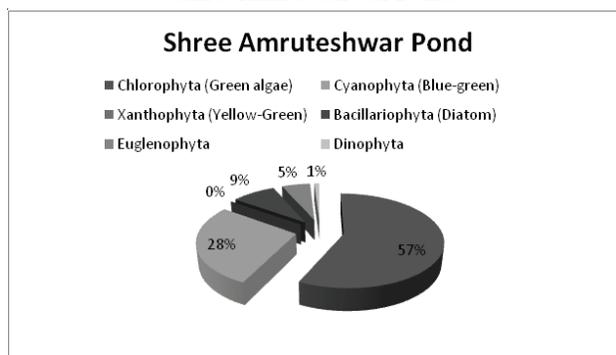


Fig. 2. Phytoplankton distribution in Gunani Pond

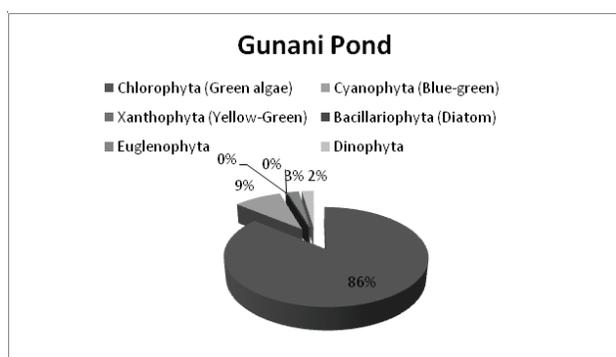
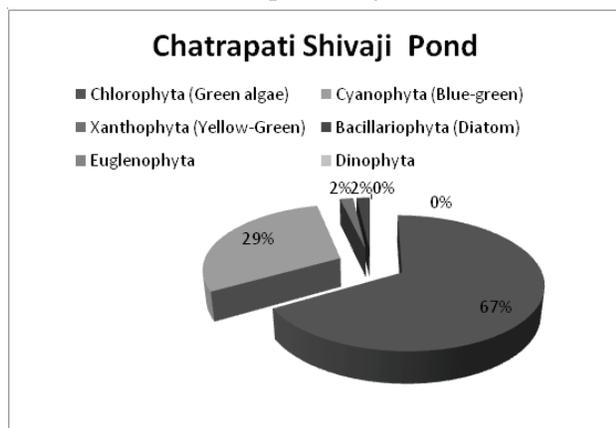


Fig. 3. Phytoplankton distribution in Chatrapati Shivaji Pond



Blue green algae showed higher percentage contribution in Chatrapati Shivaji pond and Amruteshwar pond as compared to Gunani pond. (Figs.1 and 3). Comparatively blue green algal members were better represented in Amruteshwar pond. *Lyngbya* sp was prominent here. Diatoms were at lower ebb in these three water bodies. This is in accordance with observations of Raut and Pejaver (2013).

Gunani pond and Amruteshwar pond showed higher

similarity with respect to presence of phytoplankton, as reflected in Jaccard's Index (0.53).

Conclusion

The ponds exhibited low phytoplankton diversity. The prominent presence of *Scenedesmus* sp. indicates probable pollution in these ponds. Regular monitoring of these water bodies is necessary for conservation.

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Table1. Phytoplankton Diversity

Sr. No.	Phytoplankton Density = Unit $\times 10^3$ / L			
	General	Site Location		
		Amruteshwar pond	Gunani pond	Chatrapati Shivaji pond
	Chlorophyta (Green algae)			
1	<i>Chlorella</i> sp	0	35	10
2	<i>Crucigenia</i> sp	40	40	30
3	<i>Monoraphidium</i> sp	125	90	30
4	<i>Nannochloris</i> sp	55	35	0
5	<i>Scenedesmus</i> sp	345	170	110
	Cyanophyta (Blue-green)			
6	<i>Chroococcus</i> sp	15	15	30
7	<i>Merismopedia</i> sp	55	25	30
8	<i>Anabaena</i> sp	25	0	10
9	<i>Lyngbya</i> sp	100	0	0
10	<i>Oscillatoria</i> sp	5	0	10
11	<i>Spirulina</i> sp	75	0	0
	Xanthophyta (Yellow-Green)			
12	<i>Goniochloris</i> sp	0	0	5
	Bacillariophyta (Diatom)			
13	<i>Synedra</i> sp	0	0	5
14	<i>Amphora</i> sp	80	0	0
15	<i>Navicula</i> sp	5	0	0
	Euglenophyta			
16	<i>Phacus</i> sp	55	10	0
	Dinophyta			
17	<i>Peridinium</i> sp	10	10	0
	Total Phytoplankton	990	430	270

Phytoplankton Biodiversity of Fresh Water Lake

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Abstract : Shelar Lake is a natural perennial fresh water body located in the rural area of Thane district. Phytoplankton samples were collected monthly for the period of one year i.e. from October 2009 to September 2010. In the present investigation 19 genera were recorded, belonging to chlorophyceae, cyanophyceae and bacillariophyceae; at three selected stations which show environmentally different conditions. It was observed that this ecosystem shows domination of chlorophyceae members. The cyanophyceae and bacillariophyceae were distributed almost equally at all stations.

Key Words: Phytoplankton, biodiversity, environment, fresh water.

Introduction

Lakes and reservoirs hold great promise as sources of fresh water. Unfortunately, these ecosystems are being neglected and destroyed in rural as well as in urban areas. Enhanced population explosion, rapid rate of encroachments and increase in utilization of lake water for disposal and dilution of sewage etc have not only deteriorated the water quality of lake but has also affected the biotic flora. A German Biologist Victor Hensen coined the term plankton in 1857 which means 'that which is made of drift or float'. Many workers have worked on phytoplankton. Nazneen (1980) investigated the seasonal abundance of phytoplankton while Bajpai and Agarkar (1997) studied plankton from Auli skilling field.

The Shelar lake is situated in Thane District (Maharashtra), close to the old Mumbai Ahmadabad road. Geographically it lies between 18°42' North to 20°20' North latitudes and 72°45' East to 73°48' East longitudes. It is a natural and perennial lake. During rainy season the oil and petroleum products that spill on the road, enter into the lake water thereby polluting it. On one side the lake is surrounded by agricultural land. The use of toxic chemicals, pesticides and fertilizers in agricultural practices cause pollution affecting the entire food chain. A cow shed beside the lake adds nitrogenous waste into its water, raising the organic contents to a very high level. Planktons are primary producers responsible for a large part of the Earth's global primary photosynthetic production. It is a well established fact that more than 75% of fresh water fishes feed on plankton at one or the other stage of their life cycle. Plankton responds very quickly to environmental changes because of their very short life cycle and hence their standing crop and species composition are likely to indicate the exact quality of a water body. The present study has been undertaken to study the species diversity of phytoplankton. The species assemblage of phytoplankton is very useful in assessing water quality.

Materials and Methods

Plankton net made up of silk cloth having mesh size approximately 120 µm was used. The plankton concentrate used to accumulate in the specimen jar of one litre capacity fitted at the tail end of the net. The collected plankton was preserved in 15 % formalin solution on the spot. Quantitative observations were made in the laboratory. One-litre sample was centrifuged at 15000 rpm for 15 minutes. The supernatant was discarded and total 100 ml sample was collected for study. The phytoplankton were identified by key given in APHA (2005). For the quantitative estimations of plankton Lackey drop method was used. Three stations alongside the lake were selected for study.

Results and Discussion

Phytoplankton have rapid reproduction rates and very short life cycles, making them valuable indicators of short term environmental impacts. They are directly affected by physical and chemical factors in the lake and are sensitive to pollutants. The first and foremost visible symptoms of nutrient enrichment are the prolific growth of algal communities which produce blooms. Nutrients have direct bearing on the cellular growth of algal flora (Wetzel, 2001). The qualitative and quantitative studies of phytoplankton have been utilized to assess the quality of water (Ponmanickam *et al.*, 2007). Algal groups such as Cyanophyceae, Chlorophyceae, Bacillariophyceae present in the aquatic medium provide a probable indication of the tropic nature of the specific waters.

Quantitative assessments of phytoplankton were done at all the three stations selected for study. A total of 19 algal genera were recorded during the study. Cyanophyceae was represented by 6 genera, Chlorophyceae by 9 genera and Bacillariophyceae by 4 genera (Table 1). From station A, 18 genera of phytoplankton were identified. The members from chlorophyceae were *Spirogyra* sp., *Zygnema* sp., *Oedogonium* sp., *Pediastrum* sp., *Scenedesmus* sp.,

Desmidium sp., *Ankistrodesmus* sp., *Gleotricia* sp. and *Chlorella* sp. of which all the members appeared frequently, except *Scenedesmus* sp. which appeared moderately while *Ankistrodesmus* sp. appeared rarely. Among Bacillariophyceae, members such as, *Navicula* sp. and *Melosira* sp. were observed dominant while *Nitzschia* sp. and Diatoms appeared moderately in the study period. The Cyanophyceae group was represented by *Anabeana* sp., *Nostoc* sp., *Microcystis* sp., *Spirulina* sp., *Merisnopedia* sp. and *Oscillatoria* sp. All of these were dominant except *Spirulina* sp. and *Oscillatoria* sp. which were moderately present.

At station B, from chlorophyceae members *Spirogyra* sp., *Zygnema* sp., *Oedogonium* sp., *Pediastrum* sp., and *Chlorella* sp. showed moderate appearance while *Desmidium* sp., *Scenedesmus* sp., *Ankistrodesmus* sp. showed rare appearance and *Gleotricia* sp. were absent. Among Bacillariophyceae species of *Navicula* and Diatoms showed dominance in appearance while *Nitzschia* and *Melosira* appeared rarely. Cyanophyceae was dominated by species of *Spirulina*, *Nostoc*, *Microcystis* and *Anabaena* while *Merisnopedia* and *Oscillatoria* showed rare appearance.

Station C showed all the 19 genera of phytoplankton, out of which among Chlorophyceae, species of *Spirogyra*,

Zygnema, and *Pediastrum* showed frequent appearance. Species of *Oedogonium*, *Scenedesmus*, *Desmidium*, *Chlorella* and *Ankistrodesmus* were observed moderately while *Gleotricia* appeared rarely. The Bacillariophyceae was dominated by *Navicula* and Diatoms whereas *Melosira* and *Nitzschia* were present moderately. Cyanophyceae was represented by *Spirulina* sp., *Microcystis* sp. and *Nostoc* sp. which were found dominant while *Anabaena* sp. showed moderate appearance. *Merisnopedia* sp. and *Microcystis* sp. appeared rarely.

The algal genera *Oscillatoria*, *Scenedesmus*, *Navicula*, *Nitzschia* and *Microcystis* were reported earlier from organically polluted waters (Nandan and Aher, 2005; More, 1997). Similar genera were recorded in the present investigation thereby indicating that the lake is organically polluted. Thus, algal communities can be used as indicators of pollution for assessing the water quality of the lake. *Microcystis* was used as the best single indicator of pollution and was associated with the highest degree of civic pollution (Nandan and Aher, 2005). The occurrence of *Oscillatoria* in the present study indicates pollutants of biological origin which agreed with the observations of Gadag *et al.* (2005). The fluctuation in phytoplankton appearance was reported to depend upon environmental factors (Mahar *et al.*, 2009).

Table 1. Quantitative assemblage of Phytoplankton at Shelar Lake

Species	Station A	Station B	Station C	Average
Chlorophyceae	195	156	128	160
<i>Spirogyra</i> sp				
<i>Desmidium</i> sp	87	99	96	94
<i>Zygnema</i> sp	165	121	130	139
<i>Oedogonium</i> sp	120	90	110	106
<i>Pediastrum</i> sp	113	116	141	123
<i>Scenedesmus</i> sp	69	71	94	68
<i>Ankistrodesmus</i> sp	22	42	80	48
<i>Gleotricia</i> sp	0	0	38	38
<i>Chlorella</i> sp	121	158	81	120
Group % Density	40.58	39.49	42.65	41
Cyanophyceae				
<i>Anabeana</i> sp	177	184	96	185
<i>Nostoc</i> sp	121	160	136	139
<i>Microcystis</i> sp	218	129	147	164
<i>Spirulina</i> sp	51	127	149	109
<i>Oscillatoria</i> sp	96	43	80	69
<i>Merisnopedia</i> sp	83	57	49	63
Group % Density	33.93	32.4	32.58	33
Bacillariophyceae				
<i>Navicula</i> sp	235	214	206	218
<i>Melosira</i> sp	128	91	81	100
<i>Nitzschia</i> sp	82	107	66	85
<i>Diatoms</i>	61	73	69	67
Group % Density	25.47	28.1	24.73	26

Conclusion

In the present investigation algal groups belonging to Cyanophyceae, Chlorophyceae and Bacillariophyceae were recorded. The chlorophyceae members dominated on cyanophyceae and bacillariophyceae. The order of dominance was Chlorophyceae> Cyanophyceae> Bacillariophyceae. The group percent density of Chlorophyceae members was 41% while that of Cyanophyceae and Bacillariophyceae was 33% and 26% respectively. The presence of the genera in the water, belonging to cyanophyceae and bacillariophyceae indicate presence of organic pollutants in the lake.

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Research Article

Biodiversity of Euglenophyta in Thane District

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Abstract: Euglenophyta is the division of euglenoid algae; these organisms are naked free swimming cells with one to three flagella, with grass-green, discoid, band shaped or stellate chloroplasts which may or may not possess pyrenoids. These organisms contain chloroplasts that have chlorophylls which are same as in Chlorophyceae, except for beta-carotene and at least one xanthophyll which are not present in Chlorophyceae. Collection of algal samples was performed in Thane district and specimens belonging to Euglenophyta are described in this study. It was observed that forms belonging to Euglenophyta arrive as soon as rainfall ceases. It was also observed that these forms play a key role in conversion of nitrogenous waste to easily available nutrients for successor algal forms. These forms grow more robustly in puddles than in deep lakes. During this study 17 species belonging to genera *Euglena*, *Phacus*, *Lepocinclis* and *Trachelomonas* were identified and described. Of all the specimens identified, *Euglena hemichromata* and *Phacus acuminatus* were found to be the most dominant specimens.

Keywords: *Euglena*, *Phacus*, *Lepocinclis*, *Trachelomonas*, Thane

Introduction

Euglenophyta is the division of euglenoid algae; these organisms are naked free swimming cells with one to three flagella, with grass-green, discoid, band shaped or stellate chloroplasts which may or may not possess pyrenoids. These organisms contain chloroplasts that have chlorophylls which are same as in Chlorophyceae, except for beta-carotene and at least one xanthophyll which are not present in Chlorophyceae (Smith, 1950). The nutrition of Euglenophyta may be: a) Holophytic: Use of Photosynthesis to produce carbohydrates. b) Holozoic: Ingestion of material from the environment, digestion, absorption and assimilation or c) Saprophytic: Extracellular digestion of dead matter into simple compounds for nutrition. Although any one of the above methods may be used for nutrition, the reserved foods are paramylon, which is an insoluble carbohydrate related to starch.

The cells of Euglenophyta may also contain contractile vacuoles at the anterior end of the cell. The cells of these organisms are considered to be naked; however the exterior portion of cytoplasm is differentiated into a periplast. Periplast is the outer layer of cell membrane, which may be so rigid that the cells have a definite shape; or it may be flexible and allow the organisms to change their shapes continuously as the cell moves in water. This periplast in case of Euglenophyta may be smooth or with spiral or straight longitudinal striae or have spiral ridges. Some genera in Euglenophyta have their protoplast surrounded by a lorica (Smith, 1950). The lorica is composed of gelatinous substance, with no cellulose but presence of iron and manganese compounds, which gives it reddish brown colour (Moss and Gibbs, 1979). Lorica may have different shapes and ornamentations. The gullet is a flask-shaped

part present at the anterior end of the cell, the opening of which is called the cytopharynx and the trough is called reservoir. The flagella of motile cells are inserted in the base of the reservoir and project through the cytopharynx. The nucleus in Euglenophyta is prominently seen without staining as well. All genera are uninucleate, but they may be in binucleate form if cytokinesis is inhibited (Smith, 1950).

Materials and Methods

Algal specimens were collected from Thane district from ponds, lakes and puddles. Plastic bottles were used for collection and transport of the samples. Images of these samples were recorded at 100X, 400X and 1000X magnification using Lab-O-Med Microscope with Camera and Pixel Pro Software. The length and breadth of algal specimens was measured using the software. Literature mentioned in references (David *et al.*, 2011) was used for identification of the specimens.

The locations of 8 collection sites are mentioned below:

- 1) 19.295221, 73.204357 - Titwala.
- 2) 19.157682, 73.263348 - Badlapur
- 3) 19.165318, 73.029012 - Mumbra
- 4) 19.271766, 72.970071 - Ghodbunder Road
- 5) 19.205539, 72.978944 - Khopat area
- 6) 19.177195, 73.210084 - Ambernath
- 7) 19.410385, 73.259924 - Vasind
- 8) 19.281067, 73.058311 - Bhiwandi

Results and Discussion

Collection of algal samples was done in Thane district and specimens belonging to Euglenophyta are described in this study. 17 species (Plate 1) belonging to genera *Euglena*, *Phacus*, *Lepocinclis* and *Trachelomonas* were collected, identified and described, the descriptions of which are mentioned below:

1. *Euglena acus* (Ehrenberg, 1838)

Cells 120.03 um long, 9.03um wide, body long spindle or cylindrical, with a sharply pointed posterior end; numerous discoid chloroplasts; several paramylon bodies; nucleus central; stigma(eye spot) distinct; flagellum short (Adhikary, *et al.*, 2006; Sinha and Halder, 2014).

2. *Euglena sanguinea* Ehrenberg 1830

Synonym: *Volvox calamus* A. Pritchard, *Euglena viridis var.sanguinea* F.Stein, *E.rubra* A.D.Hardy, *E.haematodes* (Ehrenberg) Lemmermann

Found in resting and dividing phase, cell size under normal conditions, 50-52um long, 23-25um wide, posterior bluntly rounded, haematochrome granules scattered (Kumavat and Patil, 2011).

3. *Phacus pleuronectus* var *prunoides* (Y.V.Roll) T.G.Popova 1955

Basionym: *Phacus prunoides* Y.V.Roll

Cells 26 um long, 21 um wide, with apical furrow up to 1/3rd of cell; ovoid or triangular; posterior part with tail-piece short and slightly curved; pellicle striated longitudinally by line.

4. *Lepocinclis ovum* (Ehrenberg) Lemmermann 1901

Basionym: *Euglena ovum* Ehrenberg

Synonym: *Chloropeltis ovum* F.Stein, *Phacus ovum* (Ehrenberg) G.A.Klebs

Cells 12 um wide, 28 um long, widely ovoid, anterior end rounded, posterior end with a short blunt tail-piece, about 3 um long; pellicle with striae having a left handed spiral; paramylon seen, eyespot big (Adhikary, *et al.*, 2006; Kumavat and Patil, 2011).

5. *Euglena tristella* S.P.Chu 1942

Cells 12 - 14um wide, 50, 66, 75um long, spindle shaped to cylindrical; attenuated at anterior end, posterior end tapering into colorless tail-piece, pellicle delicately striated; chloroplasts densely packed, fringed and tessellate, paramylon bodies irregularly star shaped.

6. *Lepocinclis limnophila* Lemmermann 1898

Cells 12.5 um wide, 80 um long, spindle shaped or cylindrical to spindle shaped, slightly truncate at the anterior end and posterior end tapering to a sharp tail-piece, pellicle lightly striated; chloroplasts numerous, small disc-shaped; paramylon bodies large, few, elongated rings or rod shaped, flagellum shorter than cell length; eyespot small; cysts unknown (Delazari-Barroso *et al.*, 2007).

7. *Euglena sociabilis* (Dangeard, 1901)

Cells 43.19um long, 17.17um wide; cylindrical; highly plastic; elongate numerous chloroplasts; paramylon bodies discoid. Posterior tapered into a short process; chloroplasts deeply lobed containing large pyrenoids covered on both sides by a watch glass shaped sheath of paramylon, stigma 4.25um in diameter, cell body spindle shaped, and euglenoid movement rare (Adhikary, *et al.*, 2006).

8. *Phacus acuminatus* A. Stokes 1885

Cells 15.8 um wide 22um long, widely ovate to triangular with straight lateral margins, very thin, greatest width below middle; shallow dorsal furrow, short extension at posterior end and incision at anterior end; chloroplasts parietal, disc shaped, numerous; paramylon body single ring like, pellicle longitudinally striated; eyespot present (Adhikary, *et al.*, 2006; Sinha and Halder, 2014).

9. *Phacus pleuronectes* (O.F.Muller) Dujardin 1841

Basionym: *Cerasteria pleuronectes* O.F.Muller

Cells 31.5 um wide, 31.5 um long, widely ovoid slightly symmetric, anterior end narrowly rounded and shallowly symmetric; anterior end narrowly rounded and shallowly bilobed; posterior end with a short 15 um long slender tail-piece, turning obliquely to one side; dorsal keel from anterior end; pellicle longitudinally striated; chloroplasts parietal, numerous, disc-shaped, paramylon usually 1 large ring shaped body; eyespot conspicuous (Saleshrani *et al.*, 2012).

10. *Phacus triqueter* (Ehrenberg) Dujardin 1841

Basionym: *Euglena triquetra* Ehrenberg.

Cells 23 um wide, 50 um long, widely ovoid, slightly symmetric, markedly concave to convex; anterior end widely rounded; posterior end abruptly narrowing to a long thin and curved tail piece, pellicle longitudinally striated; dorsal keel prominently extending full length of cell. Cell triangular in cross-section, slightly hollowed on the ventral surface; chloroplasts disc-shaped; paramylon 2 ring shaped bodies, flagellum not seen (Adhikary *et al.*, 2006; Saleshrani *et al.*, 2012).

11. *Lepocinclis tripteris* (Dujardin) Marin et Melkonian 2003

Synonym: *Euglena tripteris* (Dujardin) G.A.Klebs, *E.torta* A.Stokes, *E.pseudospiroides* Swirenko, *E.fronsundulata* Johanson, *E.trisulcata* Johanson,

Cells 17um wide, 210um long, flattened, ribbon shaped, spirally twisted & triangular in cross section, bowed inwards and giving the appearance of 3 ridges, anterior end slightly narrowed, sometimes slightly truncate, pellicle clearly striated, striae following twists, chloroplasts numerous small disc shaped without pyrenoids, paramylon bodies large, long and rod like, 2 per cell with one usually anterior and other posterior to the nucleus, flagellum not seen; swims and stops frequently.

12. *Euglena hemichromata* Skuja 1948

Cells 62-128um long (62 um long), 12-22um wide (20um wide) spindle shaped or cylindrical to spindle-shaped; anterior end slightly narrowed and rounded to apex, posterior end tapering to a long tail piece; pellicle spirally striated; chloroplasts numerous, disc shaped, usually located towards posterior end, without pyrenoids, paramylon bodies numerous, ellipsoid, massed towards the anterior end; flagellum almost as long as cell; euglenoid movement occurs (Adhikary *et al.*, 2006).

13. *Lepocinclis texta* (Dujardin) Lemmermann 1901

Basionym: *Crumenula texta* Dujardin

Synonym: *Euglena texta* (Dujardin) Hubner
Cells 22um wide, 38um long, ovoid to spheroid, anterior end slightly narrowed with a small depression at apex, posterior end widely rounded; chloroplasts small, numerous, without pyrenoids, paramylon bodies small, numerous, oval; pellicle strongly spirally striated, flagellum 1-3times longer than cell; eyespot red, close to reservoir; swims rapidly and not showing euglenoid movement.

14. *Phacus helicoides* Pochmann 1941

Synonym: *Phacus longicauda* var. *torta* Lemmermann
fo. *helicoides*, *P.torta* (Lemmermann) Skvortzov var. *tortuosa* Skvortzov

Cell 58 um long, 33 um wide elongated, margins with 3 bulges, strongly spirally twisted through 3 times, anterior end narrowing and bilobed, posterior end tapering into a twisted long, straight tail-piece 14um long. Cells striated, chloroplast small, numerous and disc shaped; paramylon 1 large body.

15. *Trachelomonas volvocina* var. *subglobosa* Lemmermann 1913

Lorica 13um wide, 15um long, almost spherical smooth, reddish brown, apical pore surrounded by a depressed collar (Adhikary, 2006; Kumavat and Patil, 2011, Solorzano *et al.*, 2011).

16. *Trachelomonas cylindrica* (Ehrenberg) Playfair 1915

Basionym: *Trachelomonas cylindrica* Ehrenberg

Synonym: *Trachelomonas euchlora* var. *cylindrica* (Ehrenberg) Lemmermann

Lorica 8um wide, 12um long, cylindrical with sides almost straight and parallel; walls smooth, light brown; apical pore with a low collar 1.3 um wide, thickened at the rim.

17. *Trachelomonas bacillifera* Playfair 1915, var. *minima* Playfair 1915

Lorica 21.5um wide, 22um long, widely ellipsoid to spherical; walls covered with blunt rod like spines, dark brown. Apical pore without a collar, but a conical opening from where the inner cell appears to be protruding out. Flagella upto 54um in length (Konrad and Patricia, 2007).

Conclusion

A total of 17 specimens belonging to Euglenophyta were identified and described in the current study. These organisms survive for a very short period of time and may be seasonal. Of all the specimens identified, *Euglena hemichromata* and *Phacus acuminatus* were found to be the most dominant specimens.

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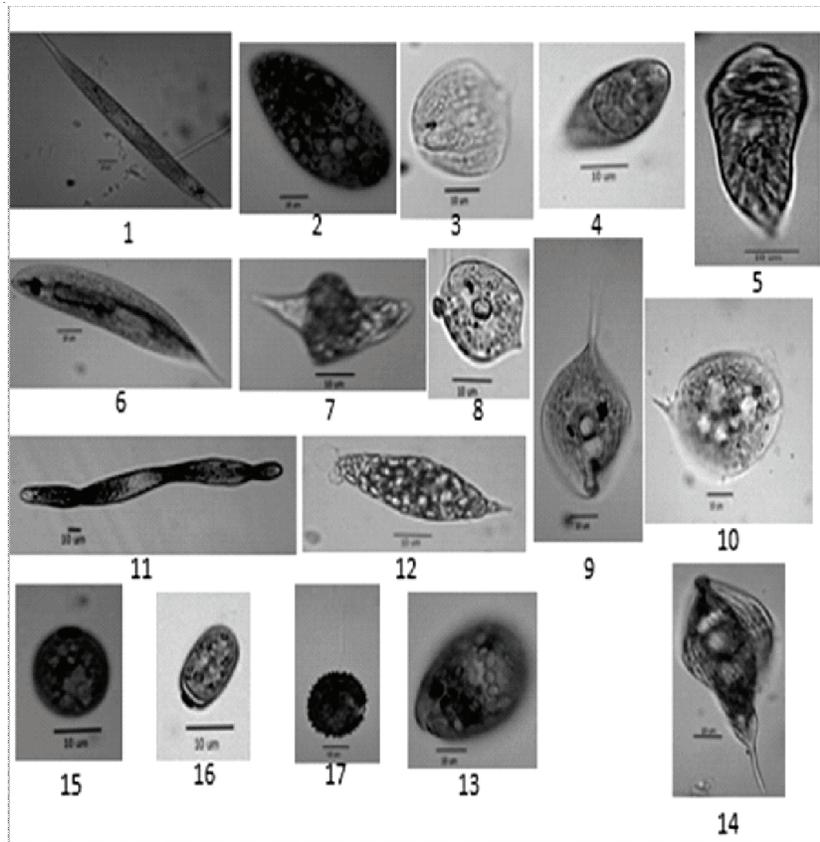


Plate 1. Euglenophyta identified from Thane District. 1. *Euglena acus* (Ehrenberg; 1838); 2. *Euglena sanguinea* Ehrenberg 1830; 3. *Phacus pleuronectus* var *prunoides* (Y.V.Roll) T.G.Popova 1955; 4. *Lepocinclis ovum* (Ehrenberg) Lemmermann 1901; 5. *Euglena tristella* S.P.Chu 1942; 6. *Lepocinclis limnophila* Lemmermann 1898; 7. *Euglena sociabilis* (Dangeard; 1901); 8. *Phacus acuminatus* A. Stokes 1885; 9. *Phacus pleuronectes* (O.F.Muller) Dujardin 1841; 10. *Phacus triqueter* (Ehrenberg) Dujardin 1841; 11. *Lepocinclis tripteris* (Dujardin) Marin et Melkonian 2003; 12. *Euglena hemichromata* Skuja 1948; 13. *Lepocinclis texta* (Dujardin) Lemmermann 1901; 14. *Phacus helicoides* Pochmann 1941; 15. *Trachelomonas volvocina* var. *subglobosa* Lemmermann 1913; 16. *Trachelomonas cylindrica* (Ehrenberg) Playfair 1915; 17. *Trachelomonas bacillifera* Playfair 1915 var. *minima* Playfair 1915

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Occurrence of Bioactive Potential Seaweeds Along the Coastline of Devgad, Maharashtra (India)

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Abstract : Kunkeshwar beach of Devgad, Maharashtra shows a variety of algal forms of various taxonomic groups. Survey of the macro algal flora found in the pre-monsoon and post-monsoon season at the rocky Kunkeshwar beach of Devgad coastline revealed the presence of macro algal members of class Chlorophyta, Phaeophyta and Rhodophyta. From among the sixteen collected macro algal species, most of the seaweeds had bioactive potential such as antioxidant, antimicrobial, antifungal, antiviral, anti-inflammatory, antibiotic potential etc.

Keywords: Bioactive potential, antioxidant, seaweeds, Devgad, Maharashtra

Introduction

Seaweeds belong to a group of plants known as algae. Seaweeds are classified as Rhodophyta (red algae), Phaeophyta (brown algae) or Chlorophyta (green algae) depending on their pigments and chemical composition. Like other plants, seaweeds contain various inorganic and organic substances which can benefit human health (Kuda *et al.*, 2002). Seaweeds are considered as sources of bioactive compounds as they are able to produce a great variety of secondary metabolites characterized by a broad spectrum of biological activities. Compounds with antioxidant, antiviral, antifungal and antimicrobial activities have been detected in brown, red and green algae (Bansemir *et al.*, 2006; Chew *et al.*, 2008).

In recent years, several marine bacterial and protocist forms have been confirmed as important sources of new compounds potentially useful for the development of chemotherapeutic agents. Previous investigations of the production of antibiotic substances by aquatic organisms point to these forms as a rich and varied source of antibacterial and antifungal agents. Over 15,000 novel compounds have been chemically determined. Focusing on bioproducts, recent trends in drug research from natural sources suggest that algae are a promising group to furnish novel biochemically active substances (Blunt *et al.*, 2005). Seaweeds or marine macro algae are the renewable living resources which are also used as food and fertilizer in many parts of the world. Seaweeds are of nutritional interest as they contain low calorie food but rich in vitamins, minerals and dietary fibres (Ito and Hori, 1989). In addition to vitamins and minerals, seaweeds are also potentially good sources of proteins, polysaccharides and fibres (Darcy-Vrillon, 1993).

The extracts and active constituents of various algae have been shown to have antibacterial activity *in vitro*

against Gram-positive and Gram-negative bacteria. The production of antimicrobial activities was considered to be an indicator of the capacity of the seaweeds to synthesize bioactive secondary metabolites (del Val *et al.*, 2001). There are numerous reports of compounds derived from macro algae with a broad range of biological activities, such as antibacterial (Nair *et al.*, 2007), antivirals (Richards *et al.*, 1978), antitumorals (Espeche *et al.*, 1984), anticoagulant (Athukorala *et al.*, 2006) and antifouling (Marechal *et al.*, 2004). Compounds with cytostatic, antiviral, antihelminthic, antifungal and antibacterial activities have been detected in green, brown and red algae (Newman *et al.*, 2003).

The present work appears to be a significant study on algal diversity of the Kunkeshwar beach, contributing to the biodiversity list of the area. The present investigation is outcome of biodiversity studies of marine macro algae and enriches our knowledge of algal flora of this area. The search for new effective medicines remains a challenge for researchers. So many investigators have focused on natural sources for new molecules with algae among the targets of these studies. Therefore in this study we reviewed the literature related to bioactivities for seaweeds of Kunkeshwar beach at Devgad (Maharashtra).

Materials and Methods

The present investigation was carried out at Kunkeshwar beach of Devgad (Maharashtra) coast. Kunkeshwar beach is rocky and at some places sandy with rocky cliffs and stones. At the site, the samples were collected manually during low tides in pre-monsoon and post-monsoon seasons. The marine algae were collected in polythene bag randomly and brought to the laboratory. The collected algal species were preserved in 5% formaldehyde and herbarium specimens were prepared for each species for identification and confirming their taxonomic position.

Identification of species was done by referring to relevant literature (Taylor, 1960; Deodhar, 1987; Jha *et al.*, 2009). Ecological notes about the locality, nature of habitat and mode of occurrence along with voucher sample number of each species, date of collection, collector's name were recorded and literature related to bioactivities were reviewed for the collected seaweeds.

Results and Discussion

Kunkeshwar beach showed presence of seaweeds belonging to various classes. The present work reports 16 species belonging to 13 genera.

Morphology and Uses (Taylor, 1960; Deodhar, 1987; Jha *et al.*, 2009):

I-Class- Chlorophyta

1. *Ulva fasciata* Del.: It was found in rock pools, deeply submerged under water. Plant shows large frond, 10-30 cm or longer, attached to substratum by circular or oblong holdfasts, basal attachment disc 2-4 mm in diameter. Thallus divided into many, more or less distinct, narrow lobes. Lobes 1-3 cm wide, flat, linear, lanceolate. Margin undulate or sinuate or irregularly dentate. This species is generally used as feed for aquaculture organisms and poultry animals.

2. *Ulva lactuca* Linn.: It was found growing on other algae or on small coralline pieces of rocks and stones, on wood and artificial substrata. Plants, initially attached to substratum; later become detached and drifting in broadly expanded and torn sheets. Holdfast very small, inconspicuous. Thallus foliaceous, membranous, expanded plane, reaching up to 18cm tall, obovate in young condition, broadly ovate or rounded expansion in older plants, rarely incised but occasionally lacinate with small perforation of various size in the thallus. Margin of thallus ruffled, wavy and folded. Surface glossy, bright green to light green, fading to yellowish and sometime darker when young. Thallus lobe varying in thickness, 40-45 μ at margins, midportions 60-65 μ . The species is eaten as food and used as animal feed. Also useful in medicine.

3. *Enteromorpha intestinalis* (Linn.) Nees: It was very common in brackish waters. Plants solitary or gregarious attached to the substratum by disc-like holdfast; tufted 1-6cm long. Frond, mostly filamentous, tubular with few contortions, clavate, expanded above, compressed, simple or branched at base. Plant later in stage, detached and floating. Apices of fronds perforated, colour deep green to yellowish green to grass green. Plants adhere firmly to paper on drying. It is edible, eaten toasted or steamed; used as animal feed and medicine.

4. *Chaetomorpha antennina* (Bory de Saint Vincent) Kuetz.: This seaweed was found intertidally on rocky

coastlines exposed to large breaking waves. Plants attached to hard rocky and similar substrata, dense, tuft, brush-like filamentous, unbranched erect stiff and rigid below, flexuous above, usually 4-10cm high, occasionally 20cm or more. Overall colour is grass green but close examination reveals alternating green and white bands. The tips become pale green or yellowish when bleached by sunlight. The species is used as food and animal feed.

5. *Caulerpa sertularioides* (Gmel.) Howe: This green alga is a littoral species and common from the surface of the sea to a few meters depth. It grows both in exposed situations as well in relatively sheltered and shallow waters, in lagoons and in intertidal zone. It is associated with other species of *Caulerpa*. Plants, coenocytic with prostrate branched cylindrical rhizome-like stolons creeping on substrata, anchored by well branched rhizoids below, forming large colonies. Stolons naked with a number of upright, delicate and flexible cylindrical axis with lateral outgrowth-the assimilators on the upper side. Assimilators flattened, feather like, 10-15cm long with lateral in two rows, pinnate. Pinnules cylindrical, slightly up-curved, opposite or sub-opposite, 3-11mm long, 180-330 μ broad; base of pinnules slightly larger than the apex; distance between pinnules equal to the width of the pinnules; apex of pinnules mucronate, rounded or conical. Colour light green to yellow green. Plants adhere very well to paper on drying. It is used as animal feed.

6. *Caulerpa peltata* Lamour: This species was found in shallow rock pools on silt covered stones, and coralline hard substrates; and abundant in low tide pools; on rocky shores, nearer low tide marks. Plants with well-developed stolons. Stolon, naked, horizontal, creeping over the substratum, robust or delicate, much branched, giving off rhizoid below and erect assimilators above. Rhizoids cylindrical, delicate, colourless. Erect axis, vertical, varying from 1-10cm in length, with numerous short branchlets. Branchlets, closely set, radiating in all directions, each branchlet terminating in apeltaete assimilating disc, the ramenta. Ramenta pointing directly obliquely upwards. Colour light green. Plant adheres partially well to paper on drying. Used as food and animal feed.

II Class- Phaeophyta

1. *Sphacelaria frucigera* Kutzing var. *princeps* Reinke: This brown alga was found in intertidal zone and estuaries on rocks, nearer low tide marks. Plants stoloniferous or endophytic below, the erect axes 0.5-3.0cm tall, 16-45 μ in diameter, sparsely branched, segments sparingly longitudinally divided and without secondary transverse divisions, hairs present 12-16 micron diameter, propugula slender, biradiate, rhizoids descending down from the base of thalli. The stalk 24 μ in diameter, cylindrical or tapering to the base, at the summit with 2 cylindrical or

somewhat tapering arms about equaling it in length, segments undivided or with a single cross wall.

2. *Padina tetrastromatica* Hauck: This algal species grows in well sheltered as well as in much exposed localities near low water mark and below; in intertidal lagoons, rock pools, tranquil bays etc. Plant, erect, in several clumps, several blades arising from the same stupose basal attachment, 12-15cm or more in length. Rhizome prostrate, attached to the substratum tufts of rhizoids. Fronds stalked, varying in size, numerous, fan shaped to reniform, thin, flat, much lobed, somewhat plicate, the larger blades loosely rolled on their longitudinal axis like a cornate, conspicuously concentrically zonate. Blade frequently split into numerous narrow segments, lower portion of segments attenuate; segments 1-2cm broad, zonation caused by rows of hairs and fructiferous organ in concentric zones. Hairs present in younger thalli; in older ones either rudimentary or absent, hair shading when fructiferous organ develop.

3. *Stoechospermum marginatum* (C. Ag.) Kuetz.: This algal species was found growing in well sheltered as well as in much exposed localities near low water mark and below; in intertidal lagoons, rock pools, tranquil bays etc.; at mid tide levels and lower, extending to upper limits of high tide mark, in favorable situations. Regularly forking plants that may reach a length of 40 cm; usually the plants are 20 -30 cm long and 8 - 11 mm broad; thallus flat, erect, spatulate, dichotomously branched respectively, without a midrib; margin entire; apex bifid or flatly truncate; section of thallus, greater part with large parenchymatous cells in the middle and on either side covered by two layers of small cells; fertile plants are easily identified on the marginal dark lines of crowded sporangia. It is used as a source of alginat and as fertilizer.

4. *Sargassum cinereum* J.Ag.: This algal species grows in lagoons and rocks in sub littoral belts and on rocks dashed by waves. Plants with short, stout main axis, bearing terate, smooth, primary branches at their upper part, beset with secondary branches and branchlets; basal leaves membranaceous, oblong, about 2.5 - 3 cm long, 7 - 8 mm broad, rounded at the apices and dentate at the margins; leaves of the branchlets lanceolate, 2 - 2.5 cm long, 3 - mm borad, cuneate at the base. Vesicles spherical, about 4 mm diameter, obovate, rounded, usually mucronate at the apices, subcylindrical below. It is used as a source of alginat, fertilizer and medicine.

III Class- Rhodophyta

1. *Gelidium pusillum* (Stackh.) Le Jolis: This algal species was found growing on rocks, stones, shells etc. Plants sexicolous, small dark red in colour, cartilaginous, forming tufts, thalli 2 -3 cm in height attaching by rhizoids, basal prostrate stoloniferous part giving rise to leafy erect

fronds, fronds up to 15 mm broad, terete in lower part, becoming flat in upper part; branching irregular or sub - pinnate; apices of fronds rounded and blunt. It is one of the potential species as source of agar.

2. *Gracilaria verucosa* (Huds) Papenfuss: This species was observed on rocks, stones, shells in brackish water etc. Plants bushy, 1-3dm tall, with age often becoming free, texture firmly fleshy, colour dull purplish, grayish or greenish translucent, branches 0.5-2 mm diameter, repeatedly dividing, alternately or occasionally dichotomously branched with numerous lateral proliferations, terete throughout, tapering to the ultimate branchlets. It is used as raw material for agar manufacture. It is also eaten raw as salad or cooked with vegetables, and as animal feed.

3. *Hypnea valentiae* (Turn.) Montagne: This algal species was found on rocks, stones, shells in intertidal zone. Plants large, bushy purplish red colour, up to 15 cm in height, branching irregularly, branches cylindrical, long, slender, 1- 2 mm broad, possessing short ramuli; ramuli with pointed tips, ramuli slightly curved toward axis. It is a carrageenan yielding plant. This seaweed is also edible and the freshly gathered seaweed is commonly prepared as salad.

4. *Hypnea musciformis* (Wulfen) Lamouroux: This species was found growing on intertidal rocks and also as epiphyte on larger algae. Plant pinkish red in colour, up to 30 cm in length, initially attached to substratum, later often free floating, freely branched; branches covered with short spine like branches, apices of branches often thickened and incurved in the form of hook like structure. All *Hypnea* species are used for food and medicines in China, Japan and other countries and yield k-carrageenan.

5. *Jania adhaerens* Lamouroux: This algal species grows on rocks, stones, shells in brackish water. Plant erect, 1 - 3.0 cm high, branching wide angled, the lower branches often arowate. Branches 100 - 200 micron diameter below, sometimes less in the uppermost branches, the segments 2 - 6 diameters long; articulation always present at the base of each branch, and commonly branches often slightly dicoted and retuse at the upper end; branch apices conical, acute. It is also used as medicine.

6. *Acanthophora spicifera* (Vahl) Borgesen: This species was observed growing on intertidal rocks and coralline stones in rock pools. Plant dark red to purple red in colour, up to 20 cm tall, bushy erect, cylindrical and attached to substratum by irregularly lobed discs; main axes without spines, branches irregular or alternate, scarce, branchlets spirally disposed, ultimate short branchlets covered with short spines.

Potential Bioactivity:

Most of the species from the collected samples viz., *Ulva fasciata*, *Ulva lactuca*, *Enteromorpha intestinalis*, *Caulerpa peltata*, *Padina tetrastrumatica*, *Stoechospermum marginatum*, *Acanthophora spicifera* and *Hypnea musciformis* are bioactive. The secondary metabolites of seaweeds *Ulva fasciata* and *Hypnea musciformis*, collected from southeast and southwest coast of India, were tested for biotoxicity potential. Both species showed potent activity in antibacterial, brine shrimp cytotoxicity, larvicidal, antifouling and ichthyotoxicity assays. The green alga *U. fasciata* exhibited broad-spectrum antibacterial activity whereas the red alga *H. musciformis* showed narrow spectrum antibacterial activity. The brine shrimp cytotoxicity profile indicated that the seaweeds were moderately toxic. The overall activity profile indicated that *U. fasciata* had more biological potency than *H. musciformis* (Venkatraman, K. 2005). *Gelidium pusillum* and *Jania adhaerens* were reported to exhibit antifungal activity (Selvin and Lipton, 2004; Ballesteros *et al.*, 1992).

Seaweeds are known as an excellent source of vitamins and minerals, especially sodium and iodine, due to their high polysaccharide content that could also imply a high level of soluble and insoluble dietary fiber (Takagi *et al.*, 1985). Venkatesalu *et al.* (2004) investigated fatty acid composition in *Ulva lactuca*, *Padina tetrastrumatica*, and *Acanthophora spicifera* collected from Mandapam coast. In DPPH scavenging assay the seaweed extracts of *Ulva fasciata* and *Chaetomorpha antennina* showed high antioxidant activity. *Stoechospermum marginatum* was the only seaweed that showed activity against *Klebsiella pneumoniae*. The extract from *Gracilaria corticata* was highly active against *Proteus mirabilis*, a Gram-negative pathogenic bacterium. The active principles of highly active seaweed *Stoechospermum marginatum* were bactericidal (Premlatha (2011). Marine brown alga, *S. marginatum* is the most potent seaweed for the development of natural weedicides as an alternative to the synthetic weedicides (Santhanam *et al.*, 2008). The agarophyte *Gracilaria corticata* is known to contain unique sulfated galactons that are nutraceutical and pharmaceutical important (Manilal *et al.*, 2010). Aqueous extracts of *Gracilaria corticata* inhibited the proliferation of human leukemic cell lines, exhibiting its anti-cancerous activity (Balakrishnan *et al.*, 2013). *Caulerpa sertularioides* exhibited highest antioxidant activities of DPPH free radical scavenging, FRAP and FIC (Zandi, *et al.*, 2010).

Acanthophora spicifera is one of the bioactive compound rich seaweed, which exhibits potent antitumor and antibacterial activity. Most of its chemical constituents such as octanol, piperazine, benzoic acid and octadecenoic acid are invariably having pesticidal, antimicrobial and anti-

inflammatory properties (Dotulong *et al.*, 2013; Flora and Maria, 2013). *A. spicifera* exhibits a promising antimicrobial activity (Narul, *et al.*, 2010). The different extracts of *A. spicifera* exhibited different levels of antioxidant and total phenolic contents. The TPC was found correlated with the antioxidant activity which indicates the roles of algal polyphenols as free radical scavengers for the extracts and methanolic extract also shows significant cytotoxicity (Narul, *et al.*, 2011).

Conclusion

Majority of the collected algal species viz., *Ulva fasciata*, *Ulva lactuca*, *Enteromorpha intestinalis*, *Caulerpa peltata*, *Padina tetrastrumatica*, *Stoechospermum marginatum*, *Acanthophora spicifera*, *Hypnea musciformis*, *Gelidium pusillum*, *Jania adhaerens* and *Gracilaria corticata* are bioactive potential seaweeds. These are also good sources of phytochemicals. Their bioactive components had strong modulating effects on oxidative stress, stress-related diseases and cancers. The antioxidant properties of several kinds of algae have been investigated for their anti-inflammatory, antinociceptive, and anti-cancer effects. The current work appears to be useful for further investigations and suggests that seaweeds may be used as alternative source for antibacterial, anti-inflammatory, anti-oxidant and anti-cancer agents in the near future.

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Taxonomy of Plasmodial Myxomycetes

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Abstract : The true slime moulds i.e. the myxomycetes is an interesting group of organisms having great scientific significance. The life cycle of myxomycetes includes two phases-vegetative and reproductive. The vegetative phase is characterized by a free living, acellular, coenocytic, mobile plasmodium. It exhibits phagotrophic nutrition. The taxonomic position of Myxomycetes is still ambiguous as this group of organisms constitutes the characteristics of both animals and fungi. Perhaps, this is the reason for inclusion of myxomycetes in both kingdoms by different scientists. Today they are included in separate Phylum Myxomycota. This paper deals with the classification of myxomycetes with respect to some members studied in Badlapur region (District Thane), Maharashtra, India.

Key words: Plasmodium, capillitia, plasmodiocarp, sporangium, aethlium

Introduction

The term Myxomycetes consists of two Greek words viz. 'Myxa'- meaning slime and 'myketes' meaning fungi. Some of these have remarkable beauty, brilliant colour and delicate structure. Plasmodial slime moulds were first scientifically reported in 1729. A plasmodial slime mould exists as a mass of protoplasm with many nuclei. This mass of protoplasm is called a plasmodium (Tortora *et al.*, 2004).

Organisms in this group have little similarity to other moulds except that they produce spores. Because they resemble amoebae in some respects, some experts have classified them as animals and called them Mycetozoa or 'fungus animal'. The term myxomycetes was first used by German botanist Heinrich Link in 1833. He regarded the myxomycetes as fungi. Anton de Bary continued the study of myxomycetes but he regarded them as protozoans and proposed the name Mycetozoa. Regardless of their relationships to other living organisms, study of myxomycetes has been carried out by botanists, especially mycologists. Myxomycetes are a universally distributed group of organisms that include about 1000 species (Stephenson and Stempen, 2000).

The Myxomycetes mostly grow in cool, moist, shady places such as decaying wood, beneath the partially decayed bark of logs and stumps and in leaf litter, soil and rarely on living parts of the plants (Stephenson, 1989). Sometimes, they do occur on other organic matter. Since climatic and other conditions are favorable in Western Maharashtra, especially in the Ghat and hill areas, myxomycetes are abundant in these areas. The life cycle of myxomycetes includes two trophic stages. Uninucleatemyxoflagellates or amoebae, and a multinucleate plasmodium. The entire plasmodium turns almost all into fruit bodies called sporocarps (sporangia, aethalia, pseudoaethalia or plasmodiocarps).

Myxomycetes are found wherever moisture is present. It is mostly found during monsoon season. In India, the monsoon season extends from June to October; particularly, July to September is the best period for maximum collection of Myxomycetes. The Myxomycetes are collected only when their fructifications are fully matured. They are variously coloured. However, there are many others, which because of minute size or dull colour, appear as part of the substratum and escape the notice of a casual observer. They can be located by a careful and trained eye.

Materials and Methods

Collection of Myxomycetes was done in Badlapur (Dist. Thane), Maharashtra, at various locations such as Kondeshwar, Bhoj, Goweli, Dahiwali, Barvi Dam, Badlapur River etc. The Myxomycetes were collected along with the substratum from the field and then immediately transferred to empty match-boxes or similar cardboard boxes. The unwanted material was removed and the collected slime moulds were preserved in separate boxes.

From the preserved material, stained slides were prepared using 8% lactophenol; cover slip was placed on the slide and the specimen was observed under microscope. Photomicrographs of the materials were taken with the help of Olympus Magnus MIPS Camera. The identification of species was done by the use of available literature (Mahajan, 1992; Mishra, 1980; Anisworth *et.al.*, 1973; Thind, 1977; Stephenson and Stempen, 2000). The classification was done by using the criteria such as presence or absence of external or internal sporangia, presence or absence of capillitia and calcareous or non-calcareous nature of peridium.

Results and Discussion

In the present studies, 7 forms belonging to 7 different myxomycetous genera were observed from locations around Badlapur city. Rostafinski (1873, 1874-76) for the first time

gave the proper basis of classification of myxomycetes. Based on this, Martin(1960), divided phylum Myxomycota into single class Myxomycetes. It is further divided into classes Ceratiomyxomycetidae and Myxogastromycetidae. These are further divided into six orders-Liceales, Echinosteliales, Trichiales, Physarales, Stemonitales and Ceratiomyxales. (Alexopoulos, 1960).

The characters of Phylum and the class are the same i. e. presence of plasmodium, fruiting bodies enclosing the spores.

Key to sub classes

1. Spores are borne externally on individual stalks, each spore germinates to produce a naked protoplast, protoplast develops into eight swarm cells, presence of hypothallus, sporophores erect, branched and anastomosing.
—————Ceratiomyxomycetidae.
2. Spores are borne inside characteristic fructifications, each spore after germination produces one or two or rarely more swarm cells or myxamoebae, Hypothallus normally inconspicuous.
—————Myxogastromycetidae.

Key for the genera collected from Badlapur and allied region

1. Spores externally on individual stalks
—————*Ceratiomyxa*.
1. Spores produced internally in characteristic fructification
2. Capillitium absent
2. Capillium absent
3. Fructification pseudoaethalloid
3. Fructifications sporangiate
4. Peridial net absent
4. Peridial net present
5. Main threads of the net short
5. Main threads of net longitudinal.
6. Capillitial threads hollow
6. Capillitial threads solid
7. Threads without spiral bands
8. Fructifications plasmodiocarpous
—————*Hemitrichia*.
8. Fructifications sporangiate

9. Peridium fugacious above
—————*Arcyria*.
9. Peridium not fugacious
10. Peridium calcareous
—————A
10. Peridium non-calcareous
—————B
11. Capillitiumphysaroid
—————C
11. Capillitium simple
—————D
- C. Fructification aethaloid
—————*Fuligo*.
- C. Fructification sporangiate
—————*Craterium*.
- D. Capillium Homogenous
—————*Physarum*
- D. Capillium Heterogenous
12. Peridium double
—————*Diderma*
12. Peridium single
—————*Didymium*

Ceratiomyxa fruticulosa– It is the monogeneric order and has been extensively studied by many researchers from various parts of the world (Crespo and Lugo, 2003; Stephenson and Stempen, 2000; Mahajan, 1992; Thind, 1977).

Hemitrichia serpula shows very attractive plasmodium which is brightly coloured and forms a hexagonal network on decaying substratum (Crespo and Lugo, 2003; Mishra, 1980; Thind, 1977). Ukkola and Rikkinen (2000) have observed three species of *Hemitrichia* but not *H. serpula* from the forest and wood lands of Western Oregon.

Arcyria cinerea was reported by Thind (1977) on rotten stumps, dead wood, decaying leaf base, of *Cycas circinalis*, dung, mosses, rotting leaves, stalk of palms, etc. In the present investigations the material was collected only from decaying leaf litter. The genus has also been reported by Crespo and Lugo (2003); Ukkola and Rikkinen (2000); Mishra (1980) and Stephenson and Stempen (2000).

Craterium leucocephalum was found on decaying leaf litter in the present investigation, which matches with the description of the genus given by Thind (1977).

Physarum bivalve has been described by Stephenson and Stempen (2000) as a species occurring on leaf litter and on living plants but in present investigation, the species was found only on dead leaf litter. Crespo and Lugo (2003) from Argentina and Thind (1977) from India have also reported this species.

Diderma hemisphericum was found on decaying wood and leaf litter in present investigation. This agrees with the observations of Thind (1977); Mahajan (1992) and Crespo and Lugo (2003). This species was found at all the locations studied.

Didymium iridis has been described by Thind (1977) as the species occurring on dead leaves and living

herbaceous plants and mosses. In the present investigation, it was observed only on dead leaves and twigs.

Conclusion

A total of seven myxomycetous genera were observed during the study. Out of these, *Diderma hemisphericum* was common in all locations. The areas with dense vegetation and decaying leaf litter were rich in Myxomycetes population. The population of Myxomycetes was abundant in August to October as against very few specimens observed from June to August. During the rest of year no specimen could be observed.

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Research Article

Study of Diversity of Microfungi in Leaf Litter of Some Sites at Sanjay Gandhi National Park, Mumbai

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Abstract : Study of diversity of any ecological niche is always desirable as it unravels the vast myriad life that constitutes the niche. The present study of diversity of microfungi was initiated with the permission granted by office of the chief conservator of forests and Director, Sanjay Gandhi National Park, Mumbai. Minuscule amount of leaf litter was brought to the laboratory for isolation of the microfungi. Different laboratory media with and without selective agents and processing conditions were adopted for preventing growth of unwanted fungi while apparently promoting growth of slow growers. Fungi belonging to thirteen different genera were identified, while some remained unidentified.

Key words: leaf litter, diversity, microfungi

Introduction

Biodiversity is a term that expresses the large variation in populations or species in a given ecological niche. Diverse group of organisms may exist in different microbial associations; nevertheless ultimately establish a proper ecological balance between and among each other. The study of fungi is one part of the biodiversity study, and is important because they contribute to vital roles in the ecosystem as well as influence human and human related activities. Further, mycological taxonomy is an endangered science, and there exist few mycologists who can both, isolate and identify fungi. There are about 1.5 million fungal species as hypothesized by Hawksworth (1991, 2001). If this estimate is correct, mycologists believe that less than 5% of fungi have been observed. This lack of basic information on taxonomic diversity has significant implications for many aspects of evolutionary biology. Literature cites several studies related to fungal diversity; many of these, conducted with physicochemical studies of soil with statistical distribution of fungi (Banakar *et al.*, 2012; Hyde *et al.*, 2007; Sankaran and Balasundaran, 2000; Blackwell, 2011; Manoharachari *et al.*, 2005; Shankar and Shashikala, 2010).

Sanjay Gandhi National park (SGNP) is the only green patch which is home to many birds and insects in the suburbs of Mumbai city. This rich and diverse forest holds more than thousand species of plants, many animals, migratory birds, reptiles, butterflies and large variety of fishes. The forest being blessed with good resources of light and water; is home to a large biodiversity. Every ecosystem has its own composition of organic matter and thus directs the adaptation and sustenance of species in it. The flora and fauna of SGNP is largely conserved. The fallen leaf litter

offers organic matter that is silently recycled by numerous interactions among the countless microbial communities. Fungi however, would be the largest contributors to degradation of this organic matter, yet attract attention as pathogens, predators, as well as producers of novel secondary metabolites. Fungal diversity would include the study of macro and microfungi. Public domains apparently have substantial data on macrofungi in this forest region. The present study focused on isolation and identification of microfungi in some selected sites of SGNP, thus featuring the diversity of that niche. Manoharachari *et al.*, (2005) have discussed the need to conserve and prospect fungal diversity in India.

Materials and Methods

Sample collection: 1-2 g of leaf litter was sampled using gloves, collected in paper bags and brought to the laboratory. These samples were held at room temperature in a cool place away from sunlight. They were processed in different ways to facilitate growth of different fungi. Sampling of leaf litter was done prior to the onset of monsoons. Also sterile Malt extract agar, Potato dextrose agar and Bread crumb agar were surrendered to open air exposure at the sampling sites for a period of 30min and 45mins. All isolation media were made to contain 0.1g/l of streptomycin.

Isolation of fungi: The collected leaf litter was processed and isolated on Malt extract agar, Czapeks Dox agar, Bread crumb agar, Bread crumb honey agar, Potato dextrose agar, Sabouraud's agar and Rose Bengal Chloramphenicol agar. The study of microfungi of two selected sites of SGNP was done by simple gravity sedimentation and a more complex isolation technique using the laboratory media mentioned above. Leaf litter suspension

was made in sterile saline. The suspensions were processed differently viz., held in a water bath at 60°C for 30min, or treated to 50% alcohol, or isolated on media containing 0.2% oxgall, 1% dichloran and 1% olive oil. All the isolated plates were incubated in a moist chamber at room temperature until visible fungal growth was obtained. The fungi were purified and transferred to Sabouraud's agar.

Identification of fungi: Fungal growth on different laboratory media was studied for their macroscopic and microscopic characteristics. The fungi were identified using the Saccardo system of classification (Barnett and Hunter, 1972; Udaya Prakash, 2010) and online classification keys.

Results and Discussion

A total of 76 fungal isolates were obtained during the study. The mycota obtained by sedimentation technique largely belonged to genus *Aspergillus*. *Penicillium* and *Aspergillus* are common fungi recovered from forests (Banakar *et al.*, 2012; Shankar and Shashikala, 2010); nevertheless different species of *Aspergillus* were recovered by both the methods. *A. terreus*, *A. niger*, *A. ustus*, *A. oryzae* and *Emericella nidulans* were identified. *Emericella* showed presence of cleistothecium with numerous globose structures. Species of *Penicillium*, *Fusarium*, *Alternaria*, *Curvularia* and *Diplodia* were recovered by simple isolation of the leaf litter suspension. However, adopting more stringent techniques of isolation with incorporation of oxgall, olive oil or dichloran apparently reduced the occurrence of weed fungi and recovered species of *Botrytis*, *Aureobasidium*, *Geotrichum*, *Botryotrichum*, *Torula* and *Scopulariopsis*. The results tally with those of Panda *et al.* (2010).

Although the actual number of microfungal species present in the leaf litter remains unknown, studies are in process to promote isolation of slow growing or sparsely distributed fungi in the samples. Also molecular identification of the isolated fungi will help confirm the species of the microfungi.

Conclusion

Diversity of microfungi in leaf litter helped identify the fungal species present in that ecosystem. The study also would also be investigating the flora in the vicinity of the collection sites, and hence ascertain the vegetation that leads to adaptation and sustenance of the fungal population.

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Research Article

Investigations on Fungal Organisms Inhabiting Wall Paints

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Abstract : The study encompasses investigation on a unique man made niche of fungi viz. painted surfaces of walls. Fungi are known to degrade paints and painted surfaces, causing visible symptoms of deterioration, which were documented on walls of indoor corridors. The study was carried out at two levels viz. ground floor and second floor. A total of 18 fungal forms belonging to 5 genera and 4 non sporulating sterile mycelia were isolated during the current investigation. The most represented genus was *Aspergillus* with nine species. The most common species encountered in the present investigation was *A. fumigatus*; next in abundance being *Penicillium citrinum*. Maximum fungal organisms were isolated from the ground floor location. Most of the fungal organisms isolated in the present investigation are known to have serious health implications which are a cause of concern.

Introduction

Mycologists unanimously agree that fungal diversity is the maximum in the tropical regions (Hawksworth, 2001) and previous surveys have amply hinted at this diversity being much greater than what was earlier believed (May, 1991; Shivas and Hyde, 1997). Translated into common language, this indicates that several fungal organisms and their roles and interactions are yet unknown or incompletely known to mankind (Hawksworth, 1991). Several fungal habitats and niches are yet to be explored fully. One such manmade habitat is over paint films at various locations. Paint, a man-made product, has a long and intimate association with human civilization that can be traced back to ancient times (Dhar, 2011; Mac Erlean, 2012; Than, 2012). Paint can be technically defined as a liquid, applied in coats or layers to surfaces, which on drying form a coloured solid coating on the surface over which it is applied. This commodity has rapidly evolved into a synthetic industrial product of mass manufacture in modern times. Various types of paints are available and extensively used today for a variety of applications (Zengolewicz, 2010). Paints and colours have evolved over the years and modern paints contain several organic and inorganic constituents, many of which offer favourable atmosphere and niches to microorganisms (Ciferri, 1999).

Fungi are well known agents causing deterioration of painted surfaces due to their hydrolytic enzyme activity and ability to exploit ecological niches offered by various organic and inorganic ingredients present in the paints. Reported incorporation of anti-microbial biocides in paints (Schwensen *et al.*, 2014) might temporarily put off the start of fungal degradation but ultimately the damage is observed to set in and is evident in form of discolourations. Apart from uneven discolourations, the other common symptoms of damage of paint films by fungi are ungainly patches of

fungal growth and pigmentations over affected painted surfaces. Conditions such as seepage of water and environment favourable to the affecting microorganisms further aggravate the situation (Hyvarinen *et al.*, 2002). In addition to causing deterioration and degradation, the fungi proliferating on the deteriorated patches of painted surfaces may also be responsible for diseases and infections in sensitive individuals in the vicinity. Attention to these issues has been drawn by several researchers (Aina *et al.*, 2011; Elumalai *et al.*, 2014).

A survey of literature revealed that information on fungal deterioration of painted surfaces of buildings in the Indian scenario is scattered and peace meal. The current investigation focuses on fungal diversity recorded from over paint films from indoor corridors of buildings housing educational institutions.

Materials and Methods

Samples of deteriorated and spoiled paint films were collected from corridors of B.N. Bandodkar College of Science, Thane, by lightly and inconspicuously scraping the discoloured wall surfaces. Corridors from two levels viz., the ground floor and second floor were considered for the current investigation. The samples of scrapings were agitated in 10 ml sterile distilled water using a vortex mixer, 0.5 ml of which was directly plated on Potato Dextrose Agar and Malt Extract Agar plates amended with chloramphenicol @ 50 µg/L. Plates were incubated at room temperature and observed from 72-120 hrs for expression of fungal growth. Fungal colonies were isolated by transferring to new plates. The isolated forms were identified using standard literature (Gilman, 1967; Subramanian, 1971; Tzean *et al.*, 1990) and confirmed at the fungal culture collection centre at Smt. CHM College, Ulhasnagar.

Results and Discussion

Fungi are known to play an important role in the deterioration of paints applied over various surfaces. Fungal growth over painted surfaces is further enhanced by conditions such as increased humidity and moisture levels. The white painted surfaces (super white washable oil bound distemper paint) in the current study viz., walls of indoor corridors, painted 5 years ago, showed symptoms of fungal deterioration such as visible fungal growth patches, fouling of the painted surface, giving a dusty appearance and small reddish brown spots of pigmentations. A total of 18 fungal forms belonging to 5 genera and 4 non sporulating sterile mycelia were isolated during the current investigation (Table 1). The most represented genus was *Aspergillus* with nine species. The most common species encountered in the present investigation was *A. fumigatus*, of which 67 isolates were obtained, followed by *Penicillium citrinum*, represented by 50 isolates. *P. citrinum* which produced reddish pigmentation on the reverse of plates, later turning dull reddish brown in colour, was most probably, responsible for the pigment spots developed on the walls. 15 fungal forms were isolated from ground floor location and 8 forms from second floor; most probably due to the former location's proximity to the ground, soil being considered the basic source of most fungi (Gilman, 1967), and increased volume of human activity and throughfare on the ground floor location. The results tally with those of Aina *et al.*, (2011), Biswas *et al.* (2013) and Okunye, *et al.* (2013).

Most of the fungal organisms isolated in the present investigation are known to have serious health implications, causing allergies, asthma and many other respiratory health risks (Hoisington *et al.*, 2014; Sharpe *et al.*, 2015) especially upper respiratory tract infections and illnesses (Liu *et al.*, 2014) which are a cause for concern. The harmful effects of mycotoxins related to carcinogenicity, immunotoxicity, mutagenicity, genotoxicity and teratogenicity are well documented (Viegas *et al.*, 2011). Aspergilli especially *Aspergillus niger* and *Trichothecium* were implicated in several human disorders and health impacts especially in immune compromised individuals (Chao *et al.*, 2011). Hence it is necessary to identify moulds and fungi responsible for such deteriorations, check on their potential to cause health related issues and take appropriate protective measures.

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Table 1. Fungal forms isolated from discoloured paint surfaces of indoor corridors

Sr. No.	Fungal Organism	Location	
		Ground Floor	Second Floor
1	<i>Absidia</i> sp.	+	
2	<i>Aspergillus flavus</i> Link	+	+
3	<i>A. fumigatus</i> Fresenius	+	+
4	<i>A. japonicus</i> Saito (<i>A. niger</i> group)	+	
5	<i>A. oryzae</i> (Ahlburg) E. Cohn	+	
6	<i>A. niger</i> van Tieghem	+	+
7	<i>A. niger</i> group	+	+
8	<i>A. tamarii</i> Kita	+	
9	<i>A. terreus</i> Thom	+	+
10	<i>Aspergillus</i> sp.		
11	<i>Penicillium citrinum</i> Thom	+	+
12	<i>Penicillium</i> sp.		+
13	<i>Trichoderma</i> sp.	+	
14	<i>Trichothecium roseum</i> (Pers.) Link	+	
15	Non sporulating (1)		+
16	Non sporulating (2)	+	
17	Non sporulating (3)	+	
18	Non sporulating (4)	+	
	Total	15	8

Identification Key to Arbuscular Mycorrhizal Fungal Genera

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Abstract : Arbuscular mycorrhiza is a widespread mutualistic symbiosis between land plants and fungi of the phylum Glomeromycota. These fungi produce extensive extraradical mycelium, tree-like structures, the arbuscules, or hyphal coils. Some also produce storage organs, termed vesicles. They produce large (40–800 μm) spores with layered walls. Spores may be formed singly, in clusters or aggregated in so-called sporocarps. Earlier, six genera viz., *Acaulospora*, *Entrophospora*, *Gigaspora*, *Glomus*, *Sclerocystis* and *Scutellospora* were recognized, but now, there are nineteen genera. All these genera differ in their spore types, size, subtending hypha, presence or absence of sporocarp, formation of vesicles and arbuscules in the host roots. The AM fungi can be identified upto genera level by observing the spore morphology, sporocarp morphology, subtending hyphae, auxillary cells, mycorrhizal anatomy, spore wall and spore germination. The phylum Glomeromycota comprises about 214 described morphospecies that traditionally have been distinguished by features into 19 genera. The way the spore is formed on the hypha is important to circumscribe genera and families, and the layered structure of the spore walls is used to distinguish species.

Keywords: Arbuscular Mycorrhizal Fungi, Glomeromycota

Introduction

The AMF structures (Fig. 1-4): Soil hyphae, also known as extraradical or external hyphae, are filamentous fungal structures which ramify through the soil. They are responsible for nutrient acquisition, propagation of the association, spore formation and other activities. VAM fungi produce different types of soil hyphae including thick “runner” or “distributive” hyphae as well as thin “absorptive” hyphae (Friese and Allen, 1991). The finer hyphae can produce “branched absorptive structures” (BAS) where fine hyphae proliferate (Bago *et al.*, 1998). Hyphae of *Scutellospora* and *Gigaspora* species produce clustered swellings with spines or knobs called auxiliary cells. In *Gigaspora*, the auxillary cells are echinulate with spines whereas in *Scutellospora* the projections on the surface of the auxillary cells are knobby and highly variable in shape and size (Bentivenga and Morton, 1995).

Hyphae within root are initially without cross walls, but these may occur in older roots. Gallaud (1905) observed that VAM associations in different species formed two distinctive morphological types, which he named the *Arum* and *Paris* series after host plants.

1. Linear (*Arum*) series associations where hyphae proliferate in the cortex by growing longitudinally between host cells. This occurs because hyphae grow through longitudinal intercellular air spaces that are present.

2. Coiling (*Paris*) series where hyphae spread by forming coils within cells because there are no continuous longitudinal air spaces.

Spores form as swellings on subtending hyphae in the soil or in roots. Spores function as storage structures, resting stages and propagules. They are the only plant-independent phase of the fungi. Their size varies strongly among the species between 20 - 100 μm . Of all the known species of AM fungi, *Glomus tenue* is the smallest with an average diameter of 10-12 μm , while in contrast *Gigaspora gigantea* is the largest recorded spore with dimensions ranging from 183-500 x 291-812 μm . Spore size varies within the same species and hence both immature and mature spores are taken into account while describing the species (Muthukumar *et al.*, 2009).

Spores usually develop thick walls with more than one layer but colour, morphology and the composition differ depending on the species (B³aszkowski *et al.*, 2002). This was the reason why they were the most important structures considered so far in the classification of arbuscular fungi until rRNA sequencing methods appeared.

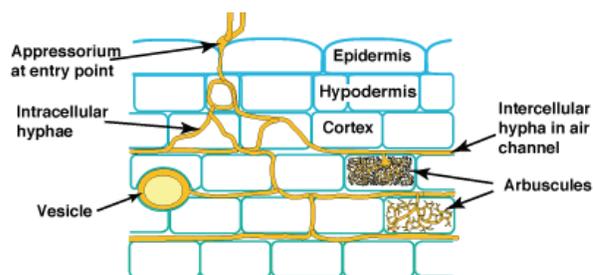


Fig. 1 AMF structures in the root: Hyphae, Vesicles and Arbuscules

Arbuscules (tree shaped structures) Arbuscules are intricately branched haustoria that are formed within a root cortex cell. Arbuscules are considered the major site of exchange between the fungus and host. Arbuscules are short-lived and begin to collapse after a few days, but hyphae and vesicles can remain in roots for months or years.

Vesicles develop to accumulate storage products in many VAM associations. Vesicles are initiated soon after the first arbuscules, but continue to develop when the arbuscules senesce. Vesicles are hyphal swellings in the root cortex that contain lipids and cytoplasm. These may be inter- or intracellular of active mycorrhizae (Bago *et al.*, 1998). *Gigaspora* and *Scutellospora* do not form vesicles within the roots.

Structures to be observed for Identification

I. Sporocarp Present: *Glomus* and *Sclerocystis*

I. Sporocarp Absent: *Acaulospora*, *Otospora*, *Entrophospora*, *Gigaspora*, *Racocetra*, *Cetraspora*, *Dentiscutata*, *Fuscutata*, *Quatunica* and *Scutellospora*

II. Subtending Hyphal attachment Absent on the Spore (Spores develop from a saccule that get detached from it): *Acaulospora*, *Archaeospora*, *Otospora*, *Entrophospora*, *Kuklospora* and *Intraspora*

a. No stalk on the spore, a single scar (cicatrix) may be seen (the spore's point of attachment to the hypha which originally bore it), *Acaulospora*.

b. No stalk on the spore, they have two scars at the opposite poles. Scars are seen after crushing the spores, *Entrophospora*.

Inner wall is complex and multi-layered in both the genera. The walls are flexible.

The two genera are distinguished by the position of the sporiferous saccule. It is produced laterally in *Acaulospora* and formed within the subtending hypha in *Entrophospora*.

II. Subtending Hyphal attachment Present on the spore: *Glomus*, *Paraglomus*, *Sclerocystis*, *Gigaspora*, *Scutellospora*, *Racocetra*, *Cetraspora*, *Dentiscutata*, *Fuscutata* and *Quatunica*.

a. Subtending hypha is attached to the spore without a significant bulbous swelling. *Glomus*- All spores in this group have a simple wall structure with no inner walls. Three types of subtending hyphae are seen: Straight, Recurved and Funnel shaped.

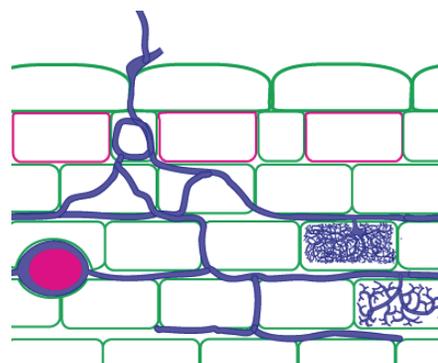
b. Subtending hypha has a globose swelling where it is attached to the spore.

Gigaspora, *Scutellospora*, *Racocetra*, *Cetraspora*, *Dentiscutata*, *Fuscutata*, *Quatunica*.

i) Spores with simple, thin bilayered wall and no inner walls- *Gigaspora*. The outer layer is rigid without lamina.

ii) Spores with complex inner walls - *Scutellospora*. The inner walls are thin and flexible or thicker, leathery to amorphous. *Scutellospora* has a characteristic germination shield.

Fig. 2 Mycorrhizas produced by the *Glomus* species:



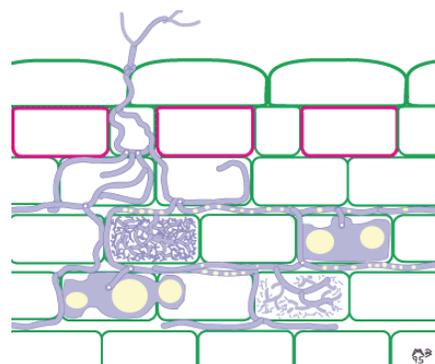
Relatively straight hyphae ramify along the root cortex (if root anatomy permits), often producing "H" branches which result in simultaneous growth in 2 directions. Staining of these hyphae is usually relatively dark.

Arbuscules can be dense and compact.

Oval vesicles, which usually form between root cortex cells, are present in many cases. These vesicles persist in roots and often develop thickened and/or multi-layered walls.

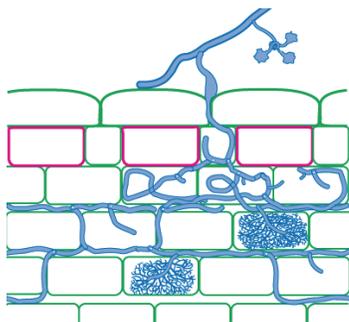
Intraradical spores in Glomaceae are usually globose, subglobose to elliptical.

Fig. 3 Mycorrhizas produced by *Acaulospora*



- Entry point hyphae have characteristic branching patterns. Hyphae in the outer cortex generally are more irregularly branched, looped or coiled than for *Glomus*. Colonies in roots are often relatively small.
- Internal hyphae are thin walled, often stain weakly and thus may be very hard to see, but may be visible due to rows of lipid droplets. External hyphae are usually also very hard to see.
- Intracellular oil-filled vesicles, that are initially rectangular, but often become irregularly lobed due to expansion into adjacent cells, are a characteristic feature.
- Intraradical spores in *Acaulospora* are pleomorphic, knobby and stain lightly in trypan blue.

Fig. 4 Mycorrhizas produced by *Scutellospora* and *Gigaspora* species



In *Scutellospora* VAM looping hyphae are often present near entry points. This genus has similar root colonisation patterns to *Acaulospora*, but hyphae in the cortex are generally thick-walled and stain darkly.

Internal vesicles are not present.

Arbuscular trunk hyphae normally are much longer and thicker than those of *Glomus*. The root colonization pattern for *Gigaspora* is very similar to that for *Scutellospora*, with wide hyphae. (Brundrett, 2004).

Conclusion

Identification of AM fungi upto genera requires careful observation of root anatomy, hyphal characters, intraradical and extraradical spores, spore colour, shape, size, spore wall, type, ornamentation and spore germination- direct or indirect. Identification up to species level requires molecular characterization.

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Research Article

Arbuscular Mycorrhizal Fungi from Kas Pathar Area of Satara District, Maharashtra.

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Abstract : Kas pathar area belongs to the Western Ghats which are known for their biodiversity. There is a need for assessment of Arbuscular Mycorrhizal status in this area. Rhizospheric soil from this area was collected to enumerate AM fungi and their respective hosts. The survey was carried out during all three seasons for three consecutive years. The collected soil samples were analysed for AM fungal spores that were subsequently identified. A wide range of dicotyledonous and monocotyledonous host species were also observed. The present study shows considerable variation in generic representation in AM fungi during different seasons. Also, it reveals the sustenance and survival pattern during unfavourable conditions. The study highlights the need for in depth analysis of various factors for a longer period of time which would be helpful to project a clear picture about the role of AM Fungi pertaining to their support to host plants and their specific contributions to the diversity in this region.

Key words: AM Fungi, Rhizosphere, Kas pathar

Introduction

Arbuscular Mycorrhizal (AM) fungi constitute a well studied and widespread symbiotic relationship with higher land plants. This group of fungi, an almost ubiquitous group of root symbionts, is known to carry out several beneficial activities and functions. Sahyadri mountain ranges, the North Western Ghats of India are among the 25 mega diversity hot spots of the world (Myers, *et al.*, 2000). The topographical, climatic and vegetational aspects of Western Ghats show distinct characteristics. Observations mentioned in this paper are from a site from this region; known as Kas Pathar, from Satara District of Maharashtra state. This site falls at 17° 55' N 73° 49' E and is 1240 meters altitude above mean sea level.

The current study was initiated with the aim of obtaining first hand information on the occurrence of Arbuscular Mycorrhizal (AM) fungal spores in the native soil. Recording the spore densities, seasonal variations in AM population and carrying out season-wise surveys of native host plants for AM fungal colonization were also planned as part of the study.

Materials and Methods

Collection and observations were made during monsoon, winter and summer seasons for three consecutive years. Attempts were made to observe and collect the samples from areas with minimum or no human interference. The rhizospheric soil samples, root samples and native hosts were collected for analysis during monsoon, winter and summer seasons, from the area of study viz. Kas pathar (plateau) in Satara district of Maharashtra.. The methodology suggested by Phillips and Hayman (1970) was

followed for clearing and staining of roots. Extraction of Arbuscular Mycorrhizal chlamydospores and the subsequent classification of AM fungi based on the spores were carried out according to standard procedures (Gerdmann and Nicolson, 1963; Schenck and Perez, 1990; Gaur and Adholeya, 1994).

Results and Discussion

The chlamydospores observed in the soil samples during all three seasons from the site of study belonged to five genera, namely, *Acaulopora*, *Entrophospora*, *Gigaspora*, *Glomus* and *Scutellispora*. Eighteen species of these 5 genera were observed as mentioned below:

1. *Acaulospora delicata*
2. *A. gadanskensis*
3. *A. spinosa*
4. *Entrophospora infrequens*
5. *Gigaspora albida*
6. *G. decipiens*
7. *G. rosea*
8. *Glomus aggregatum*
9. *G. cerebriforme*
10. *G. citricola*
11. *G. dimorphicum*
12. *G. fasciculatum*
13. *G. glomeratum*

14. *G. macrocarpum*
 15. *G. manihot*
 16. *G. mosseae*
 17. *Scutellispora alborosea*
 18. *S. gregaria*

during the study belonged to twelve angiosperm plant families (Table 1.) Among the host plants screened,

Rostellularia diffusa (Acanthaceae) was found to possess highest root colonization (29.66%) in winter as compared with other host plants screened during the three seasons. However, *Cyanotis fasciculata* (Commelinaceae), *Ericaulon tuberiferum* (Eriocaulaceae), *Euphorbia laeta* (Euphorbiaceae) and *Chlorophytum glaucum* (Liliaceae) were found negative for Arbuscular Mycorrhizal colonization. The average variation in spore population during three seasons for three consecutive years is depicted in Table 2.

Table 1. Native host plants screened during the study

S.No.	Plant Family	Native Host Specimen
1	Acanthaceae	<i>Rostellularia diffusa</i>
2	Asteraceae	<i>Senecio bombayensis</i> Balakr. <i>S. edgeworthii</i> Hook. f.
3	Commelinaceae	<i>Commelina benghalensis</i> L. <i>Cyanotis fasciculata</i> (Heyne. ex Roth.) J. A. & J. H. Schult. <i>Murdannia lanuginosa</i> (Wall. ex C. B. Cl.) Brueck
4	Eriocaulaceae	<i>Ericaulon sedgewickii</i> Fyson <i>E. tuberiferum</i> A. R. Kulkarni & Desai
5	Euphorbiaceae	<i>Euphorbia laeta</i> Heyne. ex Roth.
6	Fabaceae	<i>Crotalaria spectabilis</i> Roth. <i>Smithia hirsute</i> Dalz.
7	Lamiaceae	<i>Leucas biflora</i> (Vahl.) R. Br.
8	Liliaceae	<i>Chlorophytum glaucum</i> Dalz.
9	Orchidaceae	<i>Habenaria heyneana</i> Lindl.
10	Poaceae	<i>Arthraxon hispidus</i> (Thunb.) Makina. <i>Eragrostis gangetica</i> (Roxb.) Steud <i>Ischaemum commutatum</i> Hack. <i>Mnesithea clarkei</i> Koning & Sosef. <i>Paspallum paspalodes</i> (Michx.) Scribner
11	Primulaceae	<i>Anagallis pumila</i> Swartz.
12	Scrophulariaceae	<i>Sopubia delphinifolia</i> (L.) G. Don.

Table 2. Season-wise average spore population

S.No.	Season	Average number of spores/ g soil
1	Monsoon	34
2	Winter	297
3	Summer	249

The area under consideration is known to rich and diverse as far as flora and fauna are concerned. Such diverse vegetation is well supported by mycorrhizal associations. Muthukumar and Udaiyan (2000) studied AM fungi from Southern part of Western Ghats especially in semi arid soils. Similar work encompassing seasonal variations has been done by Mulani and Prabhu (2002). Mycorrhizal fungal colonization largely varies from season to season. High spore count during winter season was also observed by Harinikumar and Bagyaraj (1988). Mohankumar and Mahadevan (1988) reported high colonization rate during summer than rainy season. This may be due to the comparatively low temperature in tropical forest than the open plateaus which are exposed to direct sunlight and heat.

Conclusion

The spore count was found highest during winter season. Mycorrhizal spore diversity and occurrence of Arbuscular Mycorrhizal fungal propagules varied with season and was highest during winter, followed by summer and lowest during monsoon. Considerable amount of native host diversity was observed. Soil in rocky crevices showed high spore counts. Mycorrhizal propagules survive during summer season due to their association with the organic matter of the remnant root system of native vegetation of previous season. Further in depth study along with physico-chemical analysis of soil would be helpful to reveal a larger picture of this great association between host plants and AM Fungi.

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Taxonomy and Floristic Affinities of The Members of Wood Rotting Aphylophorales from Karnala (Maharashtra)

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Abstract : This work comprised a two years study on taxonomy and some qualitative aspects of wood rotting Aphylophorales in a semi-evergreen forest of Karnala in the Western Ghats. More than 150 specimens were collected and their identification revealed 17 genera and 19 species of non-poroid Aphylophorales. On the basis of detailed macroscopic and microscopic observations, identification key for the 17 non-poroid genera belonging to order Aphylophorales was prepared. The genera such as *Boidinia*, *Hyphoderma*, *Phanerochaetae* and *Vararia*, occurred on live standing trees; *Vesiculomyces* occurred on dead standing trees, while genera such as *Gloeocystidiellum*, *Peniophora*, *Radulodon*, *Tomentella* and *Xylobolus* were most abundantly found on fallen branches. The majority of these fungi cause white rot while very few cause brown rot. Analysis of the WRF was carried out which clearly indicated that majority of them belonged to southern distribution. Some of species belonged to northern distribution while very few are found in both the hemispheres. It was also observed that the distribution of Aphylophorales has close affinities with that of tropical members.

Key words: Aphylophorales, WRF, semi-evergreen forest, floristic affinities, Karnala.

Introduction

Aphylophorales, an order of the Basidiomycetes are roughly characterized by non-septate basidia, persistent gymnocarpous and non-putrescent fruit bodies which usually are not lamellate. Amongst wood rotting mycobiota, Aphylophorales constitute a major group that attack standing trees and fallen branches. They are characterized by non-poroid fruiting bodies which constitute the major group i.e. 60% while members with poroid fruiting bodies constitute 40% of the order Aphylophorales. They exhibit a variety of morphological characters (Gilbertson, 1979). Such fungi play a major role in the process of decay, resulting in serious damage to the forest economy.

Two kinds of rots are distinguished, one in which lignin and cellulose are degraded and where wood is bleached, is known as 'white rot'; while the other in which cellulose is degraded, leaving lignin more or less intact as brown residue is known as 'brown rot'. It is therefore very important to identify wood rotting Aphylophorales that cause great deal of damage to valuable forest plantations and structural timber. The present study includes detailed external and internal morphology of the basidiocarps of non-poroid Aphylophorales.

The forests of the Western Ghats by and large have rich fungal flora in the context of composition of wood rotting mycobiota. During field visits, a rich diversity of wood rotting mycobiota was observed in the preserved and protected forest at Karnala which has been declared as the first bird sanctuary in Maharashtra. On account of protection, the

vegetation has not been cut down like in other forests and also the dead branches remain lying on the forest floor. The climatic conditions in Karnala also favour the growth of wood rotting fungi.

According to Mahabale (1978), the development of deciduous forest is believed to be from evergreen to semi evergreen forest. This has exactly occurred in Karnala which provides a rich Angiospermic vegetation of unique type showing a mixture of semi-evergreen and moist deciduous forests with few isolated patches of evergreen vegetation in deep ravines (Mandavgane, 1978). Thus it appears that the existing vegetation has reached an ecologically climax condition. Endemic angiospermic taxa exist in this region. It was suggested since long that the subtropical forests in the Western Ghats of India are related with those of tropical Africa, South-East Asia and with parts of tropical America (Awasthi, 1968; Sathe, 1969).

To understand the floristic affinities of the members of Aphylophorales, the distribution of such fungi was studied.

Materials and Methods

Collection of fruiting bodies

Field work was carried out along different tracks at Karnala in different seasons. Field information included recording data on type of substratum, host plants, date and place of collection and colour and texture of fruiting bodies.

Identification of WRF

In the first stage spore prints were taken and used for identification of the fungi. Macroscopic and microscopic features of these fungi were analyzed with the standard methodology proposed for these fungi (Ryvarden and Johanson, 1980; Gilbertson and Ryvarden, 1986). Identification up to species level was done by using keys (Talbot, 1971; Rattan, 1977) for non-poroid Aphyllophorales. Measurement of hyphae, basidia, cystidia and spores were recorded.

Standard chemical tests, such as benzidine test to confirm the type of rot (Hintikka and Laine, 1970), sulphobenzaldehyde test to confirm the presence of gloeocystidia (Rattan, 1977), FeSO₄ test to confirm genus *Ramaricium* (Ginn, 1979) and Melzer's reagent test to confirm amyloid and non-amyloid nature of basidiospores (Talbot, 1954) were carried out.

Analysis of data

The occurrence of these fungi in different countries was studied.

Observations and Results

Collection and identification of WRF: More than 150 specimens were collected from the collection sites. Detailed macroscopic and microscopic analysis of these fungi revealed 17 genera and 19 species of non-poroid (NPO) Aphyllophorales. Majority of them caused white rot while very few such as *Acanthophysium apricans*, *Vararia ochroleuca* and species of *Heterochaetae* and *Hyphoderma* caused brown rot. Climatic and other conditions in Karnala favours the growth of WRF. Non-poroid members are more common on the plants with well developed bark or soft wood or under second layer canopy trees, bushes and lianas. Amongst varieties of host plants, *Mangifera indica* was the most susceptible host for *Acanthophysium*, *Boidinia*, *Dendrothele*, *Hyphoderma*, *Laxitextum*, *Pteridomyces*, *Ramaricium* and *Tomentella*. It was consistently observed that coppiced wood showed luxuriant growth of non-poroid Aphyllophorales such as *Hyphoderma*, *Ramaricium*, *Vararia*, *Phanerochaetae* with white to pinkish white basidiocarp. Species of *Gloeocystidiellum*, *Lopharia*, *Boidinia*, *Laxitextum*, *Lopharia* were observed more frequently on fallen branches of second layer of trees, bushes or climbers such as *Ficus racemosa*, *Murraya paniculata*, *Bridelia squamosa*, *Gmelina arborea*, *Smilax zeylanica*, *Combretum ovalifolium* etc. On the basis of characters observed, the identification key was prepared for non-poroid genera of Aphyllophorales.

Identification key for non-poroid genera of order Aphyllophorales: The key was constructed to emphasize macromorphological and microscopic characters in order to

facilitate the recognition of genus in the field or through microscopic examination.

1. Spores coloured, with a two layered cyanophilous wall 2
1. Spores hyaline or coloured, not cyanophilous. 3
2. Spores usually roughened, rarely smooth with cyanophilous outer wall, fruitbody greening with 10% FeSO₄ *Ramaricium*
2. Spores smooth, fruitbody not greening with 10% FeSO₄ 14
3. Dichohyphidia present, dimitic, cystidia or gloeocystidia often present, spores hyaline, echinulate, amyloid or not, fruitbody effused *Vararia*
3. Dichohyphidia absent, monomitic or dimitic . . . 4
4. Spores amyloid, smooth or asperulate to aculeate . . . 5
4. Spores not amyloid 6
5. Acanthohyphidia present, spores asperulate, rarely smooth, usually large, ellipsoid or globose, rarely cylindrical on living tree *Acanthophysium*
5. Acanthohyphidia absent, spores smooth, globose, hymenium with sterile dentate papillae composed of dendrohyphidia, fruitbody crustose to woody, effused, white or pale coloured, cystidia absent . . . *Dendrothele*
6. pores amyloid to pseudoamyloid, smooth or asperulate, gloeocystidia present 7
6. Not so 8
7. Strictly resupinate, hymenophore smooth, tuberculate or rarely finely dentate, spores asperulate, rarely smooth amyloid, cystidia thick-walled, encrusted, gloeocystidia reacting with sulphobenzaldehyde *Gloeocystidiellum*
7. Effused to effuse-reflexed, brown, tomentose, hymenophore smooth, spores finely echinulate, cystidia nil, gloeocystidia present *Laxitextum*
7. Resupinate, whitish to cream, non cyanophilous, hyphae clamped, globose echinulate spores, cystidia nil, gloeocystidia absent *Boidinia*
7. Resupinate, adnate, cream to yellow, clamp absent, gloeocystidia without oily contents, no reaction with sulphobenzaldehyde, smooth, subglobose spores *Vesiculomyces*
8. Spores globose to subglobose, hyaline to yellowish, outer wall spiny, cystidia absent, hyphae usually clamped, hymenophore resupinate and membranous *Tomentella*

8. Spores ellipsoid to oblong, smooth or warty, hyphae without clamps, hymenophore hydroid to tuberculate9
9. Hymenophore resupinate, white to cream, hydroid hyphal pegs present, cystidia present or absent..... 10
9. Hymenophore resupinate, smooth, not white to cream, cystidia present 12
10. Basidia cruciately divided, hyphal pegs made up of encrusted cystidia, basidiocarp thin, waxy to coriaceous, spores oblong, ellipsoid, smooth *Heterochaetae*
10. Basidia not cruciately divided 11
11. Hyphal pegs made up of agglutinated hyphae, basidiocarp hard and brittle, cystidia absent *Radulodon*
11. Cystidia absent, emergences on fruitbody, mono or dimitic hyphae *Pteridomyces*
12. Hymenophore resupinate, effused closely adnate, dull brown to light brown, cystidia metuloid, gloeocystidia and clamps present *Peniophora*
12. Not so13
13. Hymenophore smooth or dentate, membranous, cystidia present, hyphae with verticillate clamp *Phanerochaetae*
13. Hymenophore smooth, dentate or raduloid, basidia constricted, cystidia sometimes encrusted, gloeocystia, clamp simple, spores thin walled *Hyphoderma*
14. Spores amyloid, smooth, acanthohyphidia abundant, gloeocystidia present, clamps rare or absent, context brown, basidiocarp effused to effuso-reflexed *Xylobolus*
14. Spores non-amyloid, smooth, cystidia heavily encrusted, clamps absent, basidiocarp pileate, effuso-reflexed or patelliform, pileus tomentose *Lopharia*

The identifications revealed 19 species of the above genera (Table 1). *Dendrothele*, *Peniophora* and *Heterochaetae* were identified up to genus level. 11 species indicated with * marks were recorded for the first time from the selected site.

Floristic affinities

The analysis of identified species of non-poroid Aphyllophorales was carried out as shown in Table 1. It clearly indicates that majority of them belong to southern distribution namely, *Hyphoderma roseocreum*, *Laxitextum lutescens*, *Lopharia papyracea*, *Radulodon*

subquercinus, *Tomentella viridis*, *Vararia ochroleuca*, *Vararia rhodospora* and *Xylobolus ahmadii*.

The temperate species of Northern distribution present at the above location were *Boidinia furfuracea*, *Gloeocystidiellum porosellum*, *Hyphoderma lapponicum*, *Phanerochaetae laevis* and *Ramaricium albo-ochraceum*.

Species such as *Acanthophysium apricans* and *Tomentella viridis* are cosmopolitan in distribution.

Conclusion

The present study materially adds to our knowledge of Taxonomy of Aphyllophorales with respect to Karnala, the part of the Western Ghats. Due to climatic and other conditions, Karnala is rich in fungal flora. On the basis of detailed macroscopic and microscopic observations, 17 genera of non-poroid Aphyllophorales were identified. Total 19 species from 17 genera were identified with the help of literature available, which occurred on different habitats and host plants. The majority of these species are white rot fungi while very few are brown rot fungi. The fallen branches are the most suitable substratum for WRF, followed by live standing tree. Distribution of 19 identified species of Aphyllophorales has close affinities with those of tropical members. All species identified from Karnala are distributed in India and Ceylon. Amongst these, 11 species are recorded for the first time from Karnala.

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Table 1. Distribution of non-poroid Aphylophorales

Name	Southern distribution						Northern distribution				
	1	2	3	4	5	6	7	8	9	10	11
<i>Acanthophysium apricans</i>		+		+	+			+			+
<i>Boidinia furfuracea</i> *				+							+
<i>Gloeocystidiellum porosellum</i> *				+			+	+			+
<i>Gloeocystidiellum sulcatum</i> *				+							
<i>Hyphoderma lapponicum</i> *				+							+
<i>Hyphoderma obtusiforae</i>				+							+
<i>Hyphoderma roseocremeum</i> *			+	+							+
<i>Laxitextum lutescens</i> *	+			+							
<i>Lopharia papyracea</i>		+	+	+	+						
<i>Phanerochaetae laevis</i> *				+				+			+
<i>Pteridomyces sphaericosporus</i>						+					
<i>Radulodon subquercinus</i> *				+		+					
<i>Ramaricium albo-ochraceum</i> *				+			+	+		+	
<i>Ramaricium polyporoideum</i> *			+	+			+				
<i>Tomentella viridis</i>	+	+		+				+			
<i>Vararia ochroleuca</i> *		+		+							
<i>Vararia rhodospora</i>		+		+		+					
<i>Vesiculomyces citrinum</i>				+				+			
<i>Xylobolus ahmadii</i>				+		+					

1) Africa

2) Australia and New Zealand

3) South America and Brazil

4) India and Sri Lanka

5) Mediterranean countries

6) South Asia

7) North America and Canada

8) Europe

9) China

10) Poland, U.S.S.R., Siberia and Japan

11) Denmark, Sweden and Norway

Qualitative Screening of Lignocellulolytic Enzymes of Some Wood Rotting Fungi

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Abstract : Nine species of wood rotting fungi belonging to eight genera viz.: *Coniophora arida*, *Daedalea quercina*, *Fuscoporia senex*, *Irpex lacteus*, *Phanerchaete* sp., *Phellinus gilvus*, *Phellinus robustus*, *Lenzites eximia* and *Pycnoporellus fulgens* were screened for potential wood degrading lignocellulolytic enzymes. These were collected from different localities of Uttarakhand (North Western Himalayas). In the results, yellow opaque area around the mycelial growth showed carboxymethyl cellulose (CMC) degradation whereas zone of discoloration of the medium indicated the ligninolytic enzymatic activity of the fungi.

Key Words: Enzymes, Fungi, Laccase, Uttarakhand

Introduction

Wood tissues are degraded by fungi and these wood-decay fungi are classified as White-rot fungi, soft-rot fungi and brown-rot fungi (Deacon, 2005) according to their mode of attack. White rot fungi are efficient degraders of lignocelluloses as they can degrade both cellulose and lignin, whereas, brown rot fungi decompose hemicelluloses, cellulose and modify or cleave lignin but do not metabolise it. The soft rot fungi degrade only cellulose and hemicelluloses. White-rot fungi mineralize lignin by means of complex systems made up by extracellular oxidoreductases, such as laccases and peroxidases, low molecular-mass metabolites and active species of oxygen (Schlosser *et al.*, 1997; Johannes and Majcherzyk, 2000; Saparrat and Balatti, 2005). The ability to degrade lignin and other recalcitrant compounds such as single aromatic molecules and other xenobiotics confirms the unspecific nature of these oxidative enzymes (Johannes and Majcherzyk, 2000; Nagai *et al.*, 2002; Saparrat *et al.*, 2002; Saparrat and Guille'n, 2005).

Wood rotting fungi are capable of decomposing all the major components of wood due to production of hydrolytic and oxidative enzymes (Eriksson *et al.*, 1990). The major hydrolytic enzymes are endo 1, 4- β -D-glucanase, exo-1, 4- β -D-glucanase and xylanase (Kobakhidze *et al.*, 2012). The hydrolytic enzymes play a decisive role in the steady supply of nutrients to the growing fungi. These fungi play vital role in nature and particularly in the forest ecosystem, where they contribute significantly to carbon recycling; as the residues remaining from the harvest of trees and logs are attacked and degraded, particularly by white and brown rot fungi which are more aggressive colonizers and degraders of wood in such environment (Singh and Singh, 2014).

Qualitative estimation of lignocelluloses has been used for the study of systematics and biodiversity in fungi (Hyde, 1997). The assays for qualitative estimations are powerful tools used in screening of fungi for lignocelluloses degrading enzymes production (Thurston, 1994; Reddy and D'Souza, 1994; Pointing, 1999).

During a survey of the different ecological zones of N.W. Himalayas in the Uttarakhand, some of the Agaricomyceteous fungi were collected which were found to be very common and causing wood decay of the important timber trees. In order to use these fungi for biotechnological application these were screened for production of enzymes related to wood degradation. The objective of the present work was to determine the ability of different wood rotting fungi to produce lignocellulolytic enzymes.

Materials and Methods

Detection of Cellulolytic activity

Cellulolytic enzyme assay: The cellulolytic activity of enzymes was detected by staining of Carboxymethyl cellulose. The fungus was inoculated on Cellulolysis basal medium (CBM) for qualitative estimation of cellulolytic activity.

Endoglucanase (CMC agar): CMC degradation around the colonies (as endoglucanase activity) was determined as a yellow-opaque area that appeared against a red color for the un-degraded CMC. The methodology as suggested by Pointing (1999) was followed.

Detection of Ligninolytic activity

The ligninolytic activity of the enzymes was detected by using LME basal medium. Lignin modifying enzyme assays (LME) were carried out. The fungus was inoculated on LME basal medium for qualitative estimation of ligninolytic activity. The production of lignin peroxidase and Mn dependent peroxidase as clearance of blue coloured medium (Pointing, 1999) was studied.

Results and Discussion

Nine species of wood rotting fungi belonging to eight genera viz.: *Coniophora arida*, *Daedalea quercina*, *Fuscoporia senex*, *Irpex lacteus*, *Phanerochaete* sp., *Phellinus gilvus*, *Phellinus robustus*, *Lenzites eximia* and *Pycnoporellus fulgen* (Fig. 1) were screened for potential wood degrading lignocellulolytic enzymes. The qualitative estimation of lignocellulolytic enzymes is depicted in Table 1, Fig. 2 (Estimation of Ligninolytic activity) and Fig. 3 (Estimation of Cellulolytic activity).

Table 1. Qualitative estimation of lignocellulolytic enzymes by isolated wood rot fungi using CMC and LME assays

Sr. No.	Name of the Species	Cellulolytic activity	Ligninolytic activity
1	<i>Coniophora arida</i>	++	+
2	<i>Daedalea quercina</i> ,	+	+
3	<i>Fuscoporia senex</i>	+	++
4	<i>Irpex lacteus</i>	+	++
5	<i>Phanerochaete</i> sp.	++	++
6	<i>Phellinus gilvus</i>	++	+++
7	<i>Phellinus robustus</i>	++	+
8	<i>Lenzites eximia</i>	+	+++
9	<i>Pycnoporellus fulgen</i>	+++	+++

(+ Minimum, ++ Medium, +++Maximum activity)

Table-1 exhibits the potential ability of lignin and cellulose degrading enzymes by the mentioned wood rotting fungi viz., *Coniophora arida*, *Daedalea quercina*, *Fuscoporia senex*, *Irpex lacteus*, *Phanerochaete* sp., *Phellinus gilvus*, *Phellinus robustus*, *Lenzites eximia* and *Pycnoporellus fulgen*. It indicates that among the investigated species, there is variation in lignin and cellulose degrading ability. *Pycnoporellus fulgen* exhibited maximum cellulolytic activity whereas *Phellinus gilvus*, *Lenzites eximia* and *Pycnoporellus fulgen* demonstrated maximum ligninolytic activities. The results tally with those of Hyde (1997), Pointing (1999) and Guille' n(2000).

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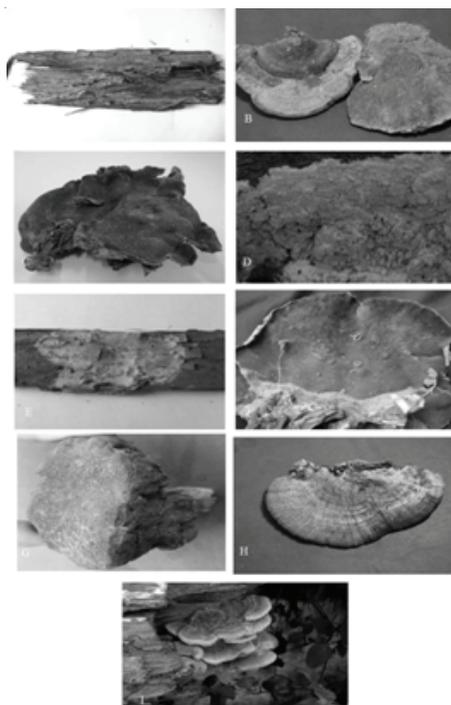


Fig. 1: Wood rotting Agaricomycetous fungi: A *Coniophora arida*, B *Daedalea quercina*, C *Fuscoporia senex*, D *Irpex lacteus*, E *Phanerochaete* sp., F *Phellinus gilvus*, G *Phellinus robustus*, H *Lenzites eximia*, I *Pycnoporellus fulgen*

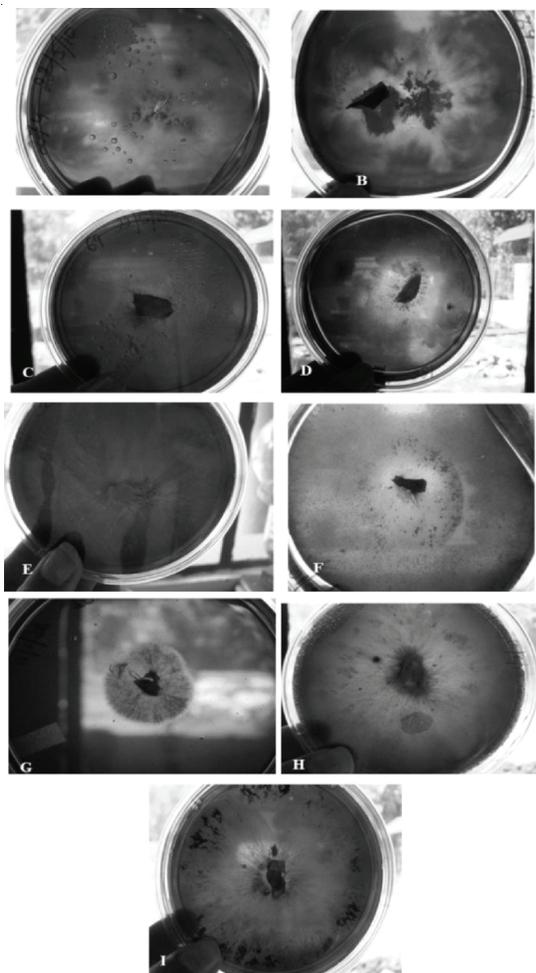


Fig. 2: Qualitative estimation of Ligninolytic enzymes: A *Coniophora arida*, B *Daedalea quercina*, C *Fuscoporia senex*, D *Irpex lacteus*, E *Phanerochaete sp.*, F *Phellinus gilvus*, G *Phellinus robustus*, H *Lenzites eximia*, I *Pycnoporellus fulgen*

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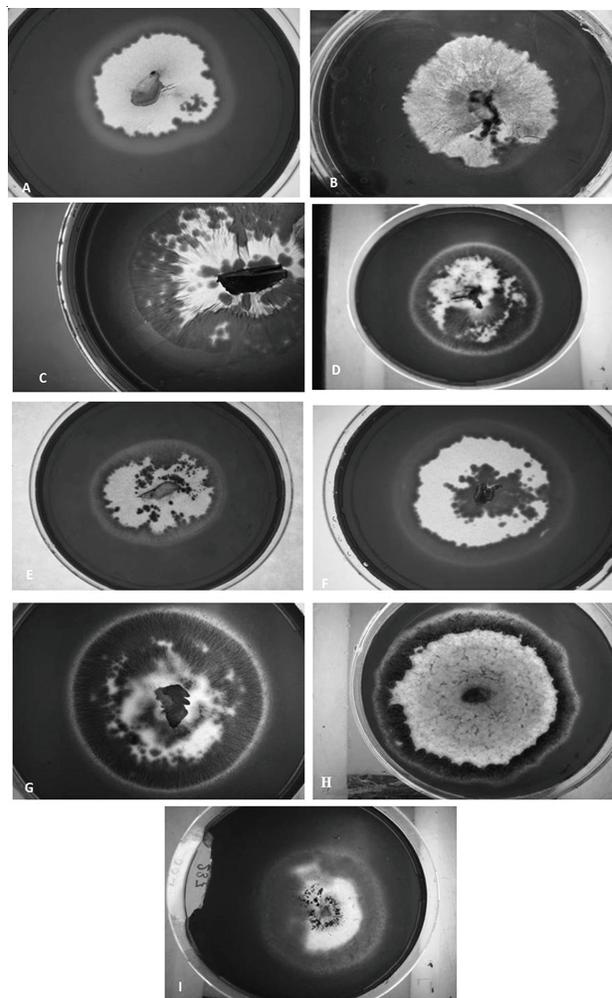


Fig. 3: Qualitative estimation of Cellulolytic enzymes: A *Coniophora arida*, B *Daedalea quercina*, C *Fuscoporia senex*, D *Irpex lacteus*, E *Phanerochaete sp.*, F *Phellinus gilvus*, G *Phellinus robustus*, H *Lenzites eximia*, I *Pycnoporellus fulgen*

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Research Article

Ascomatal hairs and ascospores as criteria for identification of some species of genus *Chaetomium*

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Abstract: The cellulolytic genus *Chaetomium* is characterized by ostiolate ascomata, clothed with hairs on top and sides, and loosely attached to the substratum by rhizoidal hyphae. The setae or hairs are very characteristic for all the species of *Chaetomium*, thereby serving as criteria for taxonomy at species level, along with asci and size and shape of ascospores. The present study deals with ascomatal hair and ascospore characteristics as criteria for classification of 5 species of *Chaetomium* namely, *Chaetomium atrobrunneum* Ames, *C. convolutum* Chivers, *C. olivaceum* Cooke and Ellis, *C. senegalensis* Ames and *C. venezuelense* Ames.

Introduction:

The cellulolytic genus *Chaetomium* is one of the largest genera amongst the Ascomycetes. Since its introduction in 1817 by Kunze, several hundreds of species were described, many of which were eventually reduced to synonymy or transferred to other genera. The latest monograph (Arx *et al.*, 1986) recognizes 92 species, most of these, with multiple synonyms. The genus is characterized by superficial ascomata, also known as ascocarps or perithecia; covered with hairs on top and sides, and loosely attached to the substratum by rhizoidal hyphae; having a wide pore or ostiole on top. The asci have various shapes and are characterized by an evanescent wall. Ascospores mature and are released inside the perithecium and then extruded out through the ostiole in the form of a rather sticky column or cirrhus. The hairs, also referred to as setae, protect the ascospores from imminent predation, support the spore mass after extrusion and facilitate slow release of ascospores for effective dispersal. In addition, fractured hairs also serve as organs of propagation (Chapman, 1975). These setae or hairs are very characteristic for all the species of *Chaetomium*, thereby serving as criteria for taxonomy at species level, along with asci and size and shape of ascospores.

The various species of *Chaetomium* are known for their cellulose degrading abilities. Equally capable of growth on open exposed surfaces, they rather prefer the under surface and are known to proliferate in enclosed dark and narrow spaces such as cavities, clefts, tunnels, infoldings and hollows in the substrate. They are equally at home in places such as abandoned nuclear reactors (Moore, 2001) or deeply seated inside vital human organs, especially in immunocompromised patients (Guppy *et al.*, 1998). Although taxonomy related literature is available, the

isolation and characterization of *Chaetomium* sps. is rather challenging. The current investigation deals with hair and ascospore characteristics as criteria for classification of 5 species of *Chaetomium*.

Materials and Methods:

Five species of *Chaetomium* viz. *Chaetomium atrobrunneum* Ames, *C. convolutum* Chivers, *C. olivaceum* Cooke and Ellis, *C. senegalensis* Ames and *C. venezuelense* Ames were isolated from mildewed paper samples using Czapek Dox Agar with cellulose (Bagool, 1982), with filter paper (Subba Rao, 1977) and Potato Malt Agar with filter paper strips (Ames, 1963), amended with chloramphenicol (50 µg/L). The isolated forms were identified using standard literature (Ames, 1963; Arx, 1986) and confirmed by NFCC, Agharkar Research Institute, Pune. Spot RT Real Time digital camera and IMAGE PRO PLUS (version 4.5) software was used for photography and measurements respectively.

Results and Discussion:

The 5 isolated species of *Chaetomium* viz. *Chaetomium atrobrunneum* Ames, *C. convolutum* Chivers, *C. olivaceum* Cooke and Ellis, *C. senegalensis* Ames and *C. venezuelense* revealed distinct patterns of ascomatal hairs, asci and ascospores.

***C. atrobrunneum* Ames-** The ascomata were superficial, dark brown, small, ostiolate, globose to sub globose, 80- 160 µm in diameter; the terminal hairs were long straight, unbranched when observed, septate, 3- 3.8 mm broad at the base and brown in colour. Asci were clavate, 8-spored, evanescent, 26-30X 10 µm; mature ascospores were pale grey- brown fusiform, 10-11 X 5.5-6.2 µm with germ pore at one end only (Fig. 1).

***C. convolutum* Chivers-** Ascomata were pale grey when young, darkening with age, superficial, globose or sub

globose, ostiolate, 280-400 X 220-250 mm, apically flattened; the terminal hairs were brown, septate, covered with minute spines, straight below and spirally coiled above, with 8-10 convolutions; with larger diameter below which evenly decreased towards the tip, 4-5 mm thick. Lateral hairs are brown, septate, 5- 5.5 mm in diameter, tapering and fading into a long hyaline tip. Asci were fasciculate, numerous, clavate, 8-spored, 45-55 X 10-15 mm broad, evanescent; mature ascospores dull olive, limoniform, slightly apiculate, at both ends, bilaterally flattened, 7.5-8.5 X 6-7 mm in dimension (Fig 2).

C. olivaceum Cooke and Ellis- Ascomata were olivaceous, appearing grey-green or brown in reflected light, spherical, globose, ostiolate, 300-400 mm in diameter, covered with a loose mass of grey to brown hairs. Terminal hairs dark, distinctly roughened, septate, , 3-5 mm in diameter, long, undulate, loosely interwoven; lateral hairs were similar, but slightly flexed, ending in a hyaline blunt tip. Asci were irregularly club- shaped; ascospores dark olive brown, ovoid, unbonate at both ends, 9-12.5 X 7.5- 9.4 mm in dimension (Fig. 3).

C. senegalensis Ames- Ascomata were pale brown, ovate, ostiolate, 150-185 mm in diameter; ascomatal hairs were undulate ribbon-like, pale brown, often branched and with tapering ends; 1.5-2 mm broad near the base; asci were fasciculate, long, cylindrical, with short stalks, 8-spored, 52-70 X 7-9 mm; ascospores uniseriate, almond shaped or inequilaterally ovate, bilaterally flattened, dark greenish brown when mature, 8.5-10 X 6.5-7.5 mm in dimension (Fig. 4).

C. venezuelense Ames- The organism appeared tangerine in colour to the naked eye. Ascomata sub globose, ostiolate, 150-180 X 120-145 mm, lightly attached to the substratum by delicate rhizoids; when mature and dry, the terminal hairs spread out from the centre like the opening of a rose blossom, the centre darkening with mass of ascospores; terminal ascomatal hairs, when young, were unbranched, septate, arcuate, blunt at the tips, 120-135 mm long, 3.5-4 mm broad near the base, slightly roughened, encrusted with coloured crystals; the ends of the aged hairs were branched, with gnarled irregular septate branches that became numerous, interlaced and fragmented easily. Lateral hairs were straight, septate, finely roughened, arising at an acute angle, tapering from the base to a narrow apex, typically unbranched, 2-3 mm wide near the base; asci were club shaped, 8- spored, usually deliquesced before maturing of ascospores; ascospores were ovate to lemon-shaped, light brown, 7.5-9.5 X 5-7 mm in dimension (Fig. 5). This relatively rare organism has also been isolated from soil and plant debris (Srivastava *et al.*, 1964, Ramesh and Raju, 1998). Millner (1977) reported this organism as a thermotolerant species.

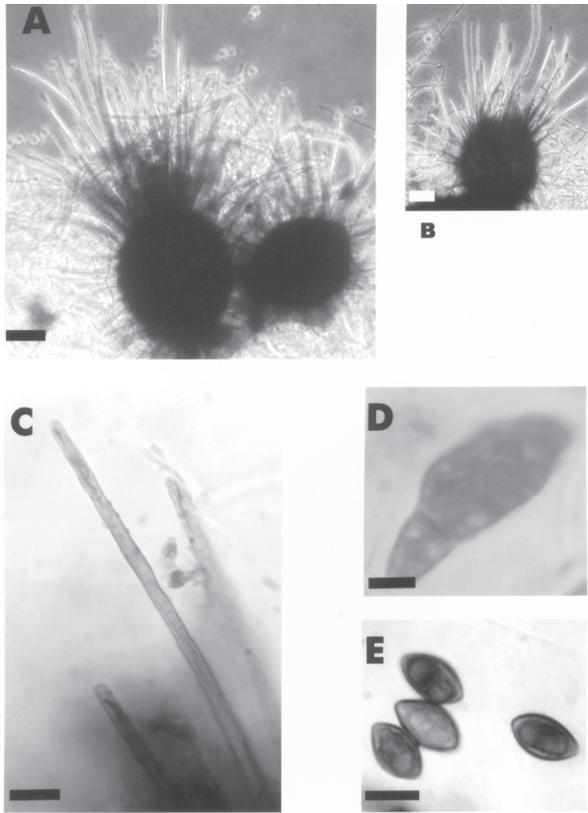
The various species of *Chaetomium* are generally considered safe for environmental and industrial applications, however many species have also been reported to cause severe complications and fatalities in immunocompromised patients (Martin *et al.*, 2014).

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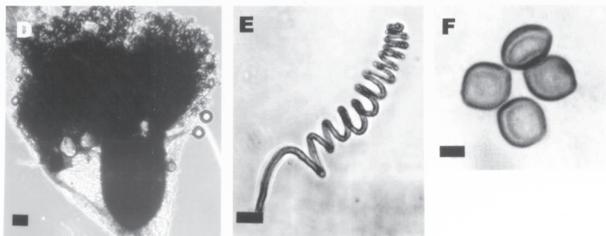
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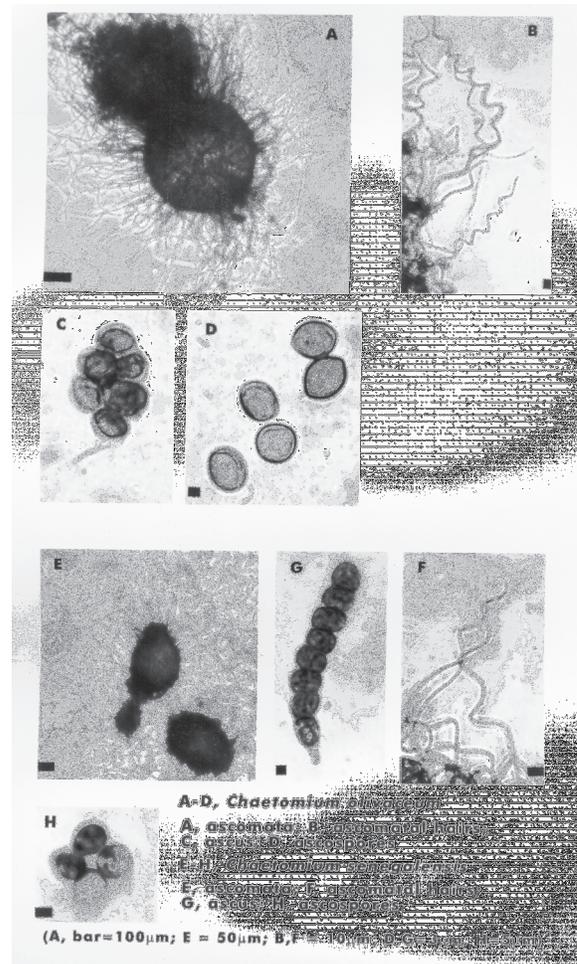
Chaetomium atrobrunneum
A, ascomata
B, ascoma
C, ascomatal hairs
D, ascus
E, ascospores
 (A, bar = 50 μm; C, E, bar = 10 μm; D, bar = 5 μm)

Fig. 1



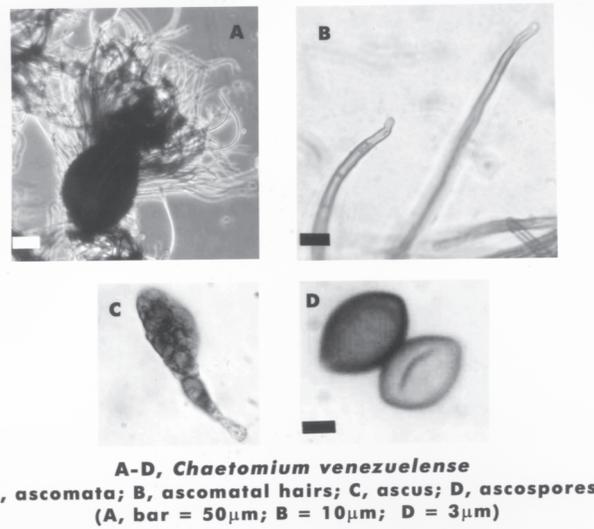
D-F - Chaetomium convolutum
D, ascomata ; **E, ascomatal hair** ; **F, ascospores**
 (A,D,bar = 50 μm; B,E, = 10 μm; C=5 μm F=3 μm)

Fig. 2



A-D, Chaetomium venezuelense
A, ascomata ; **B, ascomatal hairs**
C, ascus ; **D, ascospores**
E, ascus
G, ascospores
 (A, bar=100 μm; E = 50 μm; B, F = 10 μm)

Fig. 3 & 4



A-D, Chaetomium venezuelense
A, ascomata ; **B, ascomatal hairs** ; **C, ascus** ; **D, ascospores**
 (A, bar = 50 μm; B = 10 μm; D = 3 μm)

Fig. 5

Behaviour of Fungal Spore Taxa in the Atmosphere of Kalina Campus of Mumbai University

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Abstract : Present communication is a part of aerobiological studies on the Vidyanagari Campus at Kalina, University of Mumbai, undertaken for a period of one year and deals with behaviour of fungal spore taxa of the campus environment. These were next in abundance to the particles of plant origin and were found in all exposures in all the months. They included *Aspergillus* and *Penicillium* (Aspergilloid forms), *Alternaria*, *Cladosporium*, *Dreschlera* and *Helminthosporium* (Dreschleroid spores), *Nigrospora*, and *Curvularia*; ascospores and uredospores, in order of abundance. Aspergilloid spores were most dominating types amongst all the fungal spores. Seasonal / monthly abundance of each taxon and its frequency has been determined. The study would have significance in allergy and crop epidemiology.

Introduction

Aerobiology is an interdisciplinary science having implications in allergy and crop pathology. Numerous investigations have been undertaken highlighting different aspects of aerobiology. The implications of aerobiology in treatment of allergenic rhinitis and asthma have gained profound significance. In India a good amount of work in clinical aerobiology is being done in several centres, the major one being CSIR centre for biochemicals, New Delhi (Nair *et al.*, 1986).

Pollen calendars and aeromycoflora records are now available for different parts of India. A large number of investigators are also working on individual crops with reference to their airborne diseases. Detailed investigations on diurnal periodicity of spores and pollen grains of the atmospheres are needed to pursue the prevalence of acute allergy symptoms and epidemiology of crops. Such data are also getting fast accumulated.

Since initiation of aerobiological studies in Mumbai (Dosi and Kulkarni, 1981), there have been several contributions to this study from the city (Ghai, 1984; Subrahmanyam, 1985; Iyer, 1987; Rawale, 1989; Shailajan, 1991). Aerobiological surveys have been undertaken from Lucknow (Khandelwal, *et al.* 1988), Gwalior (Jain and Mishra, 1988; Datta and Jain, 1990), Balrampur (Srivastava and Shukla, 1990), Jabalpur (Verma and Khare, 1988; Sheorey, 1989; Verma, 1990), Bhagalpur (Ghani and Kale, 1992), Aurangabad (Rao, 1987), Gulberga (Mari Bhat and Rajasaab, 1988, 1991), Imphal (Singh and Singh, 1990), Bhopal (Dubey *et al.*, 1988), Gaya (Sinha and Mishra, 1988), Bangalore (Gangal, 1992), Kerala (Gopi, *et al.*, 1990) and other parts of the country.

Rai and Singh (1988) made a comparative survey of fungal spores in polluted versus unpolluted environments. A review of airborne *Aspergilli* was published by Ramlingam (1988). The significance of airborne *Candida albicans* has been brought out by Chatuvedi *et al.* (1988). Singh *et al.*

(1990) and Gangwar *et al.* (1988) have contributed to the prevalence of clinically important thermophilic actinomycetes associated with pneumonitis in the atmosphere. Fungal spores in library environment have been studied (Tilak and Pillai, 1988). Aeromycology of straw store houses has been studied by Vittal and Chinraj (1990). Fungal spores in bakery environment (Singh, *et al.*, 1990) and poultry sheds (Verma and Bhandari, 1992) have been investigated. Aerobiological work with reference to crop pathology was undertaken by Srivastava *et al.*, (1990) and Murdhankar and Pande (1991).

The present contribution is part of the aerobiological studies on the Vidyanagari campus, Mumbai University and deals with behaviour of fungal spore taxa in this comparatively uncongested greener, open vegetated area of Mumbai.

Materials and Methods

One year aerobiological survey of the University of Mumbai campus at Kalina was carried out from February 1993 to January 1994 using modified Durhams gravity Sampler (Plate 1, Fig. 1) and exposure of nutrient media to the atmosphere. Aeroscope was installed at 45 m on the terrace of Department of Life Sciences building in the campus.

Slide exposure: For slide exposure in aeroscope, microslide smeared uniformly with glycerine by means of a brush was placed in the slide holder of the aeroscope and exposed for 24 hours. At a time, two slides were kept in the aeroscope in the afternoon (at 2.00 to 2.30 pm) on every Monday throughout the period of survey. Exposed slides were made permanent by using safranin stained glycerine jelly. The slides were labelled indicating exposure date. Each slide was scanned thoroughly under 10X45 magnification and notes were prepared by counting number and kind of fungal spores observed under the area covered by cover-slip.

Identification of Airborne fungal spores: Fungal spores were identified with reference to standard

micropreparations made based on sporulating colonies developed on the nutrient medium exposed air.

Petriplate exposure: The petriplate sampling was carried out for a period of one year from February 1993 to January 1994, near aeroscope. Two petriplates containing Czapek-Dox agar medium were exposed for 15 minutes, twice in a month, along with slides. The exposed plates were incubated at room temperature for 3-4 days. The identification was undertaken at the genus level using standard literature.

Exposural Site: Vidyanaagari campus of Mumbai University, Santacruz(E) is an open area of 573 h bounded by discontinuous wall of 2 m height. The broken peripheral edges are dotted by slums. It is situated equidistantly on Kurla-Santacruz road. The habitated area including various departments, administrative offices and residential quarters occupies only 1/6 of the total area of the campus. The whole area can be basically categorized as marshland with numerous ponds, puddles and lakes with luxuriant wetland vegetation for almost throughout the year.

Table 1: Meterological data during the period of study

	Max. Temp	Min. Temp	Humidity	Rain fall
January	33.00	18.00	49.00	—
February	33.50	18.20	49.20	—
March	30.50	21.00	51.00	—
April	34.60	23.60	58.00	—
May	33.00	27.30	71.00	—
June	32.30	28.00	74.00	—
July	31.00	26.00	80.60	0.8.56
August	29.70	25.00	79.70	09.62
September	30.00	24.00	75.80	11.60
October	32.20	42.50	75.80	00.05
November	33.20	22.40	50.80	—
December	31.60	17.30	50.30	—

Results and Discussion

Meterological data, collected from newspapers is presented in Table 1.

Prevalence of fungal spores: These were next in abundance to particles of plant origin. Their average number varied from 22 per exposure in June and September to 72 per exposure in November (Table 2, Fig. 2). Distinct seasonal

trend was not seen. The fungal spores belonged to *Aspergillus*, *Penicillium* (Aspergilloid forms), *Alternaria*, *Cladosporium*, *Dreshlera* and *Helminthosporium*, *Nigrospora* and *Curvularia* and also ascospores and uredospores.

- i) *Aspergilloid Spores* :These included spores of *Aspergillus* and *Penicillium* (Plate II, 1). They were found in the exposures of all months. These were dominant amongst the total fungal spores found in the atmosphere. Their average number per exposure ranged from 8 in June to 46 in November (Table 2, Fig 3). Early summer and winter months showed higher frequencies (Table 3, Fig. 4).
- ii) *Alternaria*: Conidia of *Alternaria* (Plate II, 2) were of universal occurrence and were found invariably in all the exposures. The number per exposure varied from 2 in September to 10.7 in January (Table 2, Fig. 3). Summer months of February to May, winter months of January and early rainy months of June showed higher frequencies (Table 3, Fig. 4).
- iii) *Cladosporium*: Spores of *Cladosporium* (Plate II, 3) were also universal and found in all exposures. Their count per exposure varied from 1.6 in June and September to 9 in November (Table 2, Fig 3). Comparatively higher frequencies were found in late summer months of April, May and early winter period of November (Table 3, Fig. 4).
- iv) *Dreshleroid spores*: These included conidia of *Dreshlera* and *Helminthosporium* (Plate II, 4). They were found in exposures of all the months except August. Their average number per exposure varied from 0.25 in January to 3.2 in November (Table 2, Fig 3). However colonies of *Helminthosporium* were not isolated from petriplate exposures and those of *Dreshlera* only in Month of November (Table 3, Fig. 4).
- v) *Curvularia*: Spores were 3-4 septate, hyaline, found in the exposures of April, July, September and November (Plate II, 5). Average count per exposure varied from 0.4 in July and November to 1.33 in September (Table 2, Fig. 3).
- vi) *Nigrospora*: These were one celled, spherical, black coloured, opaque spores(Plate II,6). They were found in the exposures of September to December months. Their average number per exposure varied from 1.2 in December to 2.5 in October (Table 2, Fig. 3).
- vii) *Ascospores* : Two celled hyaline *ascospores* were found from January to June and in August, October, November (Plate II,7). They were absent in July,

September and December. Their number per exposure varied from 0.4 in November to 5 in March and May (Table 2, Fig. 3).

- viii) *Uredospores* : These were one celled, thick walled brown coloured of April, May, June and September, October, December. Their number per exposure varied from 0.2 in December to 4 in September (Table 2, Fig. 3).

The atmosphere was very rich in fungal spores for all the months of the year. No distinct seasonal trend could be marked. Gopi *et al.* (1990) described their concentration to be maximum during rainy season; Verma (1990) reported high concentrations from January to March and low concentration in June and Mari Bhat and Rajasab (1991) described September to March as ideal period for high concentration of fungal spores.

Earlier investigations (Dosi and Kulkarni, 1981; Iyer, 1987; Rawle, 1989) reported Mumbai atmosphere to be rich in fungal spores as compared to pollen grains, however at the present site the bioparticles of plant origin dominated over the fungal spores in all the months. This is probably due to congested areas investigated by early workers with minimum of vegetation. In contrast, the present site is open area with maximum of greenery throughout the year.

Amongst fungal spores Aspergilloid spores had highest frequency followed by *Alternaria*, *Cladosporium*, *Dreschlera*, Ascospores, Uredospores etc. Similar results were also presented in other investigations from Mumbai (Ghai, 1984; Subramanyam, 1985; Iyer, 1987; Rawle, 1989). At Jabalpur (Verma, 1990) and Gulberga (Mari Bhat and Rajasab, 1991) also, *Aspergillus* was reported to occupy the first position amongst fungal spores found in air whereas in Balrampur (Srivastava and Shukla, 1990), Kerala (Gopi, *et al.* 1990) and Secunderabad (Nayar, 1993) *Alternaria* has been reported to occupy the first place; while at Tiruchirapalli (Satheesh, *et al.*, 1993) and Guwahati (Sarma and Sarma, 1993) *Cladosporium* was reported as the dominant component of air. The sequence of abundance varied at different sites.

Spores of *Aspergillus* and *Penicillium* were dominant components of the air amongst the airborne fungal spores in all the months of the year. Early summer and winter months showed higher frequencies of these spores. These results tally with findings elsewhere (Mari Bhat and Rajasab, 1990; Gopi, *et al.* 1990; Nayar, 1993).

Spores of *Alternaria* were found throughout the year. Their frequency was highest from February to May, fairly high in January and June and low in September. These were also reported as regular components of atmosphere (Mari Bhat and Rajasab, 1990; Gangal, 1992; Gopi *et al.* 1990;

Nayar, 1993).

Spores of *Cladosporium* are found in the atmosphere in all the months as reported by earlier workers from the city (Iyer, 1987, Rawle, 1989). Their frequency was quite high in summer months of April, May and early winter month of November. They were less in abundance in June.

Dreshleroid spores representing conidia of *Helminthosporium* and *Dreschlera* were found in the atmosphere in all the months except August. Their frequency was quite high in October-December. These have been reported in similar studies (Mari Bhat and Rajasab, 1990; Gopi, *et al.* 1990; Sarma and Sarma, 1993).

Nigrospora spores were found in campus atmosphere from September to December. Their count was maximum in October and minimum in December. They have also been recorded by earlier workers from Mumbai (Dosi and Kulkarni, 1981, Iyer, 1987, Rawle, 1989) and from different parts of the country (Srivastava and Shukla, 1990; Gopi, *et al.*, 1990; Verma, 1990; Mari Bhat and Rajasab, 1990; Ghani and Kale, 1992; Satheesh, *et al.*, 1993; Nayar, 1993; Sarma and Sarma, 1993).

Curvularia spores occurred in April, July September and November. Maximum count was in September and minimum in July, November. Earlier workers (Dosi and Kulkarni, 1981; Iyer, 1987; Rawale, 1989) have recorded these spores throughout year, in Mumbai. These were recorded as most dominant spores from the atmosphere over Tiruchirapalli (Sateesh *et al.*, 1993) and Secunderabad (Nayar, 1993) and occupied second position in the atmosphere of Guwahati (Sarma and Sarma, 1993).

Ascospores were found in the atmosphere in late winter months and in summer months. They were maximum in March and May and minimum in November. These have been recorded from atmosphere over Mumbai by earlier workers (Dosi and Kulkarni, 1981; Iyer, 1987; Rawale, 1989). They were also reported from similar studies elsewhere (Verma, 1990; Mari Bhat and Rajasab, 1991; Satheseesh, *et al.*, 1993).

Uredospores were found in April- June and September-October. They have also been recorded by Doshi and Kulkarni (1981), Iyer (1987), Rawle (1989), Gopi, *et al.* (1990) and Nayar (1993).

Conclusion

Fungal spores were next in abundance to the particles of plant origin and found in all the months. Their percentage frequency varied from 22 for October to 44 for November. Distinct seasonal trend was not seen.

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Table 2 : Average number of fungal spores per exposure per month

	Jan	Feb	March	April	May	June	July	August	Sept	Oct	Nov	Dec
Aspergilloid Spores	15.25	13.25	27.5	11	14	8	12.68	15	10	12	46.6	31
<i>Alternaria</i>	10.77	7	5	7.75	8.53	9.33	4	4	2	4.25	10.4	5.22
<i>Cladosporium</i>	3	1.75	4	4.5	5.63	1.66	3.33	3.5	1.66	2	9.4	4.5
<i>Dreshlera/ Helminthosporium</i>	0.25	0.5	1	1	1	0.66	1	---	1.33	1.75	3.2	2.2
<i>Ascospores</i>	4.0	3.5	5	3.25	4.63	1.66	---	1	---	0.75	0.4	---
<i>Nigrospora</i>	---	---	---	---	---	---	---	---	2	2.5	2	1.22
<i>Uredospores</i>	---	---	---	2.5	0.36	0.36	---	---	3.66	1	---	0.22
<i>Curvularia</i>	---	---	---	0.5	---	---	0.36	---	1.33	---	0.4	---
<i>Rhizopus</i>	---	---	---	---	---	---	6.66	---	---	---	---	---
<i>Bipolaris</i>	---	0.25	---	---	---	---	---	---	---	---	---	---
Total Average Fungal Spores	33.27	26.25	42.5	30.5	34.15	21.67	28.03	23.5	21.98	24.25	72.4	44.36

Table 3: % Frequency of each fungal taxon

	Jan	Feb	March	April	May	June	July	August	Sept	Oct	Nov	Dec
Aspergilloid Spores	45.84	50.48	64.71	36.1	41.0	36.92	45.24	63.83	45.5	49.49	64.36	69.88
<i>Alternaria</i>	32.37	26.67	11.76	25.40	24.98	43.05	14.27	17.02	9.1	17.52	14.36	11.76
<i>Cladosporium</i>	9.01	6.67	9.41	14.75	16.48	7.66	11.88	14.89	7.52	8.25	12.98	10.14
<i>Dreshlera/ Helminthosporium</i>	0.75	1.90	2.35	3.29	2.93	3.04	3.57	---	6.05	7.21	4.41	4.95
<i>Nigrospora</i>	---	---	---	---	---	---	---	---	9.1	10.31	2.76	2.75
<i>Ascospores</i>	12.02	3.33	11.76	10.65	13.56	7.66	---	4.25	---	3.09	.55	---
<i>Uredospores</i>	---	---	---	8.19	1.05	1.66	---	---	16.65	4.12	---	0.49

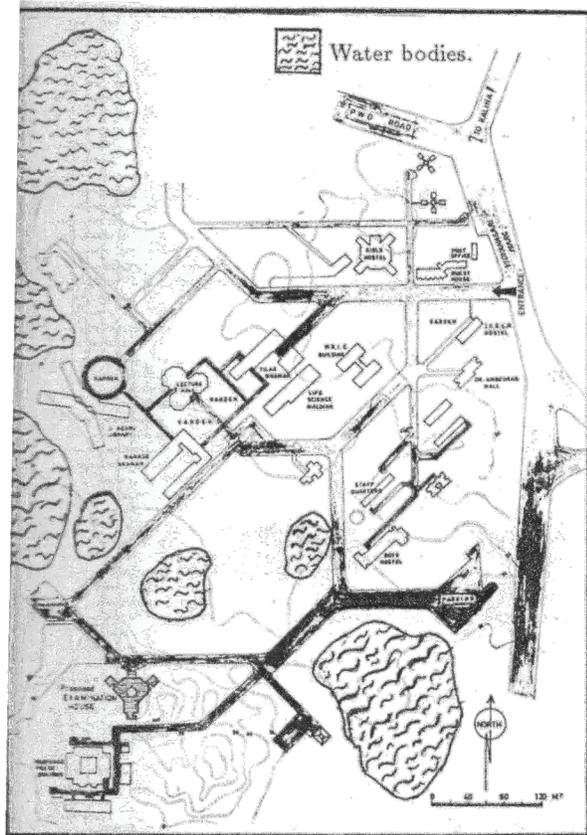


Fig. 1: Map of Bombay University Campus at Vidyanagari showing positions of aquatic bodies.

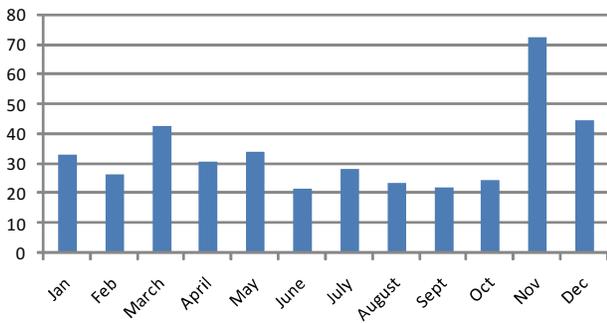


Fig. 2 Average fungal spores per exposure

Plate I
Aeroscope

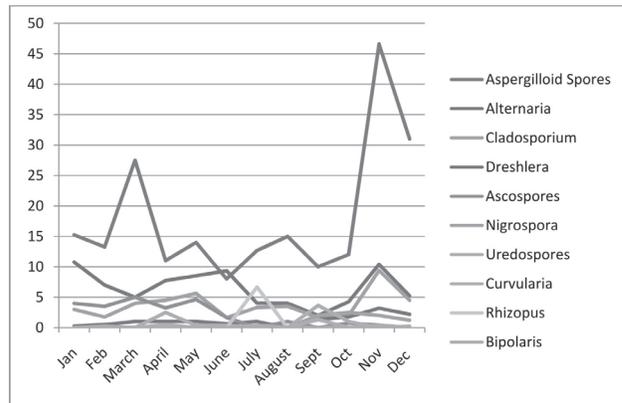


Fig. 3 Monthly variations in different spore taxa per exposure

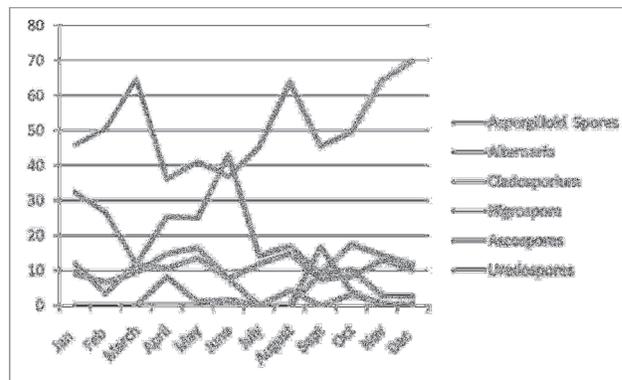
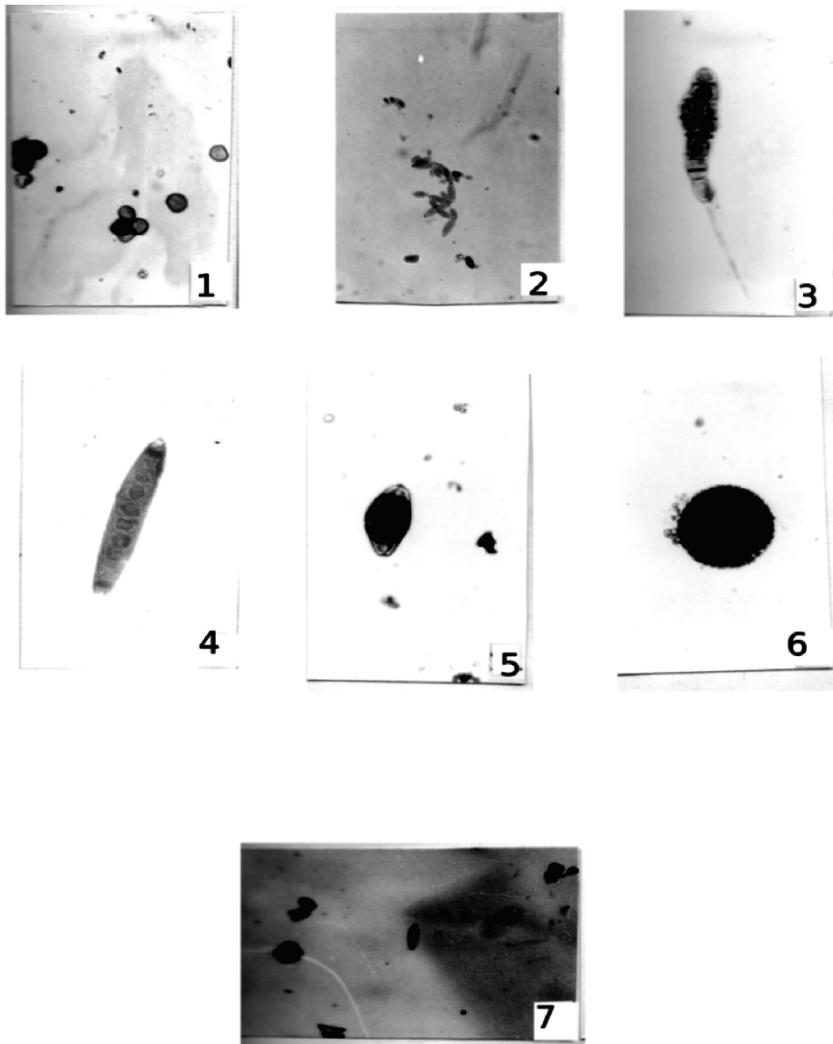


Fig. 4 Frequency of fungal spore taxa per exposure

Plate II

1. Aspergilloid spores, 2. *Cladosporium*, 3. *Alternaria*, 4. *Helminthosporium / Drehslera*, 5. *Curvularia*, 6. *Nigrospora*, 7. Ascospores



Study of Common Plants of Medicinal Value in Sangola Taluka of Solapur District, Maharashtra (India)

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Abstract :During the study of medicinal plants in this region the authors came across a number of species, ten of which are discussed. They have great value in the cure the various ailments and diseases which are inhabiting in the said area. *Achyranthes aspera* Linn., *Abutilon indicum* (L.) Sweet, *Tephrosia purpurea* Linn., *Xanthium strumarium* L., *Aerva javanica* Burm. F., *Cuminum cyminum* Linn., *Fonniculum vulgare* Mill., *Daucus carota* Linn., *Pongamia pinnata* (L.) and *Ricinus communis* Linn. are discussed with respect to distribution, chemical composition and their uses. All species are being reported for the first time as medicinal plants from this region.

Key words: Medicinal plants, Sangola, Maharashtra

Introduction

Sangola taluka belongs to Solapur district of Maharashtra, India. Classified as a drought prone area, shallow and poor type of soil, non retentive of moisture, marks this part, along with scanty and uncertain rainfall. Due to non uniform rains, scarcity conditions prevail in the talukas. Generally monsoon period is from the second fortnight of June to the end of September bringing rains from South-West monsoon. This region was selected for the study of medicinal plants. Sangola taluka has number of rural areas which are very rich in biodiversity.

Medicinal plants have played an essential role in the development of human culture. Many of the modern medicines are produced indirectly from medicinal plants. Plants are directly used as medicines by a majority of cultures around the world. Medicinal plants are resources of new drugs. Cultivation and preservation of medicinal plants protects biological diversity.

Plants have always been the main forms of medicine in India and now they are becoming popular throughout the world. People from countries outside India are consulting trained herbal professionals and have started using plant medicines. It is estimated that about 70,000 plant species have been used for medical purposes. All these plants provide starting material for the isolation or synthesis of conventional drugs.

In the present work an attempt is made to present some interesting ethno medicinal observations recorded in Sangola division, Solapur district, Maharashtra, India. The study of medicinal plants was practically neglected from this region. Hence, it was felt to undertake the study. The findings of this study can provide useful leads for

pharmacological conformation of the reported uses which might in time become useful for mankind.

Materials and Methods

The study is based on common plants of medicinal values in Sangola taluka, district Solapur, Maharashtra, India. The survey method was used for collection of data. Different rural localities were visited throughout the year and samples of leaves, stem, bark and wood of angiospermic medicinal plants were collected. During the field work and gathering of information, help was taken from traditional healers, vaidyas, village elders, chiefs and knowledgeable persons; both men and women. Prior informed consent was taken from the knowledge providers.

The methodology described by Chadwick and Marsh (1994), Martin (1995) and Jain and Mudgal (1999) was adopted for study. Structured questionnaires, interviews and observations were used to illustrate information from the resource person. Detailed interviews were conducted with herbal specialists from the rural areas. Overall documentation the treatment pattern of various species were checked and confirmed. The specimens were collected and observed in their natural habitat and identified. Detailed information was collected on the basis of health profile, social, economic and cultural aspects.

Results and Discussion

Survey of the taluka revealed several species of medicinal plants from different localities, ten of which are discussed in the current study viz., *Achyranthes aspera* Linn., *Abutilon indicum* (L.) Sweet, *Tephrosia purpurea* Linn., *Xanthium strumarium* L., *Aerva javanica* Burm. F., *Cuminum cyminum* Linn., *Fonniculum vulgare* Mill., *Daucus*

carrota Linn., *Pongamia pinnata* (L.) and *Ricinus communis* Linn.. At the time of study rural people shared his valuable information about the medicinal plants. Details are mentioned below:

1. Prickly Chaff Flower

Scientific Name: *Achyranthes aspera* Linn.

Vernacular Names: Kutri, Aghada, Chirchita, Latjira, Pandhara-aghada

Parts used: Whole leaves, roots, flowers, fruits and seeds.

Family and Distribution: Amaranthaceae; it is of common occurrence throughout India and the tropical world. It is an invasive species found throughout tropical Asia, Africa, Australia and America. Abundant as a weed in dry areas and wastelands, from sea level to 2100m altitude. It was recorded in Haldahiwadi, Jawala and Sangola in the current study.

Chemical composition: Plant yields achyranthin and Betaine. Plants contain triterpenoid saponins which possess oleanolic acid as the aglycone. Ecdysterone, an insect moulting hormone, and long chain alcohols are also found in *Achyranthes aspera*. Seeds contain *Achyranthes* saponin A and its ester names as *Achyranthes* saponin B3. The presence of ecdysterone is also reported. Shoots contain an essential oil, tannins and glycosides.

Uses: For snake bites the ground root is given with water until the patient vomits and regains consciousness. A fresh piece of root is used as tooth brush. Seven leaves crushed and taken as a single dose twice a week on Tuesday and Sunday can effectively treat the bite of a dog if delivered within 21 days after the bite. The plants are use medicinally for several diseases such as piles, colic, boils etc. It is pungent, purgative, diuretic and astringent.

2. Country mallow, Indian Abutilon

Scientific Name: *Abutilon indicum* (L.) Sweet

Vernacular Name: Mudra, Kanghi

Parts used: Whole plants

Family and Distribution: Malvaceae; native to tropical and subtropical regions, it is found throughout the hotter parts of India. It was found in Sangewadi, Ekhatpur, Kamalapur of Sangola.

Chemical composition: Beta Sitosterol is present in plants. The main constituents are alantolactone, isoalantolactone, helenin and gallic acid from the roots.

Uses: It is sweet, cooling, digestive, laxative, expectorant, diuretic, astringent, analgesic, anti-inflammatory, anthelmintic, demulcent, and aphrodisiac. It is useful in gout, tuberculosis, ulcers, bleeding disorders, and worms. Decoction used in toothache and tender gums. Demulcents of leaves are locally applied to boils and ulcers. Roots are prescribed in fever, chest affection and urethrities. The leaves are used in gonorrhoea, chronic bronchitis, bleeding piles, leprosy, bark is astringent and diuretic.

3. Fish Poison, Wild Indigo

Scientific Name: *Tephrosia purpurea* Linn.

Vernacular Name: Sarphonk, Sharpunkha

Source: Leaves, Seeds, Roots and Bark.

Family and Distribution: Fabaceae; It is found throughout India and Sri Lanka in poor soils. It was found in Wanechinchale, Medshingi, Narale and Sangola.

Chemical composition: Roots contain the flavonoids apollinine, semiglabin, semiglabinol, tephroglabin, tepurindiol, pongamol, iso-lonchocarpin, o-methylpongamol, lanceolatin A & B. The leaves contain a flavonoid rutin, a triterpenoid lupeol and a sterol Beta-sitosterol, novel flavonoids tephrosin A and B and tephrosone, an isoflavone, 7,4-dihydroxy-3, 5-dimethoxyisoflavone and a chalcone tephropurpurin.

Uses: Used as a fish poison; the leaves and seeds contain tephrosin, which paralyzes fish. Larger doses are lethal to fish, but mammal and amphibians are unaffected. It is also used traditionally as folk medicine. According to *Ayurveda*, the plant is digestible, anthelmintic, alexiteric, alterative and antipyretic. It is used in the treatment of leprosy, ulcers, asthma, and tumors, as well as diseases of the liver, spleen, heart, tumours leprosy, diuretic, allays thirst, enriches blood, useful in treatment of bronchitis, inflammation, boils, pimples.

4. Rough Cocklebur, Common Cocklebur, Clotbur, Broad bur, Burdock Datura

Scientific Name: *Xanthium strumarium* L.

Vernacular Name: Ghagara, chota datura, Chota gokhuru, sankhahuli, shankeshrvar

Parts used: Leaves, root, fruits and seeds

Family and Distribution: Asteraceae; it has probable origin in North America and has extensively naturalized elsewhere. A medicinal plant commonly found as a weed, widely distributed in North America, Brazil, China, Malaysia and hotter parts of India. It was found in Waki and Shivane.

Chemical composition: Chemical constituents such as sesquiterpenes, lactones, xanthinin, stereoisomer, xanthumin, xanthatin, glycoside, phenols, polysterols are present in all plant parts. Toxic principle, a sulphated glycoside, is xanthostrumarin. Atractyloside, the main toxic compound extracted from this plant, is kaurene glycoside.

Uses: The herb is traditionally used in treating several ailments. Extracts of the whole plant, especially leaves, roots, fruits and seeds are used for the treatment of leucoderma, poisonous bites of insects, epilepsy, salivation, long-standing cases of malaria, rheumatism, tuberculosis, allergic rhinitis, sinitis, urticaria, rheumatoid, arthritis, constipation, diarrhoea, leprosy, lumbago, pruritis, bacterial and fungal infections.

5. Kapok Bush, Aerva, Pillow Bush, Snow bush

Scientific Name: *Aerva javanica* Burm. F.

Vernacular Name: Bhui, Kapurmadhura, Kapurimadhuri, Kapuriphuti, Kurma

Parts used: Leaves, whole plants

Family and Distribution: Amaranthaceae; it has a native distribution incorporating much of Africa, and the south-west and south of Asia. The plant has naturalized in northern of Australia. It was found in Junoni, Kole and Nazara of Sangola taluka.

Chemical composition: In the course of screening program six natural products were isolated from the whole plant. The constituents are Isoquercetrin, 5-methylmellein, 2-hydroxy-3-o-beta-promeverside naphthalene-1,4-dione, Apigenin 7-0-glucuronide, Kaempferol-3-0-beta-D-glucopyranosyl-(1-2)-alph-l-rhamnopyranoside-7-0-alpha-L-rhamnopyranoside and 7-(1,hydroxyethyl) -3,4-dihydrobenzopyran.

Uses: It is used in hemorrhoids, skin dryness and self cracking of skin. It is used for fodder, veterinary medicine, food, floss, stuffing and caulking, fuel and lighting; household, domestic and personal items. It is used for stuffing pillows and animal saddles, also eaten by sheep. Kapok leaf extract and powder is diuretic. They help to treat stomachache, kidney stone problems, urinary troubles and burning sensation of urine.

6. Cumin, White cumin

Scientific Name: *Cuminum cyminum* Linn.

Vernacular Name: Jira, Jeera, safed jira.

Part used: Seeds

Family and Distribution: Umbelliferae; it is native of east Mediterranean to India but now commonly grown in

the Punjab and Uttar Pradesh for aromatic fruits. North Gujrat especially Unja is well known for its cultivation. It is also found and cultivated in sangola in rural areas of Narale and Junoni.

Chemical composition: The fruit contain fatty oil, resin, mucilage, protein compounds and an essential volatile oil which gives it its characteristic odour and taste. Its main constituent and important aroma compound is cumin aldehyde, perilla aldehyde, alph and beta-pinene, dipentene, p-cymene, beta-phellandrene, cuminal-dehyde(4-isopropylbenzaldehyde).

Uses: Cumin acts as a galactagogue, carminative and aids digestive system function better. According to the Indian Herbal Medicine, cumin balances vata and kapha. Cumin is also used in treating inflammation, indigestion, flatulence and as an appetizer.

7. Fennel, Indian Sweet Fennel

Scientific Name: *Foniculum vulgare* Mill.

Vernacular Name: Sanuf, Badi-Sanuf.

Parts used: Leaves, Stem, Root, Seed and Fruit.

Family and Distribution: Umbelliferae (Apiaceae); Originally indigenous to South Europe, it is now widely cultivated throughout the temperate and sub-tropical regions of the world for its aromatic fruits. In Sangola it was recorded in Chick Mahud, Bhoose, Walekhindi and Dongargaon.

Chemical composition: The volatile oil content is 0.7-1.2% in Indian variety, but it is 4-6% in Europe varieties. Methyl chavicol was detected from oil. Fruits also contain pentosan, pectin, trigonelline, fenchone, seselin, anethole and choline. The essential oil contains sesquiterpene, germacrene-D and b caryophyllene.

Uses: Fennel seeds are used for their anti-inflammatory, antispasmodic, antimicrobial properties and estrogen promoting action. Fennel seeds are widely used in the treatment of anaemia, menorrhagia, dysmenorrhoea, fibroids, stomachaches, sore throat, coughs, bad-breath, skin diseases, eye infections, intestinal worms, flatulence, gum infections, excessive weight and poor milk secretion in breast feeding women.

8. Carrot

Scientific Name: *Daucus carrota* Linn.

Vernacular Name: Gajar

Parts used: Flowers, Roots, leaf and seed.

Family and Distribution: Apiaceae; plant is native to temperate regions of Europe, southwest Asia and naturalized to North America and Australia. In india it is grown in Punjab,

Uttar Pradesh and Madhya Pradesh. It was found everywhere in Sangola.

Chemical composition: The main chemical constituents of carrot seed oil include a-pinene, camphene, b-pinene, sabinene, myrcene, y-terpinene, limonene, b-bisabolene, geranyl acetate and carotol.

Uses: According to the clinical reports beta-carotene can significantly lower the risk of heart attacks and strokes in women. Carrots are used in herbal medicine to treat problems such as intestinal parasites, persistent diarrhea, different digestive problems as well as high cholesterol problems.

9. Pongam

Scientific Name: *Pongamia pinnata* (L.)

Vernacular Name: Karanj

Parts used: Seed oil, roots, bark, leaves, flowers.

Family and Distribution: Papilionaceae; native in tropical and temperate Asia including parts of India, China, Japan, Malasia, Philippines, the Seychelles, the United States, Australia and Pacific islands. Commonly found near banks of streams in Peninsular India. It was found in Sangola, Mahud, Watambare, Junoni and Sangewadi.

Chemical composition: The pongam plants contain main chemical constituent such as alkaloids demethoxykanugin, gamatay, glabrin, glabrosaponin, kaempferol, kanjone, kanugin, karangin, neoglabrin, pinnatin, pongamol, pongapin, quercitin, saponin, b-sitosterol, and tannin etc.

Uses: *Pongamia* seeds and oil is anthelmintic, styptic, and depurative. It is useful in rheumatism arthritis, whooping cough, skin ailments and scabies. Seed oil is mainly used in cosmetics, in soap making and as a lubricant. Seed oil is also used as insecticidal, nematicidal and bactericidal.

10. Castor oil plant, Castor Bean, Wonder Tree

Scientific Name: *Ricinus communis* Linn.

Vernacular Name: Arandi, Erand

Parts used: Seed, root

Family and Distribution: Euphorbiaceae; this is a small tree, cultivated chiefly in Andhra Pradesh, Maharashtra, Karnataka and Orissa. Castor is indigenous to the southeastern Mediterranean Basin, Eastern Africa, and India, but is widespread throughout tropical regions. It was recorded in Sangola, Walegaon, Ekhatpur, Wasud and Jawala.

Chemical composition: The main chemical composition of *Ricinus* oil is monoterpene including monoterpene hydrocarbons and oxygenated monoterpene, alpha-thujone, 1,8-cineole, alpha-pinene, camphor, camphene, ricinine.

Uses: Castor oil has widely been used as a laxative to clear digestive tract most especially in children and to include labor pains. A poultice of the roots and leaves is administered for wounds, boils, sores and as a galactagogue. Castor oil is used for expelling worms, treating colds, colic, convulsions, fever, gout, nerve pain, rheumatism, swellings, tumors, and warts.

Findings of the investigation, chemical compositions and uses of the studied plants are in agreement with those of Pandey (1990), Levinson (1996), Acharya and Shrivastava (2008), Dike and Obembe (2012) and Rao *et al.* (2012).

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Comparative Study of Island Flora Along the Konkan Coast

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Abstract: Present work is the compilation of the flora of islands of Konkan coast. The areas under study included the Elephanta and Madh Islands near Mumbai, Jacinto Island near Vasco city and Cumberjua Island near old Goa. The vegetation of these areas was studied by making regular field visits (from 2009 to 2014). The data collected during these field trips showed presence of approximately 565 Species of flowering plants belonging to more than 111 families. The study also showed that the flora of Elephanta Island is rich and diverse yet constantly under threat since the place is a tourist spot. The vegetation of Jacinto island is less disturbed and shows high species diversity in spite of having smaller area than that of Elephanta island and Cumberjue island. No mangrove species are found on this island. The flora of Cumberjue island remains restricted in the small patches of rich vegetation due to loss of habitat. Maximum number of mangrove species was found in Cumberjue and Madh island. Madh island is connected to the main land of Mumbai by reclaimed land area of mangrove habitat. The floras of these islands are more or less similar to the inland flora of Konkan coast. Some of the plant species belonging to evergreen forests of higher altitudes are also found growing in these islands e.g. *Alseodaphne semicarpifolia* Nees. in Jacinto Island, *Litsea ghatica* Saldanha. in the Elephanta Island and *Memecylon umbellatum* Burm.f. in the Cumberjue Island. This data will be useful for the vegetation studies of other islands of Konkan coast.

Key Words: Konkan coast, Elephanta island, Madh island Jacinto island, Cumberjua island, island flora.

Introduction:

Konkan strip of land is 800 km long and 27- 48 km broad starting from Tapi basin to Goa. It is bounded by the Sahyadri hills on the east and the Arabian Sea on the west. Maharashtra state has about 720 km long indented coastline, which is marked by the presence of major estuaries and narrow creeks. It comprises the coastal districts of Thane, Raigad, Greater Bombay, Ratnagiri and Sindhudurg (Plate 1).



Plate .1: Map of Maharashtra state showing five districts of Konkan Coast

Konkan coast is an important sector on the West coast of India, because of its physical distinctiveness, biota and marine resources. The coastal region is hilly, narrow,

highly dissected with transverse ridges of the Western Ghats and at many places extending as promontories, notches, sea caves and submerged shoals and offshore islands. There are many small islands in the Arabian Sea along the Konkan coast. Islands are completely surrounded by sea water and therefore are separated from main lands. Although together occupying only 8% of the total surface, they account for 20-25% of global plant growth. Coastal plains include taxonomically very rich and productive ecosystems on the earth. Hence present study was undertaken to survey and compare the flora of the islands of Jacinto (Goa), Cumberjua (Goa), Elephanta (Raigad), and Madh near Mumbai.

Jacinto Island:

It is situated near Vasco city of Goa. It is 1.5 km. inside from the coast (coordinate of 15°24'15" N & 73°51'53" E) and has an area of about 15 acre. The Jacinto island was named after St. Jacinto church. Its population is about one thousand. People residing on this island are having fishery as business. Earlier people used to go to Jacinto Island by walking at the time of low tide but now new bridge has been constructed in the year 2009.

Cumberjua Island:

It is an island town located at coordinate of 15°30'36" N, 73°57'3" E on the banks of the Mandovi River in Goa. It is situated to the east of Panaji at a distance of 20 Kilometers, and the area measures about 24, 01,550 sq. meters.



Plate no.2: Satellite images of Jacinto Island



Plate no.3: Satellite image of Cumberjua Island

Elephanta Island:

It has an area of 16 km² (6.2 sq miles). It is located approximately at 18°57'2N 72°56'2E / 18.95°N 72.93°E. / 18.95; 72.93 The area comes under the jurisdiction of the Raigad district in Maharashtra State. Elephanta Island (also called Gharapuri Island or *place of caves*) is one of the islands in Mumbai Harbour, east of Mumbai. The name *Elephanta*,

was given by 17th century Portuguese explorers, after seeing a monolithic basalt sculpture of an elephant found near the entrance. The island has a population of about 1,200, and rice farming, fishing, and repairing boats are their main occupations (Pradhan 1957). The fore shore is made up of sand and mud with mangrove bushes on the fringe. The vegetation of this island was studied by John Graham in 1839(Almeida M.R.. 1996).



Plate no.4: Satellite images of the Elephanta island

Madh Island:

It is located approximately at N 19°15'422" E 72°07'8'815". This island is bounded by Arabian Sea to west and malad creek on east. It is a group of several quaint fishing villages and farmlands in northern Mumbai.



Plate no. 5: Satellite image of the Madh Island

These coastal islands are facing serious threats to their natural habitats and the diverse animal and plants communities inhabiting them. Islands around the world are under tremendous pressure from growing human population and the resulting exploitation of resources, habitat

destruction and introduction of invasive species. Anthropogenic activities in these unique ecosystems have drastic impact on their biodiversity and distinct habitat. Island make up only about 5 % of the earth's land surface but constitute areas of high endemism (ENVIS, 2014) since 1500, the majority of the recorded species extinctions has happened on islands and represents over 50% of the extinction in the past 20 years. The primary cause of this extinction is the introduction of alien species and habitat destruction (ENVIS, 2014).

Methodology:

Field work was carried out twice on every island from 2009 to 2014. List of plants prepared and some uncommon specimens were collected for further identification and authentication. Monsoon flora was not recorded as no transport means were available. During the field visit plant characters were noted and photographs were clicked. Herbarium sheets were prepared for the reference. Plant specimens were identified with the help of standard literature (Almeida, 1996; Cooke, 1901; Hooker, 1872).

Result and Discussion:

1. Jacinto Island: Forest vegetation is evergreen type. 438 species of angiosperms belonging to 391 genera and 83 plant families were recorded (Fig.1). Though it is an island, no mangroves were growing in the periphery region of the island. This may be due to the rocky shore and lack of marshy soil. The flora of this island resembles more or less the inland flora of Konkan coast. Some of the plant species (e.g. *Alseodaphne semicarpifolia* Nees.) belonging to evergreen forests of higher altitudes are also found growing in this islands (Almeida, 2004).

Total no. of species: 438

Total no. of Dicotyledonous species: 390

Total no. of Monocotyledonous species: 48

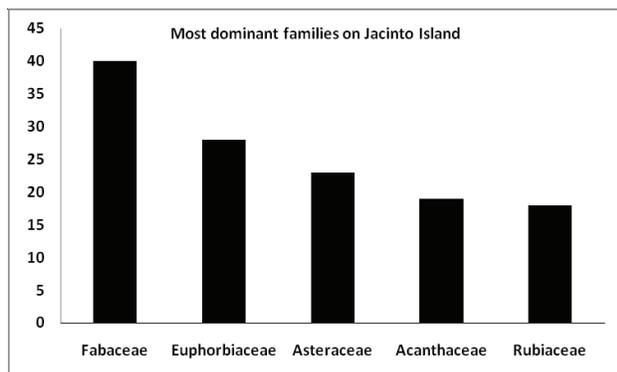


Fig. 1 : Dominant Flora on Jacinto island

2. Cumberjua Island: Vegetation of this island is of mixed type. The island is surrounded by many species of mangroves. About 409 species belonging to 369 genera and 98 plant families were recorded (Fig.2). The vegetation was thick in patches due to high population density. It is surrounded by many species of mangroves in contrast to Jacinto island. Mangrove species like *Rhizophora mucronata* Poir and *Bruguiera gymnorrhiza* Lamk. were recorded. Due to loss of habitat, the flora of Cumberjua island remained restricted in the small patches of rich vegetation. Maximum number of mangrove species was found in Cumberjue island.

Total no. of species: 409

Total no. of Dicotyledonous species: 367

Total no. of Monocotyledonous species: 42

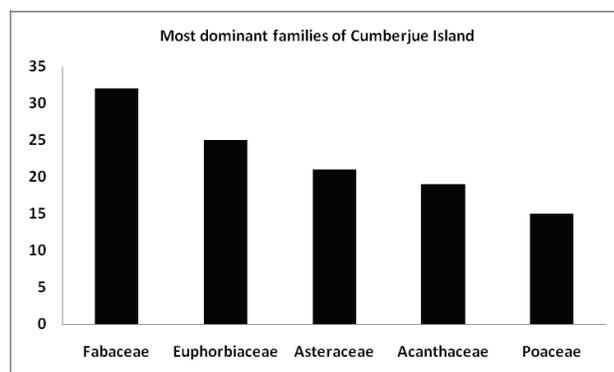


Fig. 2 : Dominant Flora on Cumberjue island

3. Elephanta Island: There were 335 species of angiosperms belonging to 200 genera and 87 plant families (Fig.3). The forest vegetation was mixed type. Forest growth with clusters of mango, tamarind, and karanj trees covered the hills with scattered palm trees. Rice fields were seen in the valley (Pradhan 1957). The fore shore was made up of sand and mud with mangrove bushes on the fringe. The flora of Elephanta island is rich and diverse yet constantly under threat since the place is a tourist spot. Plant species like *Crataeva tapia* Linn., *Aerides praemorsum* Willd. And *Litsea ghatica* Saldanha. were found in this island .

Total no. of species: 335

Total no. of Dicotyledonous species: 300

Total no. of Monocotyledonous species: 35

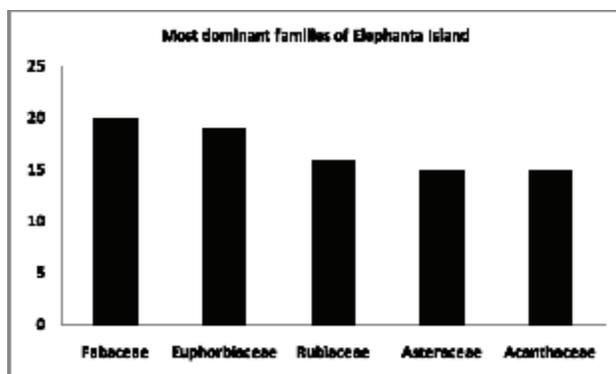


Fig. 3 : Dominant Flora on Elephanta island

4. Madh Island: Vegetation is very rich with palms and several mangrove species. 274 species of angiosperms belonging to 250 genera and 80 plant families were recorded during visit (Fig.4). *Sterculia villosa* Roxb. was endemic to Madh island. This island is famous for sap of *Borassus flabellifer* (Todi). The vegetation of this area was earlier studied by G. L. Shah in 1965.

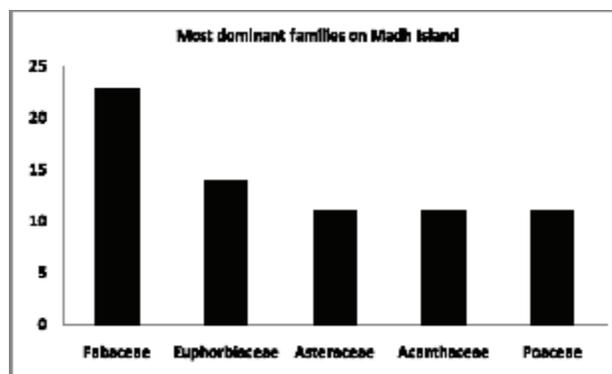


Fig. 4 : Dominant Flora on Madh island

Total no. of species: 274

Total no. of Dicotyledonous species: 252

Total no. of Monocotyledonous species: 22

A list of plants species recorded in these islands and their distribution is given in the following table.

Table 1: A list of plant species exclusively recorded in the islands of Jacinto, Cumberjue, Elephanta and Madh

S.no.	Jacinto Island	Cumberjue Island	Elephanta island	Madh Island
1.	<i>Millettia tomentosa</i> (Roxb.) S inclair	<i>Magnolia grandiflora</i> Linn.	<i>Capparis tensa</i> Dalz.	<i>Calophyllum inophyllum</i> Linn.
2.	<i>Polyalthia cerasoides</i> Benth. & Hook.f.	<i>Cananga dorata</i> (Lamk.) Hook.f. & Thoms.	<i>Kleinhovia hospita</i> Linn.	<i>Abelmoschus manihot</i> (L.) Medicus ssp. <i>tetraphyllus</i> (Roxb. ex Hornem.) Brassum
3.	<i>Portulaca pilosa</i> Linn.	<i>Abelmoschus esculentus</i> (L.) Moench.	<i>Grewia subinqualis</i> DC.	<i>Adiantum digitata</i> L.
4.	<i>Abutilon persicum</i> (Burm.f.) Merrill	<i>Murraya paniculata</i> (Linn.) Jack	<i>Zizyphus xylopyra</i> Willd.	<i>Cesiba pentandra</i> (L.) Gaertn.
5.	<i>Koeleria vitifolia</i> (Linn.) Almeida & Patil	<i>Semecarpus anacardium</i> Linn.f.	<i>Acacia farnesiana</i> (Linn.) Willd.	<i>Muntingia calabura</i> Linn.
6.	<i>Dombeya calamintha</i> Schum.	<i>Spondias pinnata</i> (Linn.f.) Kurz.	<i>Parkia biglandulosa</i> Wt. & Arn.	<i>Pongamia pinnata</i> (L.) Pierre
7.	<i>Pterospermum maceiifolium</i> (Gaertn.) Willd.	<i>Crotalaria lutescens</i> Dalz.	<i>Suzigium laevissimum</i> Lank.	<i>Adiantum hercynicum</i> Linn.
8.	<i>Sterculia guttata</i> Roxb.	<i>Tephrosia strigosa</i> (Dalz.) Santapa & Maheshwari	<i>Opuntia stricta</i> Mill.	<i>Cucurbita maxima</i> Wt. & Arn.
9.	<i>Triumfetta pilosa</i> Roth.	<i>Vigna unguiculata</i> (Linn.) Walp.	<i>Dentella repens</i> (Linn.) J.R. & GForst.	<i>Pluchea tomentosa</i> DC.
10.	<i>Apidopterys indica</i> (Willd.) Hochrest.	<i>Bauhinia acuminata</i> Linn.	<i>Grangea maderaspatana</i> (Linn.) Bois	<i>Diospyros melanoxylon</i> Roxb.
11.	<i>Paranigra monophylla</i> Wight.	<i>Cassia alpinia</i> Linn.	<i>Diospyros montana</i> Roxb.	<i>Hymenocallis tenuiflora</i> Herb.
12.	<i>Allophyllus cobbe</i> (Linn.) Raesch.	<i>Cassia alata</i> Linn.	<i>Vallis solanacea</i> (Roth.) O. Kuntze	<i>Apluda mutica</i> L.
13.	<i>Litchi chinensis</i> S onnerat	<i>Albizia canara</i> (Roxb.) boivin.	<i>Nymphoides indicus</i> (Linn.) O. Kuntze.	
14.	<i>Alysicarpus bupleiifolius</i> (Linn.) DC. var. <i>hybridus</i> DC.	<i>Bruguiera gymnorhiza</i> Lamk.	<i>Litsea ghatica</i> Saldanha.	
15.	<i>Crotalaria pallida</i> Ait.	<i>Rhizophora mucronata</i> Poir.	<i>Viscum articulatum</i> Burm.f	

16.	<i>Crotalaria calycina</i> Schrank.	<i>Centella asiatica</i> (Linn.)Urban.		
17.	<i>Crotalaria filipes</i> Benth.	<i>Hebeotis auricularia</i> Linn.		
18.	<i>Crotalaria prostrata</i> Rottl.	<i>Exora coccinea</i> Linn.		
19.	<i>Crotalaria verrucosa</i> Linn.	<i>Capsicum annuum</i> Linn. Var. <i>acuminatum</i> Fingert.		
20.	<i>Dalbergia lanceolaria</i> Linn.f.	<i>Datura fastuosa</i> Linn.		
21.	<i>Desmodium heterocarpon</i> (Linn.) DC.	<i>Solanum melongena</i> Linn.		
22.	<i>Desmodium triguistrum</i> Linn. DC.	<i>Barleria longiflora</i> Linn.f.		
23.	<i>Indigofera tinctoria</i> Linn.	<i>Cinnamomum verum</i> J.persl.		
24.	<i>Vigna vexillata</i> (Linn.) A. Rich.	<i>Excoecaria agallocha</i> Linn.		
25.	<i>Zornia diphylla</i> (Linn.)Pers.	<i>Ficus nervosa</i> Heyne ex Roth.		
26.	<i>Terminalia ajuna</i> (Roxb.) Wt. & An.	<i>Arecacatechu</i> Linn.		
27.	<i>Pavetta crassicaulis</i> Bremek.	<i>Finbrizylis isnera</i>		
28.	<i>Pentas lanceolata</i> (Forsk.) DeFlers.			
29.	<i>Psychaxumbellata</i> (Wt.) Briden			
30.	<i>Baccharoides scabridum</i> (DC.) Almeida			
31.	<i>Solidago microglossa</i> DC.			
32.	<i>Spilanthes clava</i> DC.			
33.	<i>Rauwolfia tetraphylla</i> Linn.			
34.	<i>Cosmastigma cordatum</i> (Poir.)			
35.	<i>Tylophora indica</i> (Burm.f.) Merrill			
36.	<i>Exacum bicolor</i> Roxb.			
37.	<i>Ehretia indica</i> (Dennis Ex Kostel.) Almeida & Almeida			
38.	<i>Argyria elliptica</i> (Roth.) Choisy			
39.	<i>Convolvulus arvensis</i> Linn.			
40.	<i>Ipomoea acarifolia</i> (Desr.) Roemer & Schultes			
41.	<i>Merrimia hederacea</i> (burm.f.) Hall.			
42.	<i>Daurainnoxia</i> Mill.			
43.	<i>Neuracanthus trinervius</i> Wight.			
44.	<i>Callicarpa tomentosa</i> (Linn.) Murray			
45.	<i>Symphrena involucratum</i>			
46.	<i>Aristolochia bracteolata</i> Lamk.			

47.	<i>Alseodaphne semicarpifolia</i> Nees.			
48.	<i>Piper malabaricum</i> Linn.			
49.	<i>Litsea tosa</i> (Linn.) Almeida			
50.	<i>Persea americana</i> Mill.			
51.	<i>Gnidia glauca</i> (Fresen.) Gilg.			
52.	<i>Dendrothoe neilgherryensis</i> (Wight & Arn.) Van Teigh			
53.	<i>Acalypha indica</i> Linn.			
54.	<i>Croton virbakis</i> Almeida			
55.	<i>Glochidion sinicum</i> (Gaertn.)			
56.	<i>Sapium insigne</i> Trim. var. <i>Malabaricum</i> (Wight) Hook. f.			
57.	<i>Artocarpus lacucha</i> Buch.-Ham.			
58.	<i>Ficus virens</i> Dryand.			
59.	<i>Crinum latifolium</i> Linn.			
60.	<i>Pycnus flavescens</i> (L.) Reichb. f.			
61.	<i>Scleria lithosperma</i> (Linn.) Sw.			
62.	<i>Arundinella metzii</i> Miq.			
63.	<i>Heteropogon contortus</i> (L.) P.Beauv. ex R. & S.			
64.	<i>Sporobolus tenuissimus</i> (Schrank) O. Ktze.			

Data analysis:

565 species of plants were recorded from these four islands (Table 1). 36 plant species were found common to all the four islands. 64 plant species were recorded exclusively from Jacinto Island and 27 from Cumberjua Island. 15 species were recorded exclusively from Elephanta island and 12 from Madh island. Following is the taxonomic statistics of the plant species identified from all the 4 islands.

Total no. of species: 565

No. of Dicotyledoneae species: 505

No. of Monocotyledoneae: 60

The 5 dominant families are shown in Fig. 5.

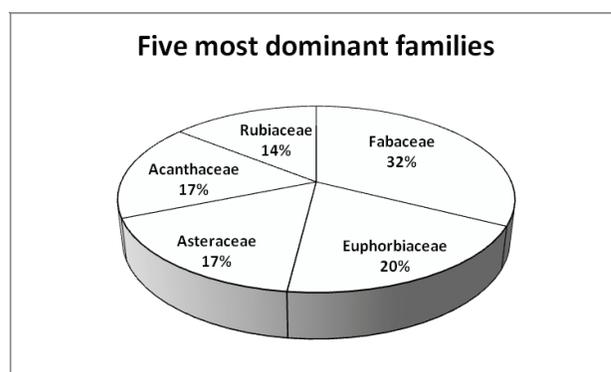


Fig. 5.

Unusual occurrence of species like, *Memecylon umbellatum* Burm.f and *Alseodaphne semicarpifolia* Nees., plant species which are normally found on areas of higher altitude of Western Ghats, were found growing near sea shore of islands of Jacinto and Cumberjue.

Maximum number of Mangrove species was found in the coastal region of Cumberjua island and Madh island (this may be due to Mandovi Creek surrounds these 2 islands).

Conclusion:

Among all the 4 islands studied, Jacinto island possesses the highest no. of exclusive species and the highest species diversity and density. Thus, Jacinto island has the richest flora. Jacinto island is apparently least affected by human activity as only few acres of land is inhabited by humans whereas the rest of land is covered by thick vegetation. Although Elephanta island has the largest area, the species diversity was found comparatively less. This is probably due to the island being one of the most visited tourist spots near Mumbai.

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Research Article

Encroachment Impact on Tungareshwar Wildlife Sanctuary, Vasai Taluka, Maharashtra

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Abstract : The area measuring 8,570 hectares (85.7 sq. km) of Tungareshwar reserved land was declared as Tungareshwar Wildlife Sanctuary (TWS) on October 24, 2003 (Gazette Notification No. WLP.1002 /CR-47/F-1). TWS with astonishing rich biodiversity of Flora and Fauna lies in Vasai Taluka of Palghar District. Recently, additional 10 sq. km of reserved land was declared as restoration zone, thus the forest area of TWS is now about 95.70 sq. km. Sanctuary lies to an altitude of about 2177 feet and is known for its two popular destinations - the Tungareshwar Mahadev Temple and Balyogi Sadanand Ashram. Balyogi Sadanand Ashram is one of the major encroachments and occupies more than 0.69 ha. of forest land illegally. In the last few years the human activities have been increased and there is a construction of concrete buildings (a lodge, prayer hall, canteen and 2 well temples). Due to this construction rich lush green diversity of flora of TWS is declining year by year.

Key words: Tungareshwar Wildlife Sanctuary, encroachment, species threat

Introduction

Tungareshwar hills are part of rich Sahyadri ranges (Almeida, 1996). During field trips to Vasai taluka from period June 2013-December 2014, Tungareshwar Wildlife Sanctuary (TWS) drew attention due to its rich, endangered, rare flora, enclosing in its arms lining between 19° 23' 38" N and 72°58'9" E. About 150 species of birds such as common kestrel, peregrine falcon, crested serpent eagle, hornbill, grey jungle fowl and various mammals like leopard, rusty-spotted cat, common palm civet, jackal, fox, common langur, common mongoose, black-naped hare, sambar and barking deer were recorded (Apte, 2007) from this area. There are two major water catchments that supply water to Vasai and Nallasopara area. TWS is well connected to Sanjay Gandhi National Park (SGNP) through Nagala block which is separated by the Bassein Creek. This becomes a corridor between SGNP and TWS for animals. TWS is popular destination for biologists, nature lovers, trekkers, mountaineers, and devotees. Tungareshwar is a dense forest providing green surroundings, flowing waterfalls and rivers during monsoon. It has been observed that in the last few years the human activities have been increased and there is a construction of concrete buildings in this reserved forest areas. Hence, this study was undertaken to study the vegetation of TWS and prepare a list of rare and endangered plants of this area.

Materials and Methods

A field survey was conducted every season from June 2013 to December 2014. Along with botanical data, local information was also collected by interviewing the villagers and local herbalists and incorporated in the field diary. Photographs were taken for the documentation purpose. The plant specimens in the form of twigs, bulbs or rhizomes were collected during the study wherever required. The

specimens were pressed, dried and the herbarium sheets were prepared. Literature survey was done to avail maximum information on TWS from previous documentation available at Blatter herbarium. Identification of the plants was done using relevant floras and comparing the specimens with the Blatter herbarium specimens.

Results and Discussion

The data obtained from the field study showed that the natural vegetation in this area is disturbed due to following activities:

1. Agricultural encroachment

Many patches of the forest land are converted into agricultural land by the villagers of Juchandra, Sativli, Parol and Tungar living along the periphery of the Sanctuary. The villagers are seen constructing concrete houses in the forest areas and cutting down the forest trees for growing paddy and vegetables. They move freely in the forest areas in hunt of natural resources such as water, wood and food required for living. Their activities for survival have introduced many exotic weeds, which are dominating and destroying natural vegetation. A list of plants cultivated as source of food is given in Table 1.

2. Land sliding due to construction of road

Land sliding is a major problem caused due to increased activities in the forest and rapid clearance of forest patches. Road widening activity taken up by the Sadanand Maharaj Ashram, has led to falling of trees during and post monsoon season. The road is maintained by the Ashram from the Parol village via Ashram till the Mahadev temple. The ashram has a medical center open throughout the year. The forest products are most likely used as medicines. The devotees

Table 1. Plants cultivated in the reserved forest area

Crop	Botanical name	Common name	Family
Cereals	<i>Eleusine coracana</i> (L.) Gaertn.	Nachano, Nazaro, Ragi, Makra, Hoda	Poaceae
	<i>Oryza sativa</i> L.	Bhat, Chaval, Rice	Poaceae
	<i>Zea mays</i> L.	Bhutta, Maka	Poaceae
Pluses	<i>Cajanus cajan</i> (L.) Millsp.	Tur-dal	Fabaceae
	<i>Lablab purpureus</i> (L.) Sweet.	Auri, Valpapdi	Fabaceae
	<i>Phaseolus vulgaris</i> L.	French bean, Loba	Fabaceae
	<i>Vigna radiata</i> (L.) Wilizeck.	Mug, Mukani, Jangli-Mug	Fabaceae
	<i>Vigna trilobata</i> (L.) Verdc.	Jangli-math, Mukni	Fabaceae
Fruit vegetable	<i>Abelmoschus esculentus</i> (L.) Moen.	Bhendi	Malvaceae
	<i>Capsicum annum</i> L.	Mirchi	Solanaceae
	<i>Coccinea grandis</i> (L.) Voigt	Tondli	Cucurbitaceae
	<i>Luffa acutangula</i> (L.) Roxb.	Piccina, Dokdka	Cucurbitaceae
	<i>Lycopersicon lycopersicum</i> (L.) Karst. ex Farwell.	Tamatar, Tomato	Solanaceae
	<i>Momordica charantia</i> L.	Karaila, Pavel	Cucurbitaceae
	<i>Momordica dioica</i> Roxb. ex Willd.	Kartoli	Cucurbitaceae
Leafy vegetable	<i>Amaranthus spinosa</i> L.	Kate-Math	Amaranthaceae
	<i>Amaranthus viridis</i> L.	Math	Amaranthaceae
	<i>Brassica oleracea</i> L.	Sarso	Brassicaceae
	<i>Brassica oleracea</i> L. var. <i>botrytis</i> L.	Cauliflower, Phulgobhi	Brassicaceae
	<i>Basella alba</i> L.	Malabar/ Ceylon spinach	Basellaceae
	<i>Colocasia esculenta</i> (L.) Schott	Alu	Araceae
	<i>Spinacea oleracea</i> L.	Palak, Spinach	Chenopodiaceae

are served a refreshing tea prepared from *Hemidesmus indicus* roots collected from forest land.

The plateau near the Ashram is rich in plant diversity.

Following wild plant species were recorded from the plateau and the areas recently affected due to the Ashram activities (Table 2).

Table 2. Plants recorded from plateau and adjoining area of ashram

Sr.no.	Botanical Name	Family
1	<i>Acampe praemorsa</i> (Roxb.) Blatt. & McC.	Orchidaceae
2	<i>Acampe rigida</i> (Buch.-Ham. ex Sm.) Hunt.	Orchidaceae
3	<i>Aerides maculatum</i> L.	Orchidaceae
4	<i>Alangium salvifolium</i> (L.f.) Wangerin	Alangiaceae
5	<i>Aspidopteris cordata</i> (Heyne.) A.Juss.	Malpighiaceae
6	<i>Bridelia spinosa</i> Willd.	Euphorbiaceae
7	<i>Capparis moonii</i> Wt.	Capparidaceae
8	<i>Capparis rotundifolia</i> Rottl.	Capparidaceae
9	<i>Carvia callosa</i> (Nees.) Bremek.	Acanthaceae
10	<i>Celastrus paniculatus</i> Willd.	Celastraceae
11	<i>Ceropegia attenuata</i> Hook.	Asclepiadaceae
12	<i>Chlorophytum borivilianum</i> Sant. & Fernan.	Liliaceae
13	<i>Chlorophytum tuberosum</i> (Roxb.) Baker.	Liliaceae
14	<i>Cottonia peduncularis</i> (Lindl.) Reichb.	Orchidaceae
15	<i>Curculigo orchioides</i> Gaertn.	Hypoxidaceae

16	<i>Curcuma aromatic</i> Salib.	Zingiberaceae
17	<i>Curcuma decipiciens</i> Dalz.	Zingiberaceae
18	<i>Dendrobium ovatum</i> (Willd.) Kranz.	Orchidaceae
19	<i>Dendrobium purpureum</i> (Rafin.) Almeida	Orchidaceae
20	<i>Dioscorea bulbifera</i> L.	Dioscoreaceae
21	<i>Dioscorea hispida</i> Dennst.	Dioscoreaceae
22	<i>Dipcadi saxorum</i> Blatt.	Liliaceae
23	<i>Drosera burmannii</i> Vahl	Dioscoreaceae
24	<i>Elephantopus scaber</i> L.	Asteraceae
25	<i>Embelia ribes</i> Burm.f.	Myrsinaceae
27	<i>Eria conrardii</i> Alm.	Orchidaceae
26	<i>Eria microchiles</i> (Dalz.) Lindl.	Orchidaceae
28	<i>Eriocaulon colbinum</i> Hk.f.	Eriocaulonaceae
29	<i>Eriocaulon diane</i> Fyson	Eriocaulonaceae
30	<i>Eriocaulon diane</i> Fyson var. <i>longibrachteatum</i> Fyon	Eriocaulonaceae
31	<i>Eriocaulon humile</i> Mold.	Eriocaulonaceae
32	<i>Eriocaulon indicum</i> Mold.	Eriocaulonaceae
33	<i>Eriocaulon margaretae</i> Fyson	Eriocaulonaceae
34	<i>Eriocaulon xeranthemum</i> Mart.	Eriocaulonaceae
35	<i>Exacum carinatum</i> Roxb.	Gentianaceae
36	<i>Flickingeria nodosa</i> (Dalz.) Seidnt.	Orchidaceae
37	<i>Glinus oppositifolia</i> (L.) DC.	Molluginaceae
38	<i>Habenaria commelinaefolia</i> Wall. ex Lindl.	Orchidaceae
39	<i>Heracleum grande</i> (Dalz. & Gibs.) Mukh.	Apiaceae
40	<i>Heterophragma quadriloculare</i> (Roxb.) K.Shum.	Bignoniaceae
41	<i>Hibiscus cannabinus</i> L.	Malvaceae
42	<i>Hymenodictyon obovatum</i> Wall.	Rubiaceae
43	<i>Jasminum malabaricum</i> Wt.	Oleaceae
44	<i>Ledebouria hyacinthina</i> Roth.	Liliaceae
45	<i>Ledebouria viridis</i> (Blatt. & Hall.) S.Dutta & Harvey	Liliaceae
46	<i>Mallotus philippensis</i> (Lamk.) Muell.	Euphorbiaceae
47	<i>Mammea longifolia</i> Planch.	Clusiaceae
48	<i>Maytenus concanensis</i>	Celastraceae
49	<i>Nervillea aragoana</i> Gaud.	Orchidaceae
50	<i>Oberonia enciformis</i> (Smith.) Lindl.	Orchidaceae
51	<i>Olex imbricata</i> Roxb.	Oleaceae
52	<i>Olea dioica</i> Roxb.	Oleaceae
53	<i>Peristylus lawii</i> Wt.	Orchidaceae
54	<i>Pimpinella heyneana</i> (DC.) Wall. ex Kurz.	Apiaceae
55	<i>Porpax jardoniana</i> (Wt.) Rolfe	Orchidaceae
56	<i>Ramphicarpa longiflora</i> (Arn.) Benth.	Scrophulariaceae
57	<i>Rhynchosia hirta</i> (Andrews) Meikle & Verde	Fabaceae
58	<i>Rhynchostylis retusa</i> (L.) Bl.	Orchidaceae
59	<i>Sageraea laurina</i> Dalz.	Annonaceae
60	<i>Semecarpus anacardium</i> L.f.	Anacardiaceae
61	<i>Toona hexandra</i> (Roxb.) Roem.	Meliaceae
62	<i>Trewia nudiflora</i> L.	Euphorbiaceae
63	<i>Zingiber cermuum</i> Dalz.	Zingiberaceae

The activities such as extracting the stones, wood and other forest products carried out in the reserve forest of Payebramhanpada and Naikpada are the major cause of disturbances in natural vegetation. Map of the area of study, human activities therein and some components of flora are shown in Figs. a-m.



Fig. a



Fig. b



Fig. c



Fig. d



Fig. e



Fig. f



Fig. g



Fig. h



Fig. i



Fig. j



Fig. k



Fig. l



Fig. m

Fig. a-m Vasai Taluka; a- Location map of study area; b. Devotee; c. Roadway from parol village in TWS; d. Soil erosion due to extension of road; e. Entrance of Ashram; f. Construction of Ashram building; g. Road widening process in TWS; h. Brick kilns on Kharbhav Chinchoti Road; i. Local's carrying *Carvia* stem from TWS; j. Paddy cultivation ; k. *Nervillea aragoana*; l. *Ceropegia attenuate*; m. *Porpax jardoniana*.

Thus, the data obtained from this study indicates that there are rare and endangered plants in this area. Measures should be taken in order to conserve these plants before they are extinct due to over-exploitation. Since Vasai population is rapidly increasing, the settlement is attracted towards the forest land as it is a remote area and natural resources becomes basic requirement for survival. Activities like burning patches of forest land for cultivation, washing bikes and trucks; disposal of wastes in the premises of TWS are seen from time to time. Mainly (~250) wild species are recorded around the ashram area.

Conclusion

Demarcation of boundaries is a major problem as the protected forest areas are scattered and surrounded by private areas. The natural vegetation of these reserved forest area is disturbed. A rapid boundary survey and marking should be done at the earliest to avoid future disturbances. Negligence may have a severe impact on the ecological balance. The plateau must be strictly prohibited for human activities as it is a home for many rare and endangered or singly reported species from Tungareashwar Wildlife Sanctuary.

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Research Article

Survey of Unconventional Leafy Vegetables Consumed by Warli Tribals of Thane District in Rainy Season

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Abstract : The paper deals with the study of unconventional leafy vegetables consumed by Warli tribals, inhabiting the northern belt (Jawhar and Mokhada regions) of Thane district in Maharashtra. Major part of this plateau is dominated by forest. Hence there is no scope for cultivation of conventional green leafy vegetables in these regions; due to which the Warli tribe is largely dependent on the naturally growing wild herbs and leafy vegetables from forests, which are available to them in the rainy season. The present survey encompasses 15 wild leafy vegetable species belonging to 13 genera and 12 plant families. Family Amaranthaceae dominated the monsoon diet of the tribal population followed by Caesalpinaceae.

Key words: Warli, rainy season, unconventional leafy vegetables

Introduction

Carbohydrates, proteins, fats, minerals and vitamins in the required quantities are must for normal healthy growth of human beings. The first three types of food components are obtained by vegetarians from cereals, pulses and oil crops, but for minerals and vitamins there is no other proper alternative source except vegetables, fruits and sprouted grains; in which contribution of dark green leafy vegetables is always in bulk. Each mineral and vitamin performs a specific function in the human body which depends upon intake of green leafy vegetables, both quantitatively and qualitatively. Though considerable progress has been made in the direction of producing more green leafy vegetables to meet the increasing demands of the growing population of India (Choudhury, 1967) the intake of leafy vegetables in average Indian diet is rather negligible as compared to that in advanced countries.

We can classify green leafy vegetables into two types on the basis of their cultivation, availability and acceptance. The vegetables cultivated on large scale, accepted easily by people and available in all seasons are termed as conventional leafy vegetables, whereas vegetables which are seasonal, not specifically cultivated; available in wild habitats and not easily accepted by common urban man are termed unconventional (Pant, 1996). The unconventional green leafy vegetables are forest dominant and used by tribals who live in the forests. Green leafy vegetables provide good nutrition and at times, also act as medicine for various ailments (Chopra *et al.*, 1956). Attempts have been made by researchers to collect ethno-botanical information on wild edible leafy vegetable plants from different parts of India (Misra, 2013).

Warlis are one of the dominant tribal communities in the Northern belt of Thane district in the state of

Maharashtra in India. This aborigine group is socio-economically and nutritionally much deprived. Their diet is simple and consists of corms, tubers, green leaves, stem pieces, flowers, fruits, seeds, etc which are available to them from their forest habitations (Chengala and Tekale, 2004). Warlis being a vegetarian tribe, their only source of vitamins and minerals is from unconventional leafy vegetables which are available to them in the monsoon season (Tekale, 1998).

The search for unconventional leafy vegetable by the tribals starts immediately after first monsoon showers. The present investigation deals with a survey of these unconventional leafy vegetables and their contribution in diet of the warli tribals of Thane district.

Materials and Methods

Wild growing leafy vegetables consumed by the warlis during monsoon season were surveyed. The study was carried out in Jawhar region of Thane district from June to September 1999. In order to cover most of the available leafy vegetables consumed by warli tribals in this region, these vegetables were collected with the help of a known and knowledgeable member of this tribe. Identification of plants was carried out with the help of standard literature (Cooke, 1967). Tribal folk were interviewed for finding the local names of vegetables, their habits and habitats.

Results and Discussion

The present survey encompasses 15 wild leafy vegetable species belonging to 12 families and 13 genera, tabulated with botanical and local names, family and habit (Table 1). Among the studied vegetables, four belonged to Amaranthaceae, two to Caesalpinaceae and rest belonged, one each, to Basellaceae, Vitaceae, Liliaceae, Verbenaceae, Cucurbitaceae, Acanthaceae, Moringaceae, Umbellifereae and Papilionaceae. Out of these fifteen leafy vegetables,

Table 1. Unconventional leafy vegetables consumed during monsoon season by Warli tribe

Sr. No.	Name	Family	Habit	Local Name
1	<i>Amaranthus hybridus</i> L.	Amaranthaceae	Erect herb	Rajgira
2	<i>Amaranthus spinosus</i> L.	Amaranthaceae	Herb	Kante math
3	<i>Amaranthus tricolor</i> L.	Amaranthaceae	Herb	Chaulai
4	<i>Basella alba</i> L.	Basellaceae	Herbaceous climber	Mayalu
5	<i>Bauhinia malabarica</i> (Roxb).	Caesalpiniaceae	Bushy tree	Korlapala
6	<i>Cassia tora</i> L.	Caesalpiniaceae	Herb	Takla
7	<i>Cayratia trifolia</i> L.	Vitaceae	Herbaceous climber	Ambetwel
8	<i>Celosia argentea</i> L.	Amaranthaceae	Herb	Kurdu
9	<i>Chlorophytum laxum</i> R.Br.	Liliaceae	Herb	Kolibaji
10	<i>Clerodendrum serratum</i> L.	Verbenaceae	Shrub	Bharang
11	<i>Cucurbita maxima</i> (Duch). ex.Lamk .	Cucurbitaceae	Climber	Dangar
12	<i>Hygrophila schulli</i> (Buch-Ham.)M.R &S.M Almeida.	Acanthaceae	Herb	Ikra
13	<i>Moringa oleifera</i> Lam .	Moringaceae	Tree	Shevgapala
14	<i>Peucedanum grande</i> C.B.Clark.	Umbellifereae	Succulent herb	Baphali
15	<i>Smithia sensitiva</i> (Ait).	Papilionaceae	Herb	Kavla

eight belonged to small herbaceous group, except *Amaranthus hybridus*, which is a large erect herb. *Cucurbita*, *Basella* and *Cayratia* are climbers, *Clerodendrum* is a shrub, where as *Moringa* and *Bauhinia* are trees. All these vegetables are of forest origin except, *Cucurbita maxima*, which is widely grown in backyards of hamlets or on roof tops. The occurrence and growth of these vegetables is natural.

Conclusion

Forest dominates the landscape in the area of study, with very less farm land. The Warlis depend on wild vegetables from the forest as a source of food. The unconventional leafy vegetables available to Warlis during monsoon are under natural stages of growth and form bulk in their diet. Out of fifteen leafy vegetables studied, plant family Amaranthaceae dominated the monsoon diet followed by Caesalpiniaceae.

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Research Article

Reproductive biology of *Peltophorum pterocarpum* (DC) K. Heyne (Fabaceae)

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Abstract : The Reproductive biology encompassing phenology, floral biology, pollination and breeding systems of *Peltophorum pterocarpum*, a semi evergreen tree from south eastern Asia, was investigated. Phenological studies indicated that although the species shows a regular flowering season, all trees do not flower every year. Flowers are typically papilionaceous; the stigma is wet papillate and the style is hollow. Anthesis took place between 1320 – 1400 h followed by anther dehiscence from 1400-1430 h and stigma became receptive between 1430 – 1530 h. Pollen-ovule ratio was calculated as 1729:1. Flowers are frequently visited by purple sunbird (*Nectarinia asiatica*), an effective pollinator. The flowers are also pollinated by honeybees, flies and butterflies. Pollen grains are oval, having an average diameter of 28.24µm. Pollen viability by FCR test confirmed that 82% pollen grains are viable on the day of anthesis. Best pollen germination along with 295.17 µm tube development was achieved in Brewbakers medium. Stigma was more receptive (up to 80%) on the first day of flower opening. It chiefly reproduced by means of cross pollination, where the fruit set was only 40%, but artificial cross-pollination through xenogamy enhanced fruit set up to 80%. The plant is an obligate out-crosser and self incompatible, as confirmed by various hand pollination experiments.

Keywords: phenology, pollination biology, stigma receptivity, xenogamy

Introduction:

Reproductive biology plays an important role in biodiversity conservation. This is largely because, the evolutionary success and survival of plants and angiosperms in particular is largely determined by the efficacy of their reproductive performance. Plants have evolved a wide range of reproductive strategies to optimize their fitness. Owing to the increasing and immediate concern for augmenting food supply, knowledge on reproductive biology has been utilized for herbaceous crops.

Trees have been neglected and they have not received the research attention they deserve. India is endowed with nearly 2,500 tree species (Tandon *et al.*, 2003). Conservation and genetic improvement efforts of Indian tree species suffer from lack of detailed information on reproductive biology, which is a pre-requisite for such type of studies (Bawa, 1992). It is largely because of their large size, prolonged juvenility, long life cycle, infrequent flowering and inaccessible flowers that trees present numerous problems to researchers for studying various aspects. Several of these species have a wide distribution range in the Indian subcontinent, with extensive intra-specific variability, constituting the reservoir of gene pool (Tandon *et al.*, 2005).

Peltophorum pterocarpum (DC) K. Heyne (Fabaceae) is a fast growing medium sized tree native to the Indo-Malayan region, especially Andamans, commonly known as copper pod. It is also known as as Son Mohur due to its golden yellow flowers. The yellow is the source of yellow

dye. The bark is a constituent of soga, a yellowish brown dye used in batik (Almeida and Chaturvedi, 2006). Each leaf has a long rachis with many pairs of pinnae. Each pinna has stalklets with tiny oval leaflets. It shows simultaneous vegetative and reproductive growth. The leaf fall and renewal is simultaneous with maximum leaf fall in third week of January and leaf renewal in February and March. Fruiting occurs in the last week of April and fruits mature in six to seven months. The tree is under the threat of extinction due to urbanization and industrialization. There is an urgent need for its conservation and it can be achieved by understanding its reproductive biology. The present paper is part of the attempt made to understand the floral and pollination biology of cultivated specimens of *Peltophorum pterocarpum* at Parel in Mumbai, with particular reference to its breeding system.

Materials and Methods

The present investigation was carried on 10 cultivated trees of *Peltophorum pterocarpum* (DC) K Heyne growing at five different places at M.D.College campus, Parel, Mumbai city. Flowering phenology was observed at plant and inflorescence level with reference to day to day flowering pattern. 10 inflorescences, selected at random from different individuals, were tagged before initiation of flowering and followed daily until flowering ceased. The number of open flowers was recorded and tagged to avoid recounting next day. Fifty flowers/plant were sampled to record floral morphology, anthesis, anther dehiscence and stigma receptivity. Number of pollen/anther/flower was measured

by the method described by Barret (1985). The mature anthers were crushed in lactophenol-glycerine with aniline blue. A known dilution was placed on the grid and 10 replicate counts were made using hemocytometer. These slides were also used to measure the size of pollen grains. Pollen viability was checked in fresh dehiscid anthers from the first day to full bloom till the end of the flowering season by Fluorochromatic reaction (FCR) test (Heslop-Harrison and Heslop-Harrison, 1970) and by 1% TTC method (Hauser and Morrison, 1964). To study the pollen germination in vitro, pollen grains were incubated in sucrose medium of different concentrations (2, 5, 10, 15, & 20 %) and Brewbakers medium (Brewbaker and Kwack, 1963) containing 2% sucrose for two hours. After two hours the percentage of pollen germination and tube elongation was noticed. Stigma receptivity was studied visually with the help of hand lens and by hydrogen peroxide (H_2O_2) test (Scribailo and Posluszny, 1984). Pollen- ovule ratio was calculated by dividing the number of pollen grains by the number of ovule/ flower (Cruden 1977).

Compatibility system (autogamy, geitonogamy and xenogamy) was tested using controlled pollination studies in emasculated and tagged flowers. Manual self- and cross-pollination experiments were performed by dusting pollen, obtained from freshly dehiscid anthers on receptive stigma. The pollinated flowers were re-bagged and observed periodically for fruit formation. Foraging behavior of insects was recorded in the morning (04.00-10.00h), afternoon (13.00-14.00h) and evening (18.00-21.00h). Pollination efficiency of different insects was checked by observing pollen load on their body parts under microscope (Kearns and Inouye, 1993). In view of production of large quantity of pollen/flower, the possibility of wind pollination was evaluated by hanging glycerine smeared slides at the height of flowering branches in the morning hours. These were examined under microscope for the presence of pollen grains in the evening.

Results and Discussion

Floral biology: The flowers are golden yellow and arranged in lateral panicles (Fig. 1). 30- 40 flowers were present per inflorescence. A visibly differentiated bud took 12-14 days to develop into a flower and 2-3 flowers/ inflorescence opened every day and each flower lasted for 16-24h. The flowers opened between 1320 – 1400 h followed by anther dehiscence from 1400-1430 h and the stigma became receptive between 1430 – 1530 h showing protandrous nature. Pollen grains were oval, tetracolporate, $28.24 \pm 2.5 \mu m$ in diameter and the exine was thick and reticulate. They were produced in large quantities as there were 3125 ± 123 pollen/anther and $13,69,375 \pm 11369$ per flower. Pollen viability was $45.9 \pm 5.5\%$. The pollen ovule ratio was 1729:1. The floral biology is shown in Table 1. The

pollen: ovule ratio and pollination experiments are suggestive of facultative xenogamy.

Table 1. Floral biology of *Peltophorum pterocarpum*

Floral characters	Observation
Flowering period	April -December
Flower opening time	1320 – 1400 h
Flower colour	Golden yellow
Anther dehiscence time	1400-1430 h
Stigma receptivity	1430 – 1530 h
Stigma type	wet papillate
Mean no. of pollen grains/anther	3125 ± 123
Mean no. of pollen grains/flower	$13,69,375 \pm 11369$
Pollen size	$28.24 \mu m$
Pollen ovule ratio	1729:01:00
Pollen fertility	90%
Pollen viability	92%
Pollen germination %	98%

Pollination biology (Fig. 2): Freshly opened flowers are brightly coloured and attract a large number of visitors. Maximum visitations occurred between 0930-1730 h during the full bloom period. The insects visiting the flowers were black ants (*Camponotus campestris*), honey bees (*Apis dorsata* and *Apis indica*), Butterflies, wasps and purple sunbird (*Nectarinia asiatica*) (Table-2). Honey bees started floral visits with the opening of flowers and anther dehiscences and each visit lasted for less than a minute (25-45 seconds). The pollen grains stick to the abdomen, thorax and legs of honey bees and they move to other flowers. In their visits to another flower the pollen was transferred to the virgin stigma of bagged flowers from which the bags were removed at the time of anthesis. The butterflies made 5-8 visit/flower with each visit of 20-30 seconds. They inserted their proboscis in between the stamens and ovary for nectar and came in contact with the pollen released by the dehiscid anthers. On their visit to another flower, while collecting nectar, the pollen from their proboscis was transferred to the stigma. As nectar is located deep in the keel, penetration and active foraging becomes necessary to access it. Purple sunbirds were also recorded to visit. On the basis of visitation rates, pollen load on body parts and transfer of pollen on virgin stigma it was found that honey bees, butterflies and purple sunbird are the most efficient pollinators. The other insects visiting the flowers were merely visitors or nectar robbers. Absence of pollen on the hanged glycerine smeared slides indicated that this species is not pollinated by wind.

Table 2. Pollinators and their characteristics

Visitors	Visiting time	Foraging nature	Foraging hours
<i>Apis dorsata</i>	day	Pollen and Nectar	0900-0160h
<i>Apis indica</i>	day	Pollen and Nectar	0930-01330h
Butterflies	day	pollen	0630-0140h
Purple sunbird (<i>Nectarinia asiatica</i>)	day	Pollen and Nectar	1330-0150h
Black ants (<i>Camponotus campestris</i>)	day	Nectar	0700-0170h
Large ants	day	Nectar	0730-01530h

Breeding System: There was only 40% fruit set in open pollinated flowers. The bagged flowers failed to produce fruits, thus indicating that the plant is self-incompatible. The emasculated bagged flowers by geitonogamy exhibited 56% fruit set and there was 76% fruit set by xenogamy (Table 3). The high pollen ovule ratio and the pollination experiments are suggestive of facultative xenogamy. Bala and Kaul (2010), recorded mixed mating system in *Murraya koenigii*. According to them anthesis is soon followed by anther dehiscence which overlaps stigma receptivity. High pollen: ovule ratio and male-biased sex-allocation ratios and the results of pollination experiments support mixed mating system in *Murraya koenigii*.

Singhal *et al.* (2010) found that the natural pollen transfer in the species was highly efficient and high pollen-ovule ratio indicated toward the obligate out breeding nature.

According to them, *Aegle marmelos* is self – incompatible and reproduce successfully through geitonogamy and xenogamy. The pollination experiments in the present study also suggests facultative xenogamous nature of breeding system in *Peltophorum pterocarpum*.

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Table 3. Fruit set in different modes of pollination

Treatments	No. of flowers pollinated	No. of flowers set fruit	% of fruit set
Bagged (autogamous self)	25	0	0
Emasculat ion and hand crossing	25	14	56
Emasculat ion and hand out crossing	25	19	76
Natural pollination	25	10	40

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Research Article

Influence of different soils on the distribution of flavonoids in chromatographic extracts.

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Abstract: The aim of the investigation was to determine variation in the concentration of the potential flavonoids, owing to soil type. *Curcuma longa* and *Curcuma amada* were grown in three different soils after which rhizomes were harvested and analysed for concentration of flavonoids. It was observed that there was slight difference in concentration of flavonoids which showed up in chromatography.

Key words: *Curcuma longa*, *Curcuma amada*, flavonoids, chromatographic extracts

Introduction

Chemotaxonomy of plants is a fast developing field. Chromatographic techniques have been used in separation of plant varieties and chemical traces by Teas *et.al.*, (1959) and Wulff and Stahl (1960), but few data exist as to the effect of different environment factors on chromatographic pattern. It is known that plants take up different minerals, not because the need is inherent, but because they are available in the soil solution. According to Overstreet and Jacobson (1952), roots have limited selectivity and their absorption mechanism permits the uptake of chemicals which undergo chemical combination with the plant that may appear in chromatogram. The aim of the study was to determine if varying soils would change the chemical content in *Curcuma longa* and *Curcuma amada* and if same could be observed in the chromatographic pattern

The genus *Curcuma* (Family: Zingiberaceae) comprises of more than 80 species of rhizomatous herbs. They occur in wild and cultivated forms and are widely distributed throughout the tropics of Asia, Africa and Australia. The most common species is *C. longa* (turmeric), which is used as a natural food colourant and as an ingredient in various medicinal formulations. The medicinal properties of *C. longa* have been attributed to the presence of curcumin, essential oils and phenolics (Angel *et al.*, 2012). *Curcuma amada*, popularly known as mango-ginger is having characteristic odour similar to raw mangoes (*Mangifera indica* L.) and used as major ingredient in pickles, candies, salads, sauces and chutneys (Yogamaya *et.al.*, 2012). Therapeutically, mango ginger is used to treat a range of mood and medical disorders in traditional and *Ayurvedic* medicine (Policegoudra *et.al.*, 2011). *Curcuma* plants have a camphoraceous aroma and contain many functional compounds such as phenolics, flavonoids and different antioxidant enzymes (Krishnaraj *et.al.*, 2010).

Flavonoids are widely occurring polyphenolic compounds and are extremely important because of their medicinal effects. (Bernardi *et al.*, 2007). Flavonoids are useful secondary metabolites in assessing the relationship among closely related species or in studies of intra-specific variation, and they are also occasionally useful in assessing phylogenetic relationships at higher levels. The various terpenoids, sterols and flavonoids have systematic significance and can be used for solving taxonomic problems.

Materials and Methods

5 g rhizomes of *C. amada* and *C. longa*, grown in different soils, and were washed thoroughly in tap water to remove soil particles followed by sterile distilled water. They were cut into small pieces, shade dried and ground to fine powder. Dried and powdered samples were soxhlet extracted with methanol for 48 hours and the solvent was evaporated to dryness using water bath set at 60°C. After that, the residues were weighed and stored at 4°C until use.

Flavonoids were extracted for colorimetric analysis. About 1 gm each of dewaxed powdered plant sample was extracted with 25 ml of 95% ethanol under 200 rpm shaking for 24 hr. After filtration, the filtrate was adjusted to 25 ml with 80% ethanol and stored in an amber bottle. Total Flavonoids were determined by colorimetric analysis

Aluminum chloride method was used for flavonoid determination (Olajire and Azeez, 2011). In Normal phase TLC was performed on pre-coated (0.25 mm) silica gel. The plates were developed separately in BAW (*n*-butanol-acetic acid-water, 4:1:5, top layer). The chromatograms were observed in UV light (254 nm) before and after exposing to ammonia vapors.

Results and Discussion

The flavonoid content, determined by Aluminium chloride forms acid stable complexes with the C-4 keto group and either the C-3 or C-5 hydroxyl group of flavones and flavonols. In addition it also forms acid labile complexes with the ortho-dihydroxyl groups in the A- or B-ring of flavonoids (Mabry *et.al.*, 1970). Results indicated that there were variations in flavonoid contents of *Curcuma longa* and *Curcuma amada* growing in garden soil, sandy soil and clay soil. Maximum flavonoid content was observed in *Curcuma longa* as compared to *C. amada* (Table 1), and the same was observed in chromatographic pattern (Table 2).

Table 1. Flavonoid content in varying soils by colorimetric analysis

Sr.no	Soil	<i>Curcuma longa</i>	<i>Curcuma amada</i>
1	Garden soil	0.08	0.04
2	Sandy soil	0.06	0.02
3	Clay soil	0.12	0.06

Table 2. Flavonoid content in varying soils by chromatographic pattern

Sr.no	Soil	<i>Curcuma longa</i>	<i>Curcuma amada</i>
1	Garden soil	0.16	0.09
2	Sandy soil	0.13	0.06
3	Clay soil	0.18	0.11

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Molecular Systematics: Revolutionization Due to Chemotaxonomy of Biomolecules

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Abstract : Biomolecules may be inorganic or organic substances possessing chemotaxic behavior in the environment. On the basis of motility of action, the role of biomolecules in systematic molecular revolution having societal applications is focused in the present paper.

Key words: chemotaxis; nucleic acid; Characterization

Introduction

Molecular systematics reflects the natural relationships among all plant taxa. Biomolecules are the main compounds that give chemical systematic profile. Differences between biomolecules, from various plant parts were difficult to recognize among different species of plants (Pavlovic *et al.*, 2013). Hence biochemical systematics supported the classification of plants on the basis of chemical constituents, with molecular characteristics. These chemical constituents found in different groups of plants have great taxonomic significance. Techniques for comparison of these compounds are time-consuming and expensive and yet insufficient to cope up with comparisons on large scale for the classification of natural products.

Recently, genome can be replaced by nucleic acids and amplification of DNA fragments has changed the situation. DNA sequencing, gene coding and at the same time computer technology has improved dramatically to deal with the huge amounts of data and chemical information that are generated in these studies. These factors and technologies enable the chemotaxonomist to assess natural relationships among plant families (Duminil and Michele, 2009). Chemical features available for comparison at plant family level and above as compared to DNA sequences and difficulties in selecting and interpreting chemical characters may give the direction to molecular systematic study for revolutionization of chemotaxonomy of biomolecules.

New molecular data such as DNA sequences have provided source of heritable information in order to determine common ancestry. The set of morphological data with a genetic basis is a small subset of molecular information. The maximum number of independent characters of an organism is limited by number of nucleotide pairs in its DNA (Hillis, 1987). Morphological recognition of plant species has limitations. Hence, molecular markers as tools for species delimitation have increased over the past few years. In

principle, all nuclear, mitochondrial and chloroplastic plant genomes can be used to delimit species. However, the mitochondrial genome is generally insufficiently polymorphic among individuals to be informative, despite the existence of universal primers. (Duminil *et al.*, 2002).

Characterization of molecules

The closing years of the past century saw the shift and concentration of macromolecular studies towards DNA and RNA, resulting in the establishment of an emerging field of chemotaxis of biomolecules (Table 1).

Parents to offspring –transfer of DNA

All living organisms follow central dogma of life. Closely related organisms have a high degree of agreement in the molecular structure of these substances, while the molecules of organisms distantly related usually show a pattern of dissimilarity. Genetic modification of plant cells by *Agrobacterium* is the only known natural example of DNA transport between kingdoms (Piers, *et al.*, 1996; De Groot, 1998 ; Kunik *et al.*, 2001).

Agrobacterium have been used in a variety of ways by humans, mainly for the bacteria's ability to transfer DNA. This ability can be used to create mutant or transformed organisms (Tepfer, 1990). As the insertion of DNA is random in the host cell, the T-DNA can disrupt and silence a certain gene, creating a mutant strain of the organism that can be used for research. The T-DNA can also be altered so transformed organisms express the product of the T-DNA inserted gene. These transformed organisms can be used for research as well as creating GMO's for agricultural uses (Tzfira *et al.*, 2008).

Systems biology studies biological systems by systematically perturbing them (biologically, genetically, or chemically); monitoring the gene, protein, and informational pathway responses; integrating these data; and ultimately,

Table 1. Techniques and applications of biomolecules

Sr. No.	Biomolecule	Technique	Application
1	Carbon	Accelerator mass spectrometry	To count the individual isotopes of the carbon
2	Drug Discovery	Bio- MS	Encompasses <i>in vitro</i> , cellular, and <i>in vivo</i> pharmacological and clinical applications
3	Proteins	Capillary electrophoresis IsoElectric Focusing (CIEF)	Molecular weight
		ESI-MS/MS (Electro Spray tandem Mass Spectrometry)	Identification of proteins
		MALDI-TOF (Pavlovic <i>et al.</i> , 2013; Zeller-Péronnet <i>et al.</i> , 2013)	Peptide sequence, mass and predictable fragmentation patterns.
		capillary electrophoresis and mass spectrometry Fluorescence	Quantification of the amount of protein
4	Glycoalkaloids, Glycoproteins, Polysaccharides, Peptides.	Fast Atom Bombardment Mass Spectrometry FAB/MS,	Analysis
5	DNA	The MALDI-TOF mass spectrometer	Measurement of the exact mass of DNA fragments and is capable of accurately predicting the sequence of a DNA fragment based on the molecular mass.

formulating mathematical models that describe the structure of the system and its response to individual perturbations (Ideker and Galitski, 2001).

Conclusion

Preparing a vision for the future genomics research has been both daunting and invigorating. Readiness of experts needs to put up bold and fine ideas to segregate chemical compounds on the basis of functional and structural applications in society; also addressing their self-interest areas and engaging in debates on opportunities and priorities, has added richness to chemotaxonomy.

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Ethnobotanical Research and Applications of Few Species of Genus *Piper* Linn.

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Abstract : Ethnobotany is considered as a branch of ethnobiology, the study of past and present interrelationships between human cultures and the plants, animals, and other organisms in their environment. Like its parent field, ethnobotany makes apparent the connection between human cultural practices and the sub-disciplines of biology. Ethnobotany is the science of people's interaction with the plants. In other words, it is the marriage between cultural anthropology and botany, a study that investigates the roles of plants as medicine, nourishment and natural resources. The investigation of plants and their uses is one of the most primary human concerns. People have always been dependent on plants for their primary needs since ancient era and thus they have accomplished as well as exchanged the knowledge regarding the significance of plants for benefit of mankind. Ethnobotany also serves to emphasize upon role of plants in ancient civilization as well as in modern era of bioengineering of new crops. However, indigenous cultures and practices also play a crucial role in ethnobotany as they possess a previously undervalued knowledge of enormous utilization of plants. The present work provides the ethnobotanical and botanical descriptions and illustrations of few *Piper* species (belonging to the family Piperaceae) that are popularly used as vegetables, spices and medicine as well as for traditional ceremonies. The work deals with the economic, traditional as well as pharmacognosical significance of the Genus *Piper*. The study shows relevance of phytochemical analysis of Genus *Piper* with its use as medicine and food.

Keywords: Ethnobotany, interrelationships, economic, pharmacognosy, *Piper*.

Introduction

Ethnobotany is the study of how people of a particular culture and region make the use of indigenous plants. Ethnobotanists explore how plants are used for such things as food, shelter, medicine, clothing, hunting, and religious ceremonies. These plants are known as ethnobotanicals. Ethnobotanical studies range across space and time, from archaeological investigations of the role of plants in ancient civilizations to the bioengineering of new crops. Furthermore, ethnobotany is not limited to non-industrialized or non-urbanized societies. In fact, co-adaptation of plants and human cultures has changed and perhaps intensified in the context of urbanization and globalization in the twentieth and twenty-first centuries. Nonetheless, indigenous, non-Westernized cultures play a crucial role in ethnobotany, as they possess a previously undervalued knowledge of local ecology gained through centuries or even millennia of interaction with their biotic (living) environment. The significance of ethnobotany is manifold. The study of indigenous food production and local medicinal knowledge may have practical implications for developing sustainable agriculture and discovering new medicines. Ethnobotany also encourages an awareness of the link between biodiversity and cultural diversity, as well as a sophisticated understanding of the mutual influence (both beneficial and destructive) of plants and humans.

Piperaceae is grouped in about 8-12 genera and about 1200- 5000 species which are confined to tropical and subtropical portions of the world. It is commonly known as pepper family. These are mostly herbs and shrubs but there are also small trees and woody climbers. The genus *Piper* Linn., the largest in the family, occurs throughout the tropical and subtropical regions of the hemispheres. As conventionally construed, *Piper* is a large pantropical genus. More than 3000 species have been recorded (Rahiman and Nair, 1983), but because of the large number of species, wide distribution, small, achlamydous and closely aggregated flowers, many unisexual species and lack of critical phyletic study (Hooker, 1886; Lawrence, 1951), an acceptable species concept could not be established till date. Pipers are generally perennial shrubs bearing adventitious or sometimes epiphytic roots. Leaves are alternate, petiolated and with deciduous stipules. Leaf blade is simple, ovate, lanceolate or elliptic. Leaves are pinnately costate or multicostate. Inflorescence is spike or catkin; oppositifolius. Flowers are usually dioecious; unisexual; sessile; with the peltate or copular bracts. Stamens are 1-4 with 2-celled anthers. Ovary is superior; 1-celled, free with solitary ovule. Fruit is sessile, oblong or globose, pulpy, green, red, yellow, drupe or berry. Seeds are with thin testa (Cheng *et al.*, 1999). Pipers are of huge economic and medicinal significance. Boiled stem and leaves of *Piper* are used as medicine while roots are used to cure stomachache,

common cold, etc. the aromatic leaf is masticatory, used with lime, catechu, arecanut and other species, and sometimes with tobacco, acts as a stimulant, intoxicant, carminative, astringent, aphrodisiac and antiseptic. Leaf juice has fungicidal and nematocidal properties due to the presence of essential oil. Seeds powdered and given with honey are used in cough, cold and asthma. *Piper* leaves contain aromatic and acrid volatile oils with compounds and elements such as cadinene, carvacrol, caryophyllene, chavicol, eugenol, terpinyl, chavibetol, acetate (Dyer *et al.*, 2004), piperine, piperlongumine, pyridine alkaloids, sesamin, tannins, oxalic acid iron (de Waard and Anunciado 1999).

There is meager anatomical and taxonomical work carried out in genus *Piper*. Family Piperaceae has undergone considerable changes in the circumscription of various taxonomic ranks. Howard (1973) considered the family as the most difficult family. Therefore an attempt has been made to recognize the medicinal and traditional significance of *Piper* species.

Materials and Methods

Piper diversity was surveyed in different locations of various states viz., Maharashtra, Tamil Nadu, Kerala, Assam, Meghalaya, and West Bengal. Majority of plants were however obtained from Meghalaya. Literature (Chibber, 1912; CSIR, 1969) was reviewed for obtaining data.

Results and Discussion

The economic importance, cultural and medicinal uses of species of *Piper* found during the investigation are discussed below:

1. *Piper acutisleginum*: Roots are medicinal for stomachache. Boiled stem and leaves are also taken as medicine.

2. *Piper attenuatum*: The root sap is given in common colds and as a diuretic. It is used as a poultice for headache and other pains due to its intense rubefacient effect. In Malaysia, parts of the plant are put in water to scent the clothes during washing. Also used in religious ceremonies.

3. *Piper betle*: The aromatic leaf is a masticatory used with lime, catechu, arecanut and other spices and sometimes with tobacco act as a stimulant, intoxicant, carminative, astringent, aphrodisiac and antiseptic. The antiseptic activity is probably due to the presence of chavicol. It is probably an aphrodisiac, due to the presence of an alkaloid – arakene in the leaf possessing properties allied to cocaine, although in lesser quantity. Often a leaf is placed in the mouth of a corpse in order that the dead person can enjoy a last moment of pleasure before joining the Gods, since according to Indian mythology, the betel vine does not grow in heaven. Leaf is also used for eye disease, stomach

problems, wounds, as haemostat on cuts and injuries for asthma, bronchitis, colic pain, dysentery, madness, sores and syphilis. The leaf juice is applied for cold and headache. It also has fungicidal and nematocidal properties due to the presence of essential oil. The oil of Betel is used in the treatment of various respiratory catarrhs and is locally applied in diphtheria. The leaves are used in all religious ceremonies by the Hindus.

4. *Piper brachystachyum*: Seeds powdered and given with honey are used in cough, cold and asthma.

5. *Piper caninum*: It yields a type of volatile oil called Kababchini, utilized with betel leaves for chewing. They are added to the betel quid for treating hoarseness. A wash is made from the leaves is used after childbirth.

6. *Piper chaba*: The wood forms a pungent condiment. The stem is also used as a medicine. The fruits have stimulant and carminative properties and are used in haemorrhoidal as a cure for colic, dyspepsia and gastralgia. The wood and roots are used for dyeing into pale brown and brownish red colour in Bengal. In Malaya, the fruits are used as a stimulant in tonics for languidness and after childbirth and also given during digestive disorders. The stem is used in medicine as a substitute for *Piper longum*.

7. *Piper diffusum*: Juices of roots are given orally in indigestion.

8. *Piper griffithii*: Leaves have medicinal properties. The leaves are also used as spices and chewed with betel leaves.

9. *Piper longum*: It contains the same principles as Black Pepper, but is very aromatic and sweeter. The fruits and roots are useful in cold, cough, asthma, fever, gonorrhoea, leprosy, in insomnia and epilepsy, as sedative and in piles. It acts as a cholagogue and removes obstructions of the liver and spleen and also promotes digestion by its tonic properties. It is also a laxative, improves vitality, aphrodisiacal and is diuretic and used as a general tonic after childbirth. It is used in rheumatism. The roots are used in palsy, gout and lumbago. The leaves as well as roots are dried, powdered and mixed with rice powder to prepare cakes which are used for fermentation of rice-beer. In Andaman Islands, the leaves are chewed as masticatories either in fresh or in dried form. Its fruits are almost a forgotten spice except in the tropics, where the berries are extensively used in pickles, preserves and curries.

10. *Piper nigrum*: The fruits contain an acrid soft resin, volatile oil. The pungent taste is due to the resin. The berries are medicinally used as a stimulant. It is also used in intermittent fever, as a stomachic in dyspepsia, gonorrhoea, haemorrhoids, cough, flatulence and to promote secretion of bile. When roasted, the berries have been successfully

employed in stopping vomiting in cholera. In toothache, the watery infusion can be used as a rudefacient for relaxing sore throat, piles and some skin diseases. It is also used as an aphrodisiac and facilitates menstruation. Pepper has been used in vertigo coma, paralytic and arthritic disorders. With vinegar it forms a good stimulating poultice. It is diuretic and a good stimulant in cases of bites by venomous reptiles. An infusion of the seed given as an antidote to arsenic and the juice of the leaves, boiled in oil is used externally in scabies. In overdoses, pepper acts as a poison by over exerting the inflammation of the stomach and acting powerfully on the nervous system. The root is used as a tonic, stimulant and cordial, a liniment of which is used in chronic rheumatism. Strong friction with pepper, onions and salts makes the hair grow upon the bald patches left by ringworm of the scalp. Pepper is known to be poisonous to hogs. The dried pungent berries yield black pepper of commerce called *Maricha* in Sanskrit, while it produces white pepper when the pericarp is removed. As a food seasoner, pepper is used as a condiment and has excellent stomachic qualities. The unripe fruits preserved in salt and water are used as pickle by the natives of Malabar. In western countries, the pepper is used mainly for curing and preserving meat. The oleoresin of pepper has bacteriostatic and fungistatic properties.

11. *Piper peepuloides*: The stem and the roots are used as a medicine in leprosy in Khasia and Jaintia Hills. Also used as a condiment by the Khasis of Chrapunji Hills.

12. *Piper schmidtii*: Ripe seeds are used as condiments by Todas in the Nilgiris. It is sometimes referred to as 'big berry'.

13. *Piper sylvaticum*: The fruit is used as a carminative like *Piper longum*. It is used in medicine.

14. *Piper thomsoni*: The leaves are used as a 'paan' in Sikkim. The roots are macerated in water and used as a diuretic.

Pharmacognosical Properties

1. *Piper betle*: The important constituents which determine the value of the leaf for chewing, are the essential oil and glucose, fructose, maltose and sucrose sugars. The vital factor determining the aromatic value of the leaf, is the amount and nature of the essential oil present. The leaf juice is acidic in nature due to the presence of the malic and oxalic acids. The leaves also contain good amount of Vitamin B, essential amino acids, ascorbic acid and carotene 7 little amount of starch and tannin. However, alkaloids and glycosides are absent. On distillation, the fresh leaves yield two pale yellow essential oils, one light and the heavy, both having peculiar creosote-like odour, resembling that of tea, but the light one is more aromatic. These oils oxidize rapidly,

losing their characteristic ethereal odour. The heavy oil is freely soluble in alcohol and ether and sparingly so in chloroform. The crude oil, chavicol, contains a small quantity of a parallyl phenol. Betel oil, freed from phenol by caustic potash, contain several terpenes. the iso-eugenol and eugenol is found to be present. Another constituent of betel oil consists sesquiterpene, $C_{15}H_{24}$ and cubebene. Betel leaves possess an antioxidant action due to the presence of Propenyl phenols – chavicol, chavibetol, allylpyrocatechol and chavibetol acetate which also provide with fungicidal and nematocidal activities.

2. *Piper chaba*: It contains less piperine and volatile oil. A pellitorine- like alkaloid has been reported in the fruits. On steam distillation, dried fruits yield about 1% of a light green, viscous volatile oil, with an odour similar to that of Black Pepper and Ginger Oil. The stem contains the alkaloids- piperine and piplartine; B-sitosterol; glycosides; mucilage; glucose and fructose, and shows properties similar to that of *Piper longum*.

3. *Piper longum*: The fruit has shown the presence of the alkaloids- piperine and piplartine, and also two new alkaloids of which one is closely related to pellitorine, producing marked salivation, numbness and a tingling sensation in the mouth. Sesamin, $C_{20}H_{18}O_6$, dihydrostigmasterol and piplasterol are also present. On steam distillation, the fruit yields an essential oil with a spicy odour. The root also contains piperine, piplartine and traces of a yellow, crystalline, pungent alkaloid. It includes triacortane, dihydrostigmasterol, two new alkaloids- piperlongumine, $C_{17}H_{19}O_5N$ (probably identical to piplartine) and piperlonguminine, $C_{16}H_{19}O_3N$.

4. *Piper nigrum*: The fruit contains an acrid soft resin, a volatile oil, gum, 50% starch, about 5% inorganic matter, 4%- 10% alkaloid piperine, piperettine, chavicine and piperidine. The volatile oil consists of laevorotatory terpenes, L- phellandrene and carayophyllene. Pure piperine is of yellowish colour and on continued mastication gives a sharp, biting, peppery taste. Piperettine is a vinyl homologue of piperine. Chavicine, on hydrolysis yields piperidine and isochavicine acid. Piperic acid occurs in the form of yellowish hairy needles.

5. *Piper peepuloides*: The fruits contain a liquid alkaloid, but no piperine. An unusual lignin-diaeuodesmin, $C_{22}H_{26}O_6$, and a substance named pipataline, have also been reported recently. When chewed, the fruits are not pungent but exhibit strong sialogogue action, followed by numbness and tingling sensation on the tongue.

Conclusion

Members of the genus have long been closely related to Indian lifestyle, culture, tradition, belief and religion.

Many *Piper* species have high economic potential to be applied towards local and industrial uses, including pharmaceutical botany, pharmacognosy, traditional medicine, landscape decoration, aromatic, food and spice markets. The biochemical compounds found in this genus should be studied more in order to develop the potential economic and ethnobotanical applications of *Piper*. Our future research will report chemical compounds and molecular composition of every *Piper* species. In this way, we can create a comprehensive picture of *Piper* that can be used to improve pharmaceutical, medical and perfume industries. This will also benefit Indian traditional medicine, culture and national resource conservation.

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Aeromycoflora of Textile Mill and Their Allergenic Significance

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Abstract : In order to study the qualitative and quantitative prevalence of air-borne fungal flora in the indoor air of textile mill, a 2 years comprehensive aeromycological survey was carried out using gravity petridish method and a conventional Rotorod Sampler. A total of 29 genera were isolated, of which 65.64% were Aspergilli showing them as most dominant ones. Other fungal forms were *Cladosporium*(8.59%), *Penicillium*(7.37%), *Curvularia*(4.05%), *Paecilomyces*(3.29%), *Cephalosporium*(1.85%), *Rhizoctonia*(1.54%), *Mucor*(1.36%) and *Alternaria*(1.19%). Others were less than one percent. In order to study the allergenicity of the fungi clinical studies were performed with 11 suspected fungi on 156 hypersensitive patients, using modified skin prick test method. 10 fungal extracts showed more or less positive reactions. *Aspergillus fumigatus* was found, the most potent allergen followed by *Rhizopus nigricans*. *Trichoderma viride* showed a very poor response whereas *yeast* was found negative in all the patients.

Keywords: Occupational aeromycoflora, fungal prevalence, allergenic potency

Introduction

A large proportion of the human population suffers from allergies of some or the other kinds. The increased amounts of pollutants and lowered immunity levels have increased incidence of allergies. Common allergic responses are rhinitis, nasobronchial asthma, conjunctivitis, dermatitis, urticaria etc. Common allergens responsible for these conditions are pollen, dust, mites, fungi, food etc. Since fungi are one of the allergens, causing various types of allergic ailments in sensitive human population and there are few reports concerning bronchitis and other lung diseases with cotton dust (Berry *et al.*, 1974, Cayton *et al.*, 1952), the present study was undertaken to study the prevalence of fungi in the air of textile mill in Mumbai. Clinical studies of some of them were performed with an aim to find out their allergenic behaviour. The study will be helpful in diagnosis and immunotherapy of the allergic patients.

Materials and Methods

To study the incidence of aeromycoflora, a two year comprehensive aeromycological survey was carried out inside a textile mill in Mumbai by using gravity petridish and conventional Rotorod sampler.

In order to study the allergenicity of fungi, extracts of 11 fungal forms were selected for clinical observations. These extracts were tested on 156 hypersensitive patients, using modified skin prick test method.

Fungi selected for clinical studies were *Alternaria alternata*, *Aspergillus fumigatus*, *Aspergillus niger*, *Cladosporium herbarum*, *Curvularia lunata*, *Fusarium moniliforme*, *Mucor racemosus*, *Penicillium chrysogenum*, *Rhizopus nigricans*, *Trichoderma viride* and Yeast. Guidance from Bombay Hospital, Mumbai was obtained for clinical tests.

The extracts(antigens) of the fungi were prepared by stepwise mass culturing, harvesting, drying, grinding, deffating, extraction, clarification and sterilization.

Results and Discussion

The aeromycological studies revealed the presence of 29 fungal genera in the indoor air of textile mill. Aspergilli were found the most dominant fungi showing 65.62% of total aeromycoflora. Next in order were *Cladosporium* (8.59%), *Penicillium* (7.37%), *Curvularia* (4.05%), *Paecilomyces* (3.29%), *Cephalosporium* (1.85%), *Rhizoctonia* (1.54%), *Mucor* (1.36%) and *Alternaria* (1.19%). The results are shown in Table 1. *Fusarium*, *Rhizopus*, *Trichoderma*, *Sporotrichum*, *Acremonium*, *Syncephalastrum* and *Helminthosporium* were found less than one percent of total aerial fungal flora.

Drechslera, *Pithomyces*, *Trichurus*, *Absidia*, *Humicola*, *Yeast*, *Aureobasidium*, *Bispora*, *Nigrospora*, *Stigmina*, *Cephalophora*, *Diplodia* and *Torula* showed sporadic occurrence.

Table I: Incidence of dominant fungal forms and their percentage contribution to the total aeromycoflora of Textile mill

Sr.no	Fungal type	Percent contribution
1	<i>Aspergillus</i> sps.	65.62
2	<i>Cladosporium</i>	8.59
3	<i>Penicillium</i>	7.37
4	<i>Curvularia</i>	4.05
5	<i>Paecilomyces</i>	3.29
6	<i>Cephalosporium</i>	1.85
7	<i>Rhizoctonia</i>	1.54
8	<i>Mucor</i>	1.36
9	<i>Alternaria</i>	1.19

There was abundance of various types of aerial fungal forms in textile mill. The study showed highest concentration of *Aspergillus* spp. which dominated the aeromycoflora, both in frequency and distribution. A similar observation was made by Tuffnel (1960), Shukla and Misra (1986) and Shah and Bashir (2008). Similar observations were recorded by D'silva and Freitas(1981) and Subramanyam(1987) from aeromycoflora of Mumbai.

During the study *Cladosporium* spp. ranked second in order of dominance. A similar observation has been made by D'silva and Freitas(1981) and Subramanyam(1987). The dominance of *Aspergillus* in indoor air of textile mill can be attributed to the fact that these fungi are known to be ubiquitous in distribution, and they also possess high cellulose degrading capabilities (Reese and Downing 1951).

To study the allergenic behaviour, 11 fungal extracts were tested on 156 patients suffering from various types of allergies. More or less positive reactions were found in 10 of 11 fungal extracts. Only yeast showed no positive reaction at all. A less marked correlation exists between the concentration of spores and their allergenic potency as *Aspergillus fumigatus* the most dominant fungi showed maximum positive results but next to it was *Rhizopus nigricans* in allergenic potency inspite of being less prevalent fungus(less than 1%). Another example is of *Fusarium moniliforme* which is also less than 1% in air was found more potent allergen as compared to *Cladosporium herbarum*, *Alternaria alternata* less prevalent as compared to *Penicillium chrysogenum* was found more potent allergen than *P. chrysogenum*.

Conclusion

Present study proves the dominance of fungi in the indoor of textile industry. Clinical studies support and prove that fungal spores are potent allergens. There is no correlation between fungal concentration and their allergenicity. The present study has therefore thrown light on the importance of high concentration of fungal spores in textile industry which possesses dust and fibrous particles in high concentration and which can be hazardous to human health.

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Comparative Studies on Some Red Chilly Varieties Procured from Local Market

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Abstract : Sun dried chillies are the key element in many regional cuisines. Chilli flakes are common in Europe. They give hot pungent taste to food which is liked by many. The chillies also have nutritive value and can be used instead of black pepper. The fine ground form which is used in most Indian dishes also gives colour to the food which is very tempting. The present investigation deals with the length of chillies which helps in differentiating varieties as small, medium, and large. From amongst local varieties, Sankeshwari is longest, followed by Baydgi Pandi and smallest in length is Lavangi. There was significant difference in length of Sankeshwari when compared with Pandi and Lavangi varieties.

Introduction

The market for the chillies in India and tropical regions has become demanding in the vegetable- and important in the economic scenario mainly because of the great variety of products and by-products, uses and forms of consumption (Moreira *et al.*, 2006; Bento *et al.*, 2007; Henz and Ribeiro, 2008; Sudré *et al.*, 2010). Obtaining improved cultivars in the various species that comprise this genus is a potential area to amplify and sustain this agribusiness (Moura *et al.*, 2010). *Capsicum* plays a major nutritional role in many cultures by serving as a source of vitamin C (Eshbaugh, 1976) and other essential phytonutrients. The pungency associated with many forms of *Capsicum* makes the fresh or dried fruit a desirable spice, and many medicinal properties have been attributed to capsaicin and its analogs (Stewart *et al.*, 2005) The fruit length is one of the important characteristics, which helps in differentiating the varieties as small, medium, and large. The varieties of *Capsicum* exhibit significant variability in fruit length (Daniel *et al.*, 2014). Chilli is an important cash crop in India and is grown for pungent green fruits which turn red on ripening. India is the world's largest producer, consumer and exporter of chillies.

Materials and Methods

The sun dried chillies were procured from local market in Thane for the study. 4 popular varieties viz., **Baydgi, Lavangi, Pandi (Guntur) and Sankeshwari were sampled.** Fifty chillies of each variety **used in sampling. The lengths of 50 randomly selected fruits from each variety were carefully recorded.** Their weights were also recorded as suggested by Radford *et al.* (1976). **The results were tabulated and subjected to statistical analysis using various tests such as Ho, LSD (Least Significant Difference) and Descriptive Statistics.** Data were processed using Analysis of Variance (ANOVA) and SPSS software.

Results and Discussion

Fruit length is one of the important characteristics, which help in differentiating the varieties as small, medium, and large. The *Capsicum* varieties exhibited significant variability in fruit length ranging from 7.0- 15cm. Based on this variation in fruit length, the 4 varieties under study were grouped into small, medium and large. The wide variation in fruit length might be due to variation in genetic constitution of the varieties as the fruit length is controlled by three to ten pairs of genes with heritability value of 40 to 50 per cent in *Capsicum*. (Weiss, 1971; Walsh *et al.*, 2001) The fruit length might have also been influenced by agronomic and environmental conditions. ANOVA revealed the fruit lengths in the varieties studied were significantly different. The results of statistical analyses are depicted in Tables 2-4.

Sankeshwari variety of chillies, with an average length of 12.646 cm were the longest among the varieties selected for study (Fig. 1); and the 50 sun dried fruits weighed 51.070 g (Table 1). These chillies are grown at Sankeshwar in Belgaum district of Karnataka, bordering Maharashtra. Production of this variety is lesser than demand. The mean length of *Pandi* variety was 8.18 cm and the weight of 50 sundried fruits was 43.289 g. This variety popularly referred to as the 'king of chillies', obviously owing to its pungency, is produced in Guntur District of Andhra Pradesh. *Baydagi* variety, also called as *Khaddi* had mean length of dried fruits 10.566 cm and 50 pods weighed 72.496 g which is the highest weight/ 50 dried fruits recorded in the current investigation. Fruits of this variety are brilliant red with low pungency and are used to give a natural colour to the cuisine prepared. The shortest average length of 7.5 cm was recorded in *Lavangi* variety, with 50 pods weighing 31.069 g. Grown in Kolhapur district of Maharashtra, this variety is widely known for its pungency.

Table 1. Mean Lengths and weights of 50 sundried fruits

Varieties studied	Mean length of dried fruits (cm)	Weight of 50 dried fruits (g)
Sankeshwari	12.646	51.07
Pandi	8.18	43.289
Byadgi	10.566	72.496
Lavangi	7.536	31.069

Table 2. Analysis

	Sum of Squares	df	Mean Square	F	Sig.
Chilli Type	820.9036	3	273.6345333	158.9712	0
Error	337.3716	196	1.721283673		
Total	1158.2752	199			

Ho : There is no significant difference between lengths (in cms) of different types of chillies.

We reject Ho as p-value (0.00) < 0.05

Conclusion: There is a significant difference between lengths of chillies of different types.

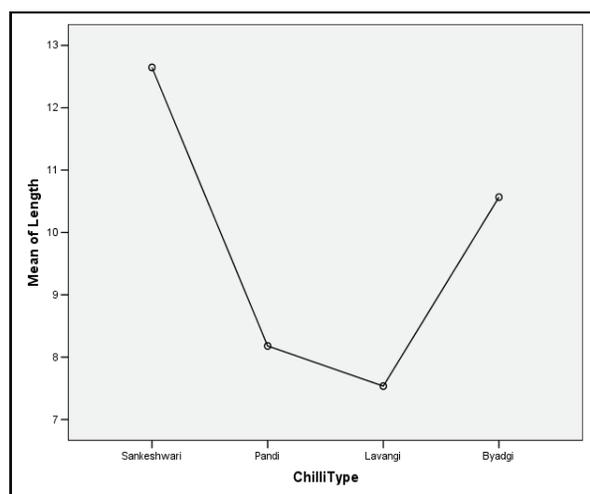
We proceed for multiple comparisons

Table 3. LSD (Least Significant Difference)						
(I) ChilliType	(J) ChilliType	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
Sankeshwari	Pandi	4.466	0.262395	0.00	3.9485	4.9835
	Lavangi	5.11	0.262395	0.00	4.5925	5.6275
	Byadgi	2.08	0.262395	0.00	1.5625	2.5975
Pandi	Sankeshwari	-4.466	0.262395	0.00	-4.9835	-3.9485
	Lavangi	0.644	0.262395	0.01	0.1265	1.1615
	Byadgi	-2.386	0.262395	0.00	-2.9035	-1.8685
Lavangi	Sankeshwari	-5.11	0.262395	0.00	-5.6275	-4.5925
	Pandi	-0.644	0.262395	0.01	-1.1615	-0.1265
	Byadgi	-3.03	0.262395	0.00	-3.5475	-2.5125
Byadgi	Sankeshwari	-2.08	0.262395	0.00	-2.5975	-1.5625
	Pandi	2.386	0.262395	0.00	1.8685	2.9035
	Lavangi	3.03	0.262395	0.00	2.5125	3.5475

All the pairs (Chilli Types) differ significantly from each other.

Table 4. Descriptive Statistics

Chilli Type	N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean		Minimum	Maximum
					Lower Bound	Upper Bound		
Sankeshwari	50	12.646	1.6207	0.229199	12.185	13.107	10.2	18.4
Pandi	50	8.18	0.9359	0.132357	7.914	8.446	6.6	10.3
Lavangi	50	7.536	0.7626	0.107846	7.319	7.753	6.1	9.5
Byadgi	50	10.566	1.6736	0.236688	10.09	11.042	6.6	13.9

**Fig. 1. Comparative mean lengths of chilli varieties studied**

Conclusion

There was a significant difference between lengths of chillies of different types. *Sankeshwari* chillies were longest among the varieties selected for study, followed by *Byadgi*, *Pandi* and *Lavangi* varieties. *Byadgi* chillies registered the maximum dry weight, followed by *Sankeshwari*, *Pandi* and *Lavangi* varieties.

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Research Article

A Comparative Study of Rice Varieties Procured from Local Market Based on Length after Cooking

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Abstract : The grain lengths of 10 varieties of locally available loose, and branded packaged rice procured from local market of Thane city, Maharashtra, India, were assessed after cooking. 6 locally available varieties selected for the study were Surti Kolam, Indrayani, Ambemohar, Vaihnavi, Dubraj and Basmati. The 4 packaged rice brands selected were Dawat, Kohinoor, Kainath and Indiatgate. India Gate was the longest variety of rice grains when cooked as compared to the rest, followed by Dawat. Ambemohar rice showed the lowest length. From amongst local loosely sold varieties selected for study, highest length was shown by Dubraj variety, followed by Indrayani and Vaihnavi.

Introduction:

Rice (*Oryza sativa*) is graded according to the characteristics of grains; the kernel appearance, size, shape, aroma, nutritional value and cooking characteristics are important for judging the quality and consumer preference of rice (Dela Cruz and Khush, 2000; Sellappan *et al.*, 2009). Kernel shape and l/b ratio are important features for grain quality assessment (Rita and Sarawgi, 2008). Aroma, hardness and roughness depend on temperature and are variety specific which affects the sensory properties of cooked rice (Yau and Huang, 1996, Anon, 2004). Individual preferences are known to vary with most consumers preferring local varieties (Tomlins *et al.*, 2005) for daily consumption and high end branded long grained varieties for special dishes and occasions.

Rice is a food crop of world-wide importance and forms the foundation of the diet of over half of the world's population. The centre of origin of rice is believed to be South-East Asia (Huang, 1998). India is one of the largest exporters of basmati rice in the world (Husaini *et al.*, 2009). Consumer demand has increased markedly for premium fragrant rice (Louis *et al.*, 2005). The aroma of scented rice is known to vary with genetic and environmental conditions (Wakte, *et al.*, 2006). Difficulty in differentiating genuine basmati from other types of rice and the significant price differences between them has led fraudulent traders to

adulterate basmati rice with crossbred basmati varieties and other long-grain non-basmati varieties (Robinson 2010).

Materials and Methods: The 10 varieties of rice samples were procured from local market in Thane, comprising six local varieties inclusive of loosely sold basmati rice and four branded and packaged basmati varieties. 50 grains of each variety were cooked in pressure cooker. The cooked grains were measured placing them on graph paper and the length was recorded in millimeters. The statistical analysis was done by Analysis of variance (ANOVA), Pair wise/multiple comparison using LSD, S.D for differing pairs. All data were analyzed using the Analysis of Variance (ANOVA) procedure using SPSS software. Differences were declared statistically significant when $P < 0.05$, where 5 % was level of significance. Interrelationships among traits values were estimated (Oko *et al.*, 2012)

Results and Discussion:

Analysis

One-way ANOVA

We use one-way to test if the average lengths of grains differ significantly.

Ho: There is no significant difference between the lengths of rice grains of different types.

Table 1. ANOVA Table

Source of Variation	Sum of Squares	df	Mean Square	F	Sig.
Rice Type	22008.8	9	2445.422	1125.87	0
Error	1064.294	490	2.172028		
Total	23073.09	499			

Decision Criteria: Reject Ho if p-value (0) is less than 0.05

Conclusion: The lengths of rice grains differ significantly for different types of rice.

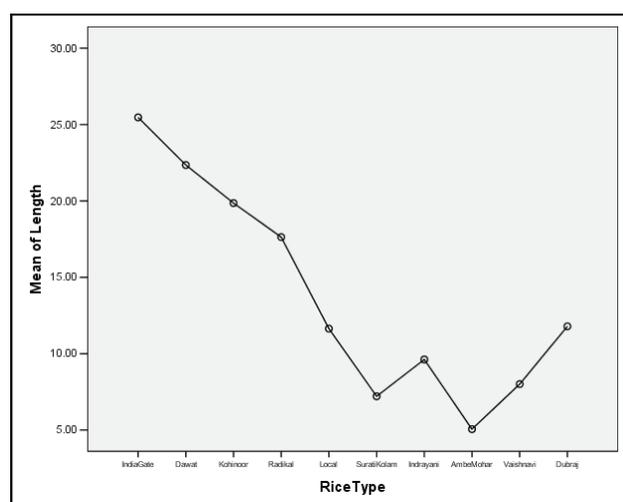
Proceed for pair wise/multiple comparisons using LSD (least significant difference) method for pair wise testing.

Table 2. Multiple Comparisons Table

(I) Rice Type	(J) Rice Type	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
Indiagate	Dawat	3.12	0.294756	0	2.5409	3.6991
	Kohinoor	5.61	0.294756	0	5.0309	6.1891
	kainath	7.838	0.294756	0	7.2589	8.4171
	Local	13.83	0.294756	0	13.2509	14.4091
	SuratiKolam	18.26	0.294756	0	17.6809	18.8391
	Indrayani	15.83	0.294756	0	15.2709	16.4291
	AmbeMohar	20.41	0.294756	0	19.8309	20.9891
	Vaishnavi	17.46	0.294756	0	16.8809	18.0391
Dawat	Dubraj	13.68	0.294756	0	13.1009	14.2591
	Indiagate	-3.12	0.294756	0	-3.6991	-2.5409
	Kohinoor	2.49	0.294756	0	1.9109	3.0691
	kainath	4.718	0.294756	0	4.1389	5.2971
	Local	10.71	0.294756	0	10.1309	11.2891
	SuratiKolam	15.14	0.294756	0	14.5609	15.7191
	Indrayani	12.73	0.294756	0	12.1509	13.3091
	AmbeMohar	17.29	0.294756	0	16.7109	17.8691
Kohinoor	Vaishnavi	14.34	0.294756	0	13.7609	14.9191
	Dubraj	10.56	0.294756	0	9.9809	11.1391
	Indiagate	-5.61	0.294756	0	-6.1891	-5.0309
	Dawat	-2.49	0.294756	0	-3.0691	-1.9109
	kainath	2.228	0.294756	0	1.6489	2.8071
	Local	8.22	0.294756	0	7.6409	8.7991
	SuratiKolam	12.65	0.294756	0	12.0709	13.2291
	Indrayani	10.24	0.294756	0	9.6609	10.8191
kainath	AmbeMohar	14.8	0.294756	0	14.2209	15.3791
	Vaishnavi	11.85	0.294756	0	11.2709	12.4291
	Dubraj	8.07	0.294756	0	7.4909	8.6491
	Indiagate	-7.838	0.294756	0	-8.4171	-7.2589
	Dawat	-4.718	0.294756	0	-5.2971	-4.1389
	Kohinoor	-2.228	0.294756	0	-2.8071	-1.6489
	Local	5.992	0.294756	0	5.4129	6.5711
	SuratiKolam	10.422	0.294756	0	9.8429	11.0011
Local	Indrayani	8.012	0.294756	0	7.4329	8.5911
	AmbeMohar	12.572	0.294756	0	11.9929	13.1511
	Vaishnavi	9.622	0.294756	0	9.0429	10.2011
	Dubraj	5.842	0.294756	0	5.2629	6.4211
	Indiagate	-13.83	0.294756	0	-14.4091	-13.2509
	Dawat	-10.71	0.294756	0	-11.2891	-10.1309
	Kohinoor	-8.22	0.294756	0	-8.7991	-7.6409
	kainath	-5.992	0.294756	0	-6.5711	-5.4129
SuratiKolam	SuratiKolam	4.43	0.294756	0	3.8509	5.0091
	Indrayani	2.02	0.294756	0	1.4409	2.5991
	AmbeMohar	6.58	0.294756	0	6.0009	7.1591
	Vaishnavi	3.63	0.294756	0	3.0509	4.2091
	Dubraj	-0.15	0.294756	0.611	-0.7291	0.4291
	Indiagate	-18.26	0.294756	0	-18.8391	-17.6809
	Dawat	-15.14	0.294756	0	-15.7191	-14.5609
	Kohinoor	-12.65	0.294756	0	-13.2291	-12.0709
Indrayani	kainath	-10.422	0.294756	0	-11.0011	-9.8429
	Local	4.43	0.294756	0	-5.0091	-3.8509
	Indrayani	-2.41	0.294756	0	-2.9891	-1.8309
	AmbeMohar	2.15	0.294756	0	1.5709	2.7291
	Vaishnavi	-0.8	0.294756	0.007	-1.3791	-0.2209
	Dubraj	4.58	0.294756	0	-5.1591	-4.0009
	Indiagate	-15.83	0.294756	0	-16.4291	-15.2709
	Dawat	-12.73	0.294756	0	-13.3091	-12.1509
AmbeMohar	Kohinoor	-10.24	0.294756	0	-10.8191	-9.6609
	kainath	-8.012	0.294756	0	-8.5911	-7.4329
	Local	-2.02	0.294756	0	-2.5991	-1.4409
	SuratiKolam	2.41	0.294756	0	1.8309	2.9891
	Indrayani	4.56	0.294756	0	3.9809	5.1391

Table 3. Descriptive Statistics

Rice Type	N	Mean	Std. Deviation	Std. Error	Mean		Minimum	Maximum
					Lower Bound	Upper Bound		
India Gate	50	25.47	1.93361774	0.273455	24.9205	26.0195	20	28.5
Dawat	50	22.35	1.92790994	0.272648	21.8021	22.8979	19	25.5
Kohinoor	50	19.86	1.69042924	0.239063	19.3796	20.3404	17	23.5
kainath	50	17.632	1.9794289	0.279934	17.0695	18.1945	14.5	23
Local basmati	50	11.64	1.31723272	0.186285	11.2656	12.0144	9	13.5
Surti Kolam	50	7.21	0.77650446	0.109814	6.9893	7.4307	5.5	9
Indrayani	50	9.62	1.02300079	0.144674	9.3293	9.9107	8	11
Amb Mohar	50	5.06	0.79948963	0.113065	4.8328	5.2872	4	6.5
Vaishnavi	50	8.01	1.52359001	0.215468	7.577	8.443	6	10.5
Dubraj	50	11.79	1.06947441	0.151247	11.4861	12.0939	9.5	13.5



India Gate brand constituted the longest variety of rice grains when cooked followed by Dawat, Kohinoor and Kainath brands of packaged basmati rice. From amongst the locally marketed varieties, highest cooked grain length was that of Dubraj variety followed by Basmati, Indrayani, Vaishnavi and Surti Kolam varieties. Ambemohar rice showed the lowest length of cooked grains. Hypothesis was set with assumption that in all the varieties the grains are of similar lengths but (H₀) hypothesis was rejected and ANOVA and pair wise / multiple comparisons (Oko *et al.*, 2012) were done.

Though India gate basmati shows the longest grain size, there was unevenness in the grain length; the shortest recorded being 21mm and longest, 28.5 mm, thus there revealing significant difference (Pandey *et al* 2007). The other varieties did not reveal significant variations in the length of grains. All Basmati varieties revealed the typical pleasant

aroma after cooking. Cooked Basmati varieties were non sticky. Amongst the locally marketed varieties, Indrayani variety was more aromatic followed by Ambemohar and Vaishnavi. Dubraj rice had longer grains, relatively less aroma and less stickiness, while Vaihnnavi variety showed stickiness on cooking. Results are in agreement with those of Pandey *et al.* (2007).

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Research Article

Addition to the records of Discodorid sea slugs along the west coast of India

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Abstract : Discodorid sea slugs are gastropod molluscs belonging to the order Nudibranchia. These belong to family Discodorididae with diversity of around 250 species worldwide. Being nudibranch, these molluscs have lost shell and no remnants are found in contrast to other shelled associates. So identification is based on the external and internal morphology. Majority of the records are from east coast of India and records from west coast are scanty. A total of 33 species have been recorded from India till now. The morphological characters were used for taxonomy of discodorids. This study is an attempt to present diversity of discodorid sea slugs recorded during 2011-2014 along the intertidal areas of Maharashtra and Gujarat. Surveys were conducted fortnightly along the few sites of Gujarat viz. Dwarka, Poshitra, Narara and Maharashtra viz. Bhatkarwada and Mirya. A total of 10 genera and 14 species of the discodorids were recorded, in which *Sclerodoris apiculata* was recorded for the first time from Gujarat; a species *Atagema tristis* was rediscovered after its last report in 1952 and two species namely *Rostanga cf. arbutus* and *Thordisa sanguinea* are new records for India.

Keywords: Opisthobranchia, Discodorididae, Nudibranchs, Nudibranchia, Taxonomy.

Introduction

Species of family Discodorididae are disc shaped marine gastropods mainly feeding on sponges. Some of the species of this family have body spicules known as Caryophyllidia. Dayrat (2010) has mentioned 35 key characters for distinction between Discodorid species.

This family has 27 genera distributed worldwide (Bouchet, 2012). There are total 33 Discodoridopisthobranch species recorded from India, belonging to 14 genera. Majority descriptions have been from the south west coast of India. Prasad *et al.* (2012) has taken a comprehensive review of Discodorid fauna of India. In addition, Prasad *et al.* (2013), Subburaman *et al.* (2013) and Apte and Bhav (2014) recorded discodorid species in their recent contributions.

The current paper presents an account of newly and previously recorded Discodorid fauna of Maharashtra and Gujarat within the study period of 2011 to 2014, along with morphological descriptions of the new records.

Materials And Methods

Study sites for the current investigation have been Konkan and Gulf of Kutch, from the states of Maharashtra and Gujarat respectively; and situated on the central west coast of India, along the Arabian Sea. Coastal areas of Maharashtra are typical rocky intertidal areas with many rock pools and boulder fields. Gulf of Kutch on the other hand, is large inlets of Arabian Sea and majority intertidal areas within it are endowed with flat, open reefs inhabited by highly diverse flora and fauna.

Collection sites in Maharashtra were Bhatkarwada (16°59'11.00"N, 73°16'26.36"E) and Mirya (17°1'12.16"N, 73°15'28.06"E) in Ratnagiri District. Those in Gujarat were Poshitra (22°24'9.01"N, 69°12'12.79"E), Dwarka (22°14'30.07"N, 68°57'22.50"E) and Narara (22°28'39.64"N, 69°43'6.23"E).

Collections of the specimens were made during low tide field surveys. Specimens were photographed *in situ* and, after collection, preserved in 4% formaldehyde.

Results And Discussion

Following is the account of the specimens collected at various collection sites and deposited at BNHS repository.

SYSTEMATICS

Subclass: Heterobranchia
 Infraclass: Opisthobranchia
 Order: Nudibranchia
 Family: Discodorididae

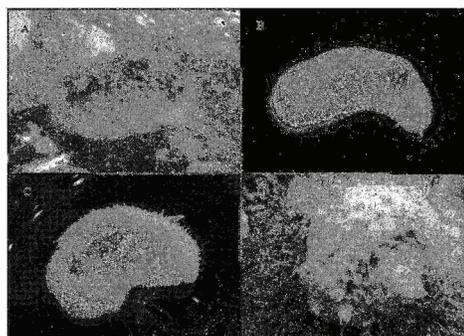


Fig. 1 (A) *Atagema tristis*; (B) *Rostanga cf. arbutus*; (C) *Thordisa sanguinea*; (D) *Sclerodoris apiculata*.

Morphological descriptions of the new records:

Atagama tristis (Alder and Hancock, 1864) (Figure 1A)

Collection site: Bhatkarwada

Collection no.: BNHS-Opistho-377

Type locality: Andhra Pradesh (Alder and Hancock, 1864)

Morphology: Specimens were found underside of the rock, along with many encrusted sponges, bryozoans and ascidians in rock pool. The body is oval and raised. The dorsum is with tubercles and ridges covered with spicules called caryophyllids which form visible network on the body. Well elevated processes appear along each side of the back. There is elevated central ridge and rhinophoral sheath. Rhinophores are retractable and lamellate, dark brown while their tips are white and pointed. Gills are horizontally arranged, are tripinnate, palewhite colored. The entire body is pale white while elevated tubercles are pale yellow-brown. Between the rhinophores and central ridge there is a dark grey or black depression. The central ridge extends between the rhinophores and gills and bears a central large brown conical protuberance behind the depression. The margins of mantle are white. Ventral surface is pale coloured; while the foot is rounded with deeply notched lamina in front. The oral tentacles are small.

Anatomy: The anatomy reveals the buccal mass with oral tube, retractor muscles and glands. The blood gland is single and small. Labial cuticle is smooth.

Radular formula: (21x26.0.26). All radular teeth are hamate and smooth while the rachidean teeth were absent.

Remark: First record from the west coast of India. Previously recorded by Alder and Hancock (1864) as *Doris tristis*; by O'Donoghue (1932) and Satyamurthi (1952) from Tamil Nadu coast.

Rostanga cf. arbutus (Figure 1B)

Collection site: Bhatkarwada

Collection no.: BNHS-Opistho-853

Type locality: Australia (Angas, 1864; Rudman and Avern, 1989)

Morphology: Specimens were found in shallow rock pool, underside of the rock along with red encrusting sponge. The body is oval, orange-red and covered with visible dense caryophyllidia. Brown orange spots are present all over the body. Rhinophores are with oblique lamellate having translucent white terminal small knob. Gills are six, tripinnate, orange and with white dustings at the tips. Other characters such as notched upper lip of foot, digitiform or conical oral tentacles are seen which confirms

the family Discodorididae.

Radular Formula

(24x39.0.39) (7mm sized specimen). Rachidean teeth are absent. Outermost lateral teeth are slender and elongated which is the exclusive character for the genus. The innermost teeth are with small denticles.

Remark: First record of the genus and species from India. Although specimen matches with the original description by Angas (1864), Rudman and Avern (1989) have stated that this species, previously thought to be distributed over Australia and Indo-West Pacific, was subsequently found to occur only in New South Wales, eastern Australia. Hence further detailed anatomical observations are necessary for confirmation of the identification.

Thordisa sanguinea Baba (1955) (Figure 1C)

Collection site: Poshitra

Collection no.: BNHS-Opistho-711

Type locality: Sagami bay, Japan (Baba, 1955)

Morphology: Specimens were found on the orange sponge in the water channels. The body form is disc like and orange-red coloured. The dorsal surface is with thick set pointed papillae. Some papillae are short and stout while some are long and slender. Papillae are whitish to transparent. Dorsal surface is with three ocellar markings. Rhinophores are lamellate and gills are tripinnate, brownish in colour. The oral tentacles are digitiform. The egg case is dark orange, simple and circular.

Radular formula: (32x3.24.0.24.3). Radula is long and narrow. Rachidean teeth are absent. Teeth are in a 32 rows, of which last 2 are worn out. The presence of outermost pectinate teeth is characteristic of the genus *Thordisa*. In a row, outermost 3 teeth are pectinate, one with slight hump on upper side and rest of the mid laterals are smooth and hamate.

Remark: First record from the Western Indian Ocean

Species: *Sclerodoris apiculata* (Alder & Hancock, 1864)

(Figure 1D)

Collection site: Poshitra

Type locality: Andhra Pradesh (Alder and Hancock, 1864)

Morphology: A single specimen was found in the open water channel, underside of rocks. The body is pale yellow, firm and with sponge like dorsal surface. Large conical tubercles are present all over the dorsal surface whereas slender papillae are present on some of the tubercles, which is the key character of the species. Gills are

five and tripinnate. Ventral surface is pale yellow, with small brown patches all over the mantle. Oral tentacles are present.

Anatomical features could not be studied since a single specimen is in the collection from the study locality.

Remark: First record from the Gujarat. Previous record of this species by Alder and Hancock, (1864) is as *Doris*

apiculata; by O'Donoghue (1932) as *Halgerda apiculata* from the locality of Vishakhapatnam Coast and Pamban. Also recorded by Apte and Bhawe (2014) as *S. apiculata* from Lakshdweep.

The other species encountered at the collection sites are recorded in Table 1.

Sr. No.	Name	Maharashtra		Gujarat		
		Bhatkarwada	Mirya	Poshitra	Dwarka	Narara
1	<i>Atagema rugosa</i> (Pruvot-Fol, 1951)	*	*	*	*	*
2	<i>Atagema tristis</i> (Alder and Hancock, 1864)	*				
3	<i>Discodoris</i> sp.	*	*			
4	<i>Hoplodoris grandiflora</i> (Pease, 1860)					*
5	<i>Carminodoris</i> sp.		*			
6	<i>Jorunna funebris</i> (Kelaart, 1859)			*	*	
7	<i>Peltodoris murrea</i> (Abraham, 1877)			*	*	*
8	<i>Rostanga cf. arbutus</i>	*				
9	<i>Sclerodoris tuberculata</i> (Eliot, 1904)			*	*	*
10	<i>Sclerodoris apiculata</i> (Alder and Hancock, 1864)			*		
11	<i>Sebadoris fragilis</i> (Alder and Hancock, 1864)	*	*			
12	<i>Tayuvali lacina</i> (Gould, 1852)			*		*
13	<i>Thordisa sanguinea</i> (Baba, 1955)			*		
14	<i>Thordisa villosa</i> (Alder and Hancock, 1864)	*		*		*

The present study is significant as three of the four species were recorded for the first time from west coast of India. Among them *Atagema tristis* was formerly recorded from east coast of India; *Rostanga cf. arbutus* and *Thordisa sanguinea* are the first records for India. *Sclerodoris apiculata* has been recorded for the first time from Gujarat state. Table 1 shows diversity of species of family Discodorididae along the sites of study. Some genera namely *Rostanga cf. arbutus*, *Discodoris* sp. and *Carminodoris* sp. require further study for confirmation of the species. Although Maharashtra and Gujarat are distinct in habitat structure; *Atagema rugosa* and *Thordisa villosa* were observed to be present in both types of intertidal habitats.

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Research Article

Shankha Soochanadhara - The Molluscan Database, An Initiative For Molluscan Database Of Kasaragod District

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Abstract : Databases are taking the role of scientific literature in distributing the information generated from research work. Molluscs are good indicators of environmental history and the highest numbers of recorded extinctions in modern times have been among the molluscs. This database is an initiative designed to enable an effective search to retrieve the information relating to the taxonomy, biodiversity and conservation of molluscs. Kasaragod, the northern-most district of Kerala is blessed with 12 rivers and has a coastline of about 29.3km, provides rich marine and freshwater diversity. A total of 15 species of Gastropods belonging to 13 families and about 16 species of bivalves belonging to 10 families were recorded. The database contains fields including Home Page, Identified species, Ecosystem, Image gallery, Google map, users sign in page, links, reference, molecular taxonomy and queries. Coastal ecosystems are among the most productive and biologically rich ecosystems in our country. The present study attempts to gather and review the available scientific information on molluscs in Kasargod in order to assist in the adequate management and protection of their populations. As the study progresses, more regions will be surveyed for creating a comprehensive database of molluscs within the state of Kerala.

Key words: Database, Taxonomy, Mollusca, Biodiversity, Kasaragod

Introduction

Biology is entering a new era in which databases are taking the role of scientific literature in distributing the information generated from research work. Database is an integrated collection of data that will help the user to manage and access the information in an easier way. There will always be a need for some continuous review and editing of the entries in a database (Robbins, 1994). A taxonomic database documents the biological taxa in a systematic manner but the accurate identification of organisms is critical in taxonomic databases.

Molluscs are good indicators of environmental history and conditions because of their low mobility, evolutionary history and their calcareous shells have a good preservation potential. The highest number of recorded extinctions in modern times has been among the molluscs (Strayer *et al.* 1986; Lydeard *et al.* 2004; Régnier *et al.* 2009) and many more species are threatened. Among the Asian countries, India is perhaps the only country that has a long record of inventories of coastal and marine biodiversity. India has a coastline of about 8000km, an exclusive economic zone of 2.02 million sq.km adjoining the continental regions and the offshore islands, productive coastal ecosystems such as estuaries, lagoons, mangroves, backwaters, saltmarshes, seagrasses, rocky shores, sandy stretches and coral reefs characterized by unique biotic and abiotic properties and processes (Venkataraman and Wafar, 2005).

'Shankha Soochanadhara -The Molluscan Database' is a type of biological database that enables the user to locate the distribution and diversity of molluscs in a specific region (Fig.1). This database is an initiative designed on the

basis of collection, isolation and identification of molluscan species from Kasaragod, the northern-most district of Kerala. It deals with the taxonomy, ecological and economic importance, status, threats of marine, brackish and freshwater molluscs. A total of 15 species of gastropods representing the families Olividae (2), Muricidae (1), Nassariidae (1), Cerithiidae (1), Ranellidae (1), Trochidae(2), Janthinidae (1), Littorinidae (1), Potamididae (1), Tonnidae (1), Strombidae (1), Turritellidae (1), Neritidae (1) are being currently listed in the database. Bivalves comprises of 16 species belonging to families Arcidae (2), Veneridae (4), Ostreidae (1), Donacidae (2), Pharidae (1), Anomiidae (1), Mytilidae (2), Placunidae (1), Cyrenidae (1), and Tellinidae (1) were recorded. The project is ongoing at present.

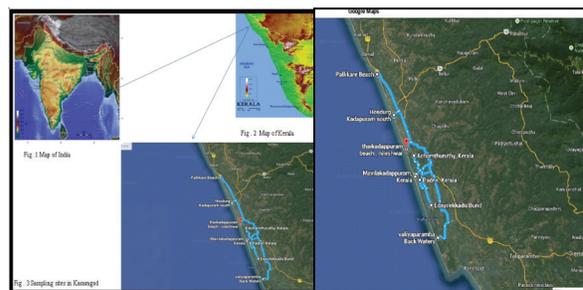


Fig. 1 Map of the sampling sites in Kasaragod district of Kerala, India.

Materials And Methods

The molluscs were collected from six regions in Kasaragod, i.e., Hosdurg (Latitude: 12 ° 18 ' 21.347 '' N % Longitude : 75 ° 5 ' 40.902 '' E), Valiyaparamba (Latitude: 12 ° 4 ' 36.009 '' N % Longitude : 75 ° 10 ' 35.134 '' E), Padanna

(Latitude: 12° 10' 52.631" N % Longitude : 75° 8' 46.484" E), Mavila (Latitude: 12° 11' 26.803" N % Longitude : 75° 7' 36.511" E), Orimukku (Latitude: 12° 11' 50.191" N % Longitude : 75° 7' 53.193" E), and Pallikkara (Latitude: 12° 23' 27.738" N % Longitude : 75° 2' 22.264" E), by hand picking method in a transect of known area using a quadrat of known size for a period of one year from October 2012 to October 2013. The samples were brought to laboratory, washed, cleaned, and photographed and preserved in 95% ethanol for further analysis. Identifications were done based on conchological characters, for gastropods the shell characters such as shape, spire length and shape, mouth opening, opercular shape, umbilicus shape and size, colour and ornamentation of the shell were also noted. The bivalves were identified mainly based on the morphology of the shell, striations or ribs on the outer surface of the two valves, their colour, luster, peculiarities of hinge and muscle scar, cardinal and lateral teeth (Gravelly, 1941 ; Satyamurti, 1952, 1956 ; Lucifora, 1978; Jorgen Moller Christensen, 1980; MacDonald, 1982; Subba Rao, 1989). The molluscan identification was done at KUFOS, Cochin.

Results And Discussion

The database is generated to enable an effective search to retrieve the information relating to the molluscan taxonomy, biodiversity and conservation (Fig.2). It includes the "Home Page" which provides the information to query the database on selected fields such as Molluscan class, species name, nature of the ecosystem i.e., marine, fresh water, brackish water, estuary and terrestrial ecosystems. Identified species are listed based on their diversity and distribution in a specific locality, i.e., list of panchayat, municipality and corporation. An image gallery is provided that allows species to be identified by browsing the images. Google map marks the sampling sites in Kasaragod district. Users can create account in our database that allows them to report the correction and provide necessary feedback. The database also allows anyone with special interest on particular species to contact and contribute information into our database. Some species have complete account while others as yet have only photographs or distribution (Fig.3). Links and reference to other web pages of molluscs are also being incorporated to provide more data. Molecular taxonomy of specific family of molluscs will be added up after the comprehensive research work.

In the present study 15 species of Gastropods belonging to 13 families, Olividae(2), Muricidae (1), Nassariidae (1), Cerithidae (1), Ranellidae (1), Trochidae (2), Janthinidae (1), Littorinidae (1), Potamididae (1), Tonnidae (1), Strombidae (1), Turritellidae (1), Neritidae (1) and about 16 species of Bivalves belonging to 10 families *Arcidae* (2), *Veneridae* (4), *Ostreidae* (1), *Donacidae* (2), *Pharidae* (1), *Anomiidae* (1), *Mytilidae* (2), *Placunidae*

(1), *Cyrenidae* (1) and *Tellinidae* (1) were recorded.

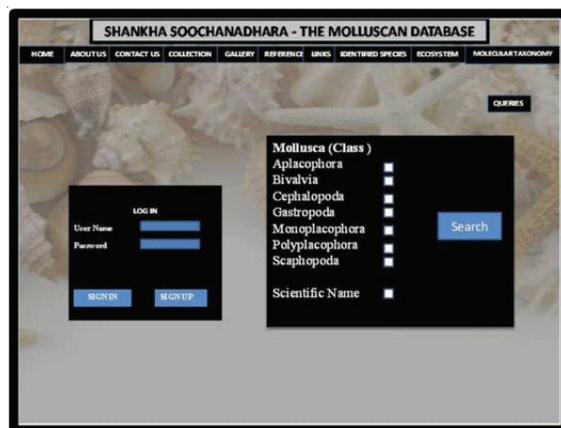


Fig. 2 Design of the database

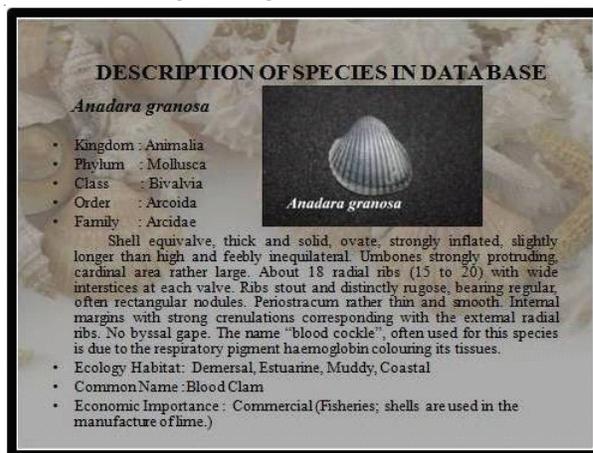


Fig. 3 Species description

Biodiversity conservation and managing are key activities for the health and existence of many ecosystems (Mitchell, 2001). Due to lack of species monitoring some threats related to molluscs are not being documented. Coastal ecosystems are among the most productive and biologically rich ecosystems in our country which include several lakes, lagoons, marshes, mangrove swamps, littoral zones and coral reefs. The decreasing biodiversity is a threat for mankind as it destabilizes the ecosystem functioning. So there is an urgent need not only to conserve, but also to improve the biodiversity level in all the ecosystems under threat.

Commercial exploitation accounts for the greater reduction of molluscan population in nature and pollution and environmental hazards can also cause death of molluscs to a lesser magnitude. (Appukuttan, 1996). Indiscriminate fishing for any ecosystem will lead to depletion of stock of the molluscan resources. The only law that governs the protection of the molluscan species is the listing of endangered species under the Indian Wildlife (Protection) Act. 23 species

of molluscs have been listed in the Indian Wildlife (protection) Act, 1972, amended in 2001.

Kasaragod, the northern-most district of Kerala is blessed with 12 rivers and has a coastline of about 29.3 km, providing rich marine and freshwater diversity. So, it is necessary to conduct detailed studies to identify the molluscan species without affecting the ecosystem balance. In this context to construct a database of the molluscs, which are endemic to each region is essential. Sustainable people-centered participatory management of coastal areas is required to ensure both ecological security of the coastal zones and the livelihood security of coastal communities. An in-depth understanding of the status of bio-resources in coastal regions holds the key for developing any effective conservation and utilization strategy. As rapid development and population growth continue in coastal areas increasing demands are expected on natural resources and on remaining natural habitats along the coasts. Environmental degradation and over-exploitation will deplete the marine and coastal biodiversity unless necessary measures are implemented for the conservation, utilization, management and the equitable sharing of marine resources.

The database will serve as a useful resource material for all those involved in contributing to the ecological and livelihood security of the coastal ecosystem. We have the goal of establishing a perfect database for each species of molluscs in this region and to encourage the volunteers and specialists to help us to prepare species accounts and to record them and to link with common man so that they can also have a ready access to taxonomic information of the molluscan species of their areas by searching with their locality and common name of the species. Species accounts will be added regularly by the volunteers and they contain special description, photos and classification of various species. It can be concluded from the present study that the study areas are rich in molluscan diversity. This study is an initial attempt to evaluate the molluscan diversity of Kasaragod. However the validation requires further investigations of various environmental components. As the study progresses, more regions will be surveyed for creating a comprehensive database of molluscs. Hence the present study attempts to gather and review the available scientific information on molluscs in order to assist the adequate management and protection of their populations.

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Research Article

Synthesis of Ecofriendly Silver Nanoparticles from Plant Latex used as an Important Taxonomical Tool for Phylogenetic Interrelationship

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Abstract: Green synthesis method of nanoparticles is an evolution from Nano biotechnology. Silver nanoparticles were successfully synthesized from AgNO₃ solution using the latex of 3 different plant taxa belonging to 3 different plant families viz. Asclepiadaceae, Euphorbiaceae and Moraceae. Nanoparticle synthesis was proved under UV-Vis absorption spectroscopy. By using different plant-latex, silver nanoparticles were synthesized which were quite stable and no visible changes were observed even after a month. Nanoparticles have great applications in the medical world such as surgery, cancer therapy, drug delivery etc. In taxonomic view, this modern tool for synthesis of ecofriendly, non-toxic, non-expensive nanoparticles to open new trends for the classification of angiosperms and detection of their phylogenetic relationships depends on plants ability for the synthesis of nanoparticles which are variable in size and concentration in case of different families, different genera even at the species level.

Keywords: Latex, Ecofriendly, Non-toxic, Non-expensive.

Introduction

Latex is the stable dispersion (emulsion) of polymer micro particles in an aqueous medium. Latex is found in nature in the form of milky fluid, found in 10% of all flowering plants (Angiosperms). It is a complex emulsion consisting of proteins, alkaloids, starches, sugars, oils, tannins, resins, and gums that coagulates on exposure to air. Green chemistry or nanoparticle is often referred to as clusters; Nano spheres, Nano rods and Nano cups are just a few of the shapes; at the small end of the size ranges from 1 to 100 nm (Sivakumar *et al.*, 2011). Green synthesis of silver nanoparticles has been reported using extracts of various plants such as *Allium cepa* (Benjamin and Bharathwaj, 2011), *Datura metel* (Ojha *et al.*, 2013), *Indigofera aspalathoids* (Krishnasamy *et al.*, 2012). It eliminates the use and generation of substances hazardous to human health and environment. Silver is an effective antimicrobial agent, exhibits low toxicity and has diverse *in vitro* and *in vivo* applications (Mani *et al.*, 2012). The synthesis of AgNPs using Euphorbiaceae, Apocynaceae, Asclepiadaceae, Moraceae, Euphorbiaceae, Musaceae and Sapotaceae plant latex was demonstrated by Amalkumar *et al.* (2011).

Materials And Methods

Source of AgNO₃: Silver nitrate (AgNO₃) analytical grade was purchased from Fisher Scientific India Pvt. Ltd.

Source of latex: Crude latex was obtained by cutting the green stems of 3 plants of different families viz. Asclepiadaceae, Euphorbiaceae and Moraceae. Milky white latex and watery latex both were stored at -20°C until use. All the aqueous solutions were prepared using triply distilled de-ionized water.

Synthesis of Silver nanoparticles: 1.5 ml crude latex was diluted to 50 ml using triply distilled de-ionized water and 25 ml of this latex solution was taken in a round bottom flask and heated at 60°C with constant stirring for 15 minutes in oil bath. Separately 25ml of 2 milimolar aqueous Silver nitrate solution was prepared and heated at 60°C with constant stirring for 15 minutes in oil bath. Latex solution was mixed with AgNO₃ solution and heated at 80°C for 30 to 45 minutes and silver nanoparticles were obtained gradually (Amalkumar *et al.*, 2011)

Characterization techniques: UV- visible spectroscopy analysis was carried out on Systronic UV-Visible absorption spectrophotometer 2450. The progress of the reaction between metal ions and plant latex were monitored by UV-Visible spectra of silver nanoparticles in aqueous solution of small aliquots of 100 µl of the sample at different wavelengths i.e. 200, 400, 600, 800 nm.

Results And Discussion

The silver nanoparticles were synthesized using *Calotropis gigantea* R.Br., *Euphoria milii* Linn and *Ficus benghalensis* Linn. Plant latex extracts were detected by UV visible spectrophotometer at various nanometers. Absorption spectra of silver nanoparticles formed in the reaction mixture at different nm i.e. 200, 400, 600 nm, revealed the particle had increasing sharp absorbance at 423, 434 and 444 nm (Figs 2-4) and gradually decreased while nanometer increased. Absorption spectra of Ag nanoparticles formed in reaction mixture after 24 hours intervals at nm showed the particle had increasingly sharp peaks between 24 to 48 hour i.e. when particles are polydispersed. Similar results, using various plant extracts,

were recorded by Elumalai *et al.* (2010).

The nanoparticles were primarily characterized by UV-Visible spectroscopy, which was proved to be a very useful technique for the analysis of nanoparticles. Reduction of Ag⁺ ions in the aqueous solution of silver complex during the reaction with the ingredients present in the plant latex extracts were observed by the UV-Vis spectroscopy revealed that silver nanoparticles in the solution may be correlated with the UV-Vis spectra. As the stem latex extracts were mixed with the aqueous solution of the silver ion complex, it was changed into colour complex due to excitation of surface plasmon vibrations, which indicated that the formation of Ag nanoparticles (Fig 1). UV-Vis spectrograph of the colloid of Ag nanoparticles has been recorded as a function of time by using a quartz cuvette with silver nitrate as the reference.

In the UV- spectrum, the broadening of peak indicated that the particles are poly dispersed. The reduction of silver ions and the formation of stable nanoparticles occurred rapidly within 2 hours of reaction making it one of the fastest bio reducing methods to produce Ag nanoparticles. The surface plasmon band in the silver nanoparticles solution remain close to 420-450 nm throughout the reaction period indicates that the particles are dispersed in the aqueous solution, with no evidence for aggregation. It was observed that the nanoparticles solution was stable for more than three months with little signs of aggregation (Table 1). The controlling procedure is successful in different plant latices. When light absorbance capacity of the medium was increased, the size of nano particles increased and when peak height for UV-Vis absorption (nm) was increased, then concentration of nano particles increased. Nano particles have a large surface area compared with the total volume. The surface area: volume ratio is interesting because chemical reactions typically occur on surfaces, so nanoparticles that have a high surface to energy ratio can be used in many interesting ways such as in catalysis.

Conclusion

The present study was carried out to explore the ability of medicinally important latex yielding plants viz. *Euphorbia milli* Linn., *Ficus benghalensis* Linn. and *Calotropis gigantea* R. Br. in the synthesis of silver nanoparticles, as reducing agent. A cost effective and environment friendly technique for the biosynthesis of silver nanoparticles from 2 mM AgNO₃ aqueous solution is discussed in the work. An insight of plants from different families being taxonomically ranked based on the Nano size of the particles (Table 2) is put forward. This can prove to be beneficial in the study of phylogenetic inter-relationships were Moraceae family is more advanced as compared to Euphorbiaceae and then Asclepiadaceae; as which the plant is able to synthesis larger Nano particles than the other plant, that

plant is more advanced.

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Fig 1:- Color change of *C.gigantia*, *E.milli* and *F. benghalensis* after 24 hrs for range 200- 600nm

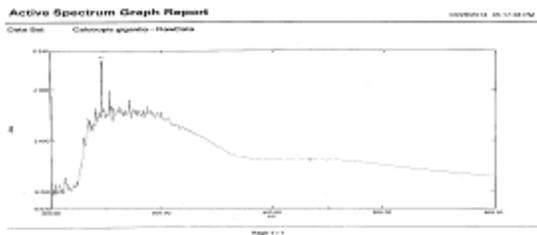


Fig. 2- UV-visible spectra of *C. gigantea* after 24 hour incubation (200- 600 nm)

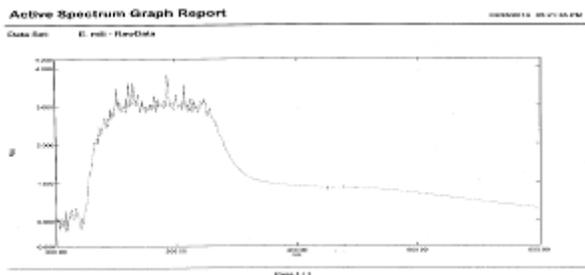


Fig. 3- UV-visible spectra of *E. milli* after 24 hour incubation (200- 600 nm)

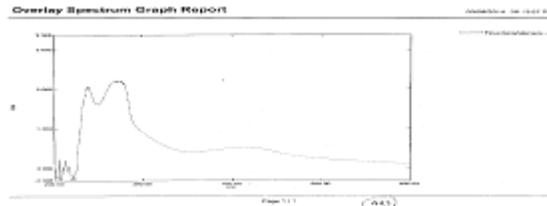


Fig. 4- UV-visible spectra of *Ficus benghalensis* after 24 hour incubation (200- 600 nm)

Table 1. Physical properties of silver nano particles

Properties	Water soluble
UV – Vis (nm) peak up	420-450
Specification	Stable for more than 30 days

Table 2. Rank of plants as depending on size of nano particles

Sl.No	Name of the Plant	Peak up	Rank
1	<i>Ficus benghalensis</i> Linn	444	1st
2	<i>Euphorbia milli</i> Linn	434	2nd
3	<i>Calotropis gigantea</i> R. Br.	423	3rd

Research Article

Proteomics and RAPD Analysis of Different Cultivars of *Mirabilis Jalapa* L.Shrutika Kumthekar¹, Jessy Pius² and Vinaya Rane*Department of Botany ^{1,2}, Department of Biotechnology*, Ramnarain Ruia College, Matunga, Mumbai

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Abstract : *Mirabilis jalapa* L., the Four-o'clock plant, a perennial herb of family Nyctaginaceae is a popular ornamental plant grown worldwide for the beauty of its flowers and sweet fragrance. In this study, SDS- PAGE and randomly amplified polymorphic DNA (RAPD) technique was employed to study the relatedness among four cultivars of *M. jalapa*. Protein profile and bioinformatics revealed the presence of proteins with molecular weight nearly about 14.7kDa, 24.7kDa, 25.7kDa, 27.1kDa, 29.0kDa, 30.1kDa, 31.0kDa, 44.4 kDa, 48.5kDa and 53.1kDa from all parts of four cultivars of *M.jalapa*. Genomic DNA isolated was PCR amplified under specific conditions. The data scored from the banding patterns were analysed in UPGMA cluster analysis programme in order to estimate the similarity indices among the genotypes and develop their consensus tree relationship. Jaccard's Coefficient of Similarity showed 100 % similarity between white flower cultivar and pink flower cultivar of *M. jalapa* forming Node-1 in the dendrogram, 40 % similarity to yellow flower cultivar forming Node-2 and with multicolour flower cultivar with the similarity index of 36.1%, forming Node-3.

Key words: *Mirabilis jalapa*, Nyctaginaceae, Proteomics, RAPD

Introduction

Mirabilis jalapa L. is a popular ornamental plant of family Nyctaginaceae, commonly known as 'Four O'clock' plant or 'Sweet Marvel of Peru. It is a perennial, multibranched herb that reaches a height of 50-100 cm from a tuberous root that enables the plant to perennate through dry and cool seasons (Sutaria, 1969). The plant is grown worldwide for the beauty of its brilliantly coloured, deep-throated flowers (white, red, pink, purple, yellow, orange or multicolour) and sweet fragrance (Taylor, 2003). Since various cultivars of *M. jalapa* are known, in the present work attempts were made to study the protein profile of four different cultivars of the plant and genetic differences among these cultivars.

Materials And Methods

Collection and identification of plant materials: The leaf, flower, root and seed of four cultivars (WFC = White flower cultivar, PFC = Pink flower cultivar, YFC = Yellow flower cultivar and MFC = Multicolour flower cultivar) of *Mirabilis jalapa* were collected from Thane area, near Mumbai. Authentication of the plant was carried out from Blatter Herbarium, St. Xavier's College, Mumbai (Accession No. 2398) and was deposited in the same herbarium.

Method For SDS – Page

Extract preparation: Leaf, flower, root and seed extracts of four cultivars of *M. jalapa* were prepared by crushing 10gm of fresh material in 100ml d/w. This was filtered and the filtrate was used for the experiment.

SDS-PAGE was carried out according to the modified method of Laemmli (1970). Modification in procedure was

only in % of resolving gel (15%) and stacking gel (5%). After the electrophoretic separation, the gel was stained with Coomassie blue. R_m values of protein marker of known size were used to generate a standard curve by plotting the molecular weights against the R_m value on semi-log graph. The molecular weight of the unknown protein was then extrapolated from its R_m value, which was then used to study the expression profile of probable proteins through bioinformatics. Sequence search was carried out using Uniprot, the Universal Protein resource, a central repository of protein data through NCBI.

Method for RAPD analysis: The entire experiment was carried out using Chromous Biotech DNA isolation kit (RKT05). Genomic DNA was isolated from fresh leaf samples (100mg) of all four cultivars according to the protocol given in the RKT05 kit (Manufactures instruction). Genomic DNA was loaded on agarose gel for checking the quality and was taken for PCR amplification under the specific conditions as given in the kit using the primer; 5'-AGGACTCGATAACAGGCT-3'. 100 bp ladder with 10 DNA fragments of the following size was also used-100 bp, 200 bp, 300 bp, 400 bp, 500 bp, 600 bp, 700 bp, 800 bp, 900 bp and 1kb. The data scored from the banding pattern (Fig.1.1) were analysed in UPGMA cluster analysis programme in order to estimate the similarity indices among the genotypes and develop their consensus tree relationship.

Results and Discussion

Poly Acylramide Gel Electrophoretic separation of proteins from different parts of four cultivars of *M. jalapa* showed a difference in their protein profile Crude extracts of different parts of four cultivars of *M. jalapa* upon SDS-

PAGE separation showed protein bands in the range 14.7kDa – 53.1kDa (Table 1). Present study revealed protein close to 24.7 kDa in all parts of four cultivars of *M.jalapa*. According to Kataoka *et al.*, (1992) several proteins were found in the genus *Mirabilis*. One of them was *Mirabilis* Antiviral Protein (MAP) isolated from the root of *M. jalapa*. MAP, a type I RIP, was purified and was revealed to be lysine rich with molecular weight close to 24.2 kDa (Takanami *et al.*, 1990). MAP was shown to inhibit protein synthesis in *Eschericia coli* as well as in eukaryotes (Habuka *et al.*, 1991). A protein close to 27.1 kDa was identified from all parts whereas another protein close to 29.0kDa was found in leaf, root and seed of four cultivars of *M. jalapa* which was comparable to the protein isolated from roots of *Mirabilis expansa* that were ME1 (27.5kDa) and ME2 (27 kDa), they showed high similarity to the MAP (Vivanco *et al.*, 1999). This strongly supported the view of Vivanco *et al.*, (1999) wherein was stated that molecular weight of MAP from *M. jalapa*, ranged from 24–29 kDa. In the present study in addition to this, proteins close to M.W 30.1, 31.0, 44.4, 48.5kDa were also observed in all parts of four cultivars of *M.jalapa* while protein close to M.W 53.1kDa was observed only in leaf extracts of four cultivars of *M. jalapa*.

Plant part:	Relative mobility (R _m)	Molecular weight (kDa)
Flower	0.02,0.11,0.13,0.15, 0.16,0.23,0.26	14.7,24.7,27.1,29.0, 30.1,44.4 and 48.5
Leaf	0.02,0.11,0.12, 0.13, 0.15,0.16,0.18,0.23,0.26 and 0.35	14.7,24.7,25.7,27.1, 29.0,30.1,31,44.4,48.5 and 53.1
Root	0.02, 0.11,0.12,0.13, 0.15,0.16,0.18,0.23 and 0.26	14.7,24.7,25.7,27.1,29.0, 30.1,31,44.4 and 48.5
Seed	0.02,0.11,0.12, 0.13, 0.15,0.16,0.18,0.23 and 0.26	14.7,24.7,25.7,27.1,29.0, 30.1,31,44.4 and 48.5

Protein expression profile study carried out through Uniprot showed the following results. 14.7kDa and 27.1kDa (EXP1, EXP2, EXP3 and EXP4) proteins as different types of cell wall proteins which have a function of plant-type cell wall organization and 29.0kDa protein as a Homeobox leucine zipper protein which helps in DNA transcription. Other proteins observed were 30.1kDa protein which is a 4,5- DOPA dioxygenase extradiol protein, 24.7kDa protein as an alpha expansin EXP7 protein that helps in cell wall organisation, 25.7kDa as 1-aminocyclopropane- 1-carboxylate synthase protein that helps in catalytic reaction and pyridoxal phosphate binding activity, 31.1kDa, an antiviral protein-MAP, 53.1kDa and 48.5kDa protein as Ribulose biphosphate carboxylase large chain protein that helps in glycolysis and 44.4kDa protein as ATP synthase that helps in proton transporting and ATP synthesis activity. In the present protein study using bioinformatics revealed,

31kDa protein as Antiviral protein which was present in all parts of the plant except flower. The study also revealed the presence of 30.1kDa protein named 4,5- Dopa dioxygenase extradiol in all parts of four cultivars which was also been reported by Sasaki *et al.*, (2009) in *M.jalapa*.

RAPD scoring matrix for four different flowered cultivars of *M.jalapa* was calculated based on presence and absence of bands by using single primer. The presence of band indicated 1 value and absence of band indicated 0 value. Dendrogram was generated based on UPGMA Jaccard's Coefficient of Similarity using MVSP program. It showed one major cluster, formed of four cultivars being studied here, with variation in their similarity, as shown in Fig. 1.2. Jaccard's Coefficient of Similarity showed 100 % similarity between WFC and PFC of *M. jalapa* forming Node-1 in the dendrogram. The Node - 1 showed 40 % similarity with YFC forming Node-2 and further this node is connected to MFC with the similarity index of 36.1%, forming Node-3. As from Dendrogram it had been clearly indicated that WFC and PFC are relatively similar compared to YFC, where as MFC is distantly separated from WFC and PFC (Fig 1.2). Our results indicated the presence of genetic variability among different *M.jalapa* cultivars. Similar type of studies were carried out on various plants by many workers for the identification of cultivars in barley (Reddy and Soliman, 1997), chickpea (Banerjee *et al.*, 1999) and pea (Samec *et al.*, 1998).

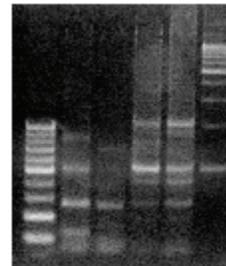


Fig. 1.1 RAPD AGAROSE GEL: (Primer). Lane description: **Lane 1: 100bp ladder, Lane 2: Sample MFC, Lane 3: Sample YFC, Lane 4: Sample PFC, Lane 5: Sample WFC, Lane 6: 500bp ladder**

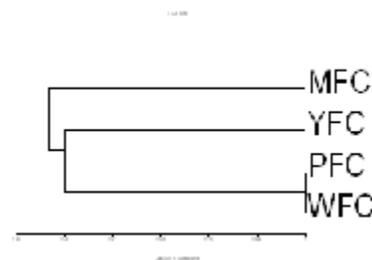


Fig.1.2 Dendrogram of four cultivars of *M.jalapa* (WFC= White flower cultivar, PFC = Pink flower cultivar, YFC = Yellow flower cultivar and MFC = Multicolour flower cultivar).

Acknowledgments

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Bioinformatics and Taxonomy Study of Ribosomal Protein L32 in *Lantana* species

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Abstract : Ribosomal proteins are vital ribonucleoprotein particles where the translation of messenger RNA (mRNA) into protein occurs. They are significant in the cytoplasm and membranes of eukaryotic and prokaryotic cells. Ribosomes are also present in all plastids and mitochondria, where they translate organelle-encoded mRNA. In recent times, bioinformatics study of ribosomal proteins has found to be important in phylogenetic relationships of different species. In the present paper, attempt has been made to study ribosomal protein L32 from twelve *Lantana* species; this may be further rationalized towards developing bioinformatics approaches for other cultivars.

Keywords: Ribosomal proteins; ribonucleoproteins; bioinformatics; taxonomy

Introduction:

Lantana camara is one of the natural biomass sources from nature. It belongs to verbenaceae family and found in tropical and subtropical region of world (Sharma and Sharma, 1989). Currently, it is common throughout India as an obnoxious weed. It contains about 150 species of perennial flowering plants. *Lantana* is a serious threat to biodiversity in several World Heritage-listed areas. It is a problem in gardens because it can cross-pollinate with weed varieties to create new, more resilient forms.

The aromatic flower clusters are mix of red, orange, yellow or blue and white florets. The flowers typically change colour as they mature. Some species are considered to be weeds. Most species need fertile organic soil while others can survive on siliceous sands. *Lantana camara* Linn contains wide array of compounds exhibiting diverse range of bioactivity (Sharma *et al.*, 2011).

Lantana also has horticultural varieties that are planted the world over as flowering ornamentals (Fig. 1). *Lantana* oil, an aromatic mixture that varies by local plant variety, is exported. In herbal medicine, infusions of the leaves and other plant parts are used as an anti-inflammatory, tonic and expectorant, and anti-rheumatic (Oyedapo *et al.*, 1999). *Lantana* extracts have also been shown to be a powerful febrifuge (Liogier, 1990). Extracts of leaves have shown strong insecticidal and antimicrobial activity. Leaves nearly eliminate damage by the potato tuber moth (Lal, 1987). Stems and leaves are used as mulch. Although of inferior quality, lantana stems are widely used as fuel (Lu-Irving and Olmstead, 2013).



Fig. 1– Different species of *Lantana*.

Studies on ribosomal proteins and ribonucleoproteins from various *Lantana* sps. and establishment of their phylogenetic relationships have gained significant momentum. Ribonucleoproteins are proteins conjugated with ribonucleic acid (RNA). They are involved in a wide range of cellular processes. Besides ribosomes, in eukaryotic cells both initial RNA transcripts in the nucleus (hnRNA) and cytoplasmic mRNAs exist as complexes with specific sets of proteins. Processing (splicing) of the former is carried out by small nuclear RNPs (snRNPs). Other examples are the signal recognition particle responsible for targeting proteins to endoplasmic reticulum and a complex involved in termination of transcription. Riboproteins are protein of the ribosome, large ribonucleoprotein particles where the translation of messenger RNA (mRNA) into protein occurs. They are both free in the cytoplasm and attached to membranes of eukaryotic and prokaryotic cells. Ribosomes are also present in all plastids and mitochondria, where they translate organelle-encoded mRNA (Söding, 2005).

In the present study, ribosomal protein L32 from 12 *Lantana* spp. namely *Lantana cujabensis*, *L. camara*, *L. micrantha*, *L. trifolia*, *L. canescens*, *L. urticoides*, *L. montevidensis*, *L. rugosa*, *L. macropoda*, *L. fucata*, *L. microcephala* and *L. viburnoides* were multiply aligned and phylogenetic relationship between them were established. This can be further rationalized towards developing bioinformatics approaches for other cultivars.

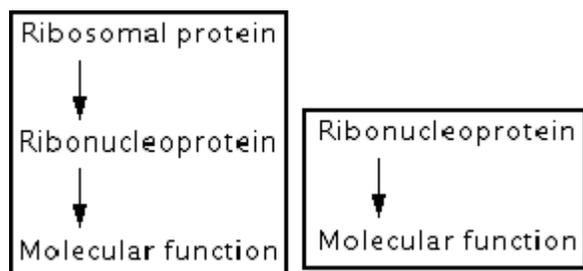


Fig. 2 - Role of ribosomal proteins and ribonucleoproteins

Materials and Methods:

The protein sequences were retrieved from UniProt Databases and compared using BLAST (Altschul *et al.*, 1990; Stutz *et al.*, 2006). The multiple alignments of the

sequences was done using Clustal W server for phylogenetic tree (Thompson *et al.*, 1994). The results were used to identify consensus and conserved amino acid residues. The output of the multiple sequence alignments were used to construct the phylogenetic trees using PhyloDraw and study relationships among the sequences (Choi *et al.*, 2000).

Results and Discussion:

The Ribosomal protein L32 proteins for all the selected species of *Lantana* viz - *Lantana cujabensis*, *L. camara*, *L. micrantha*, *L. trifolia*, *L. canescens*, *L. urticoides*, *L. montevidensis*, *L. rugosa*, *L. macropoda*, *L. fucata*, *L. microcephala* and *L. viburnoides* are coded by gene rpl32 (Table 1). The FASTA format of the sequences was retrieved from Uniprot database (Table 2). The number of identical positions between different compared sequences was found to be 49 amino acid residues which translate to 87.5% identity. The difference in molecular weight is due to different in type and number of amino acids present in the sequences (Fig. 3). To further understand the difference in these amino acid sequences, multiple alignments were performed. This helped to understand the conserved and consensus parts of the sequences (Fig. 4) and phylogenetic and principal component analysis (PCA) relationships between the sequences (Fig. 5).

Table 1. Gene and Protein sequence information

No	Entry	Entry name	Protein names	Organism	Gene names	No. of amino acids	Molecular Weight (Da)
1	K4PAY1	K4PAY1_9LAMI	Ribosomal protein L32	<i>Lantana cujabensis</i>	rpl32	54	5986
2	K4P8X8	K4P8X8_LANCA	Ribosomal protein L32	<i>Lantana camara</i>	rpl32	52	5730
3	K4PLL6	K4PLL6_9LAMI	Ribosomal protein L32	<i>Lantana micrantha</i>	rpl32	55	6083
4	K4P8Y7	K4P8Y7_9LAMI	Ribosomal protein L32	<i>Lantana trifolia</i>	rpl32	52	5730
5	K4PLL2	K4PLL2_9LAMI	Ribosomal protein L32	<i>Lantana canescens</i>	rpl32	55	6083
6	K4PBA2	K4PBA2_9LAMI	Ribosomal protein L32	<i>Lantana urticoides</i>	rpl32	52	5730
7	K4P8Q7	K4P8Q7_9LAMI	Ribosomal protein L32	<i>Lantana montevidensis</i>	rpl32	49	5385
8	K4PBA7	K4PBA7_9LAMI	Ribosomal protein L32	<i>Lantana rugosa</i>	rpl32	56	6182
9	K4P8Y3	K4P8Y3_9LAMI	Ribosomal protein L32	<i>Lantana macropoda</i>	rpl32	52	5730
10	K4P8Q0	K4P8Q0_9LAMI	Ribosomal protein L32	<i>Lantana fucata</i>	rpl32	56	6182
11	K4PAY7	K4PAY7_9LAMI	Ribosomal protein L32	<i>Lantana microcephala</i>	rpl32	53	5858
12	K4PLM0	K4PLM0_9LAMI	Ribosomal protein L32	<i>Lantana viburnoides</i>	rpl32	53	5858

Table 2. Query protein sequences of various *Lantana* species in FASTA format

```

tr|K4PAY1|K4PAY1_9LAMI Ribosomal protein L32 (Fragment) OS=Lantana cujabensis GN=rpl32 PE=4 SV=1
KKRRTSASKKRIRKNFWKGGGSRAALKAVSLGKSLSTGNSKSFVVRKRSKKSNT
>tr|K4P8X8|K4P8X8_LANCA Ribosomal protein L32 (Fragment) OS=Lantana camara
GN=rpl32 PE=4 SV=1
RTSASKKRIRKNFWKGGGSRAALKAVSLGKSLSTGNSKSFVVRKRSKKSNT
>tr|K4PLL6|K4PLL6_9LAMI Ribosomal protein L32 (Fragment) OS=Lantana micrantha GN=rpl32 PE=4 SV=1
PKKRTSASKKRIRKNFWKGGGSRAALKAVSLGKSLSTGNSKSFVVRKRSKKSNT
>tr|K4P8Y7|K4P8Y7_9LAMI Ribosomal protein L32 (Fragment) OS=Lantana trifolia GN=rpl32 PE=4 SV=1
RTSASKKRIRKNFWKGGGSRAALKAVSLGKSLSTGNSKSFVVRKRSKKSNT
>tr|K4PLL2|K4PLL2_9LAMI Ribosomal protein L32 (Fragment) OS=Lantana canescens GN=rpl32 PE=4 SV=1
PKKRTSASKKRIRKNFWKGGGSRAALKAVSLGKSLSTGNSKSFVVRKRSKKSNT
>tr|K4PBA2|K4PBA2_9LAMI Ribosomal protein L32 (Fragment) OS=Lantana urticoides GN=rpl32 PE=4 SV=1
RTSASKKRIRKNFWKGGGSRAALKAVSLGKSLSTGNSKSFVVRKRSKKSNT
>tr|K4P8Q7|K4P8Q7_9LAMI Ribosomal protein L32 (Fragment) OS=Lantana montevidensis GN=rpl32 PE=4 SV=1
ASKKRIRKNFWKGGGSRAALKAVSLGKSLSTGNSKSFVVRKRSKKSNT
>tr|K4PBA7|K4PBA7_9LAMI Ribosomal protein L32 (Fragment) OS=Lantana rugosa
GN=rpl32 PE=4 SV=1
VPPKRTSASKKRIRKNFWKGGGSRAALKAVSLGKSLSTGNSKSFVVRKRSKKSNT
>tr|K4P8Y3|K4P8Y3_9LAMI Ribosomal protein L32 (Fragment) OS=Lantana macropoda GN=rpl32 PE=4 SV=1
RTSASKKRIRKNFWKGGGSRAALKAVSLGKSLSTGNSKSFVVRKRSKKSNT
>tr|K4P8Q0|K4P8Q0_9LAMI Ribosomal protein L32 (Fragment) OS=Lantana fucata
GN=rpl32 PE=4 SV=1
VPPKRTSASKKRIRKNFWKGGGSRAALKAVSLGKSLSTGNSKSFVVRKRSKKSNT
>tr|K4PAY7|K4PAY7_9LAMI Ribosomal protein L32 (Fragment) OS=Lantana microcephala GN=rpl32 PE=4 SV=1
KRTSASKKRIRKNFWKGGGSRAALKAVSLGKSLSTGNSKSFVVRKRSKKSNT
>tr|K4PLM0|K4PLM0_9LAMI Ribosomal protein L32 (Fragment) OS=Lantana viburnoides GN=rpl32 PE=4 SV=1
KRTSASKKRIRKNFWKGGGSRAALKAVSLGKSLSTGNSKSFVVRKRSKKSNT

```

Table 2. Query protein sequences of various *Lantana* species in FASTA format

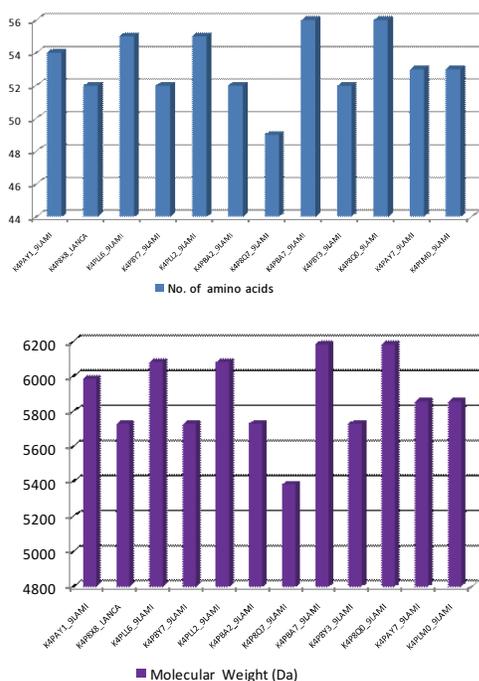


Fig. 3 Number of amino acids and molecular weight comparisons of the sequences

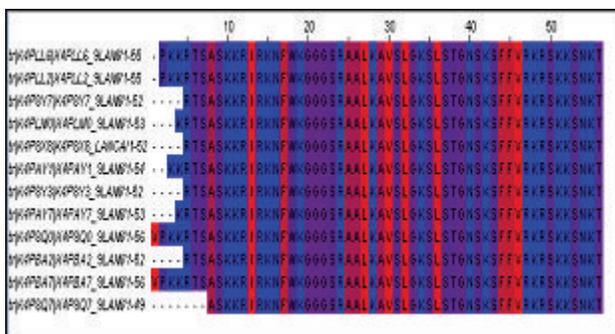


Fig. 4 Multiple sequence alignment of the sequences showing the conserved and consensus parts.

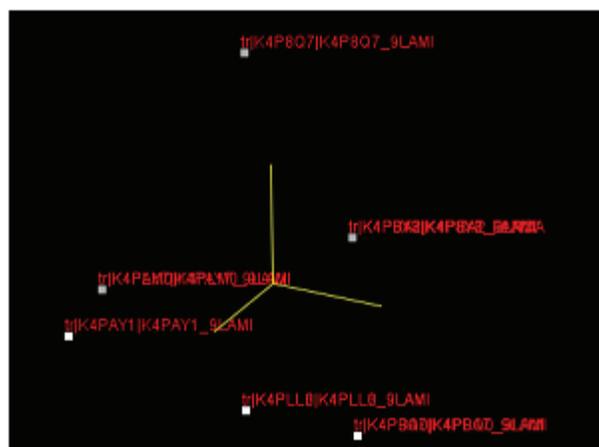
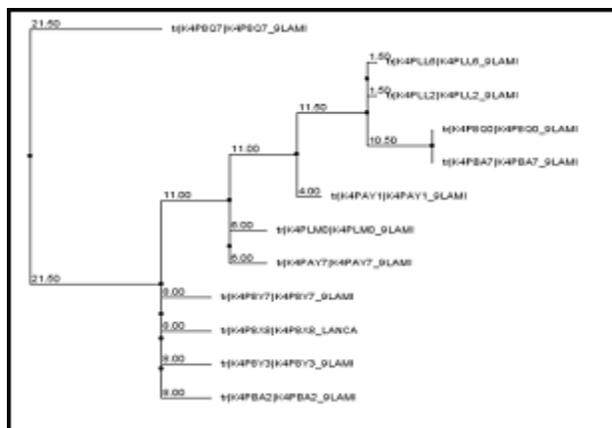
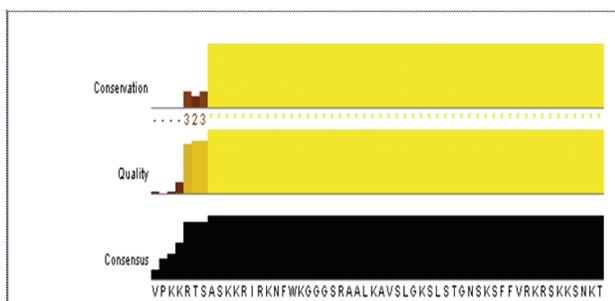


Fig. 5 Phylogenetic relationships between sequences by Neighbour Joining by Blosum62 and PCA analysis.

Conclusion:

Taxonomical studies of important ribosomal proteins L32 of twelve different *Lantana* species were performed. This knowledge may be helpful for establishment of phylogenetic relationship by using PhyloDraw which shall play important role in future taxonomic studies of plant species. These taxonomic approaches may be further rationalized towards developing bioinformatics approaches for other cultivars.

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Research Article

E-Herbarium: An ASP.NET Web Application in the Study of Plant Specimens enabling Plant Identification

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Abstract : A herbarium is a museum of preserved plants that are used for botanical research. On the same lines, but slightly different, an e-herbarium behaves as an online herbarium available to the users across the world. It works as a website which gives a similar or more helpful approach towards study of plant specimens. An e-herbarium is an effective web application in the study of plant specimens enabling plant identification as well as user and administrator involvement in data collection and management. The goal behind our e-herbarium project is to provide mainly, instant access, no damage to specimens, increased user interaction as numerous persons can work on same specimen simultaneously, and convenient access to information on descriptive details, geographical distribution, photographs, illustrations, manuscripts, published work, microscopic preparations, gene sequences and nomenclature through hyperlinks. Additionally several e-herbaria can be searched simultaneously. The present paper talks about e-herbarium developed for Department of Botany, B. N. Bandodkar College of Science using ASP.NET technology meant for producing dynamic web pages. The paper describes reasons to develop e-herbarium, working of e-herbarium, comparison with virtual herbarium, along with a discussion on developing a web application project using ASP.NET with C#.

Key words: Herbarium, plant identification, web application, asp.net with c#

Introduction

Botanical studies of a local region not only are of a didactic value, but they are also the source of information for pupils on diversity of nature and a necessity for protection of the region they live in. Different methods of collecting, preparation and preservation of plant collections are very important for botanical field studies. Processed and labeled plants are stored in herbaria in which they are conserved and then used for taxonomic, floristic and phytogeographical studies, and then as the evidence and display material (Tomoviã *et al.*, 2001).

A herbarium is a collection of preserved plants stored, catalogued, and arranged systematically for study by professionals and amateurs from many walks of life. Such collection is a vital reference when you need to identify a plant and also serves to fix forever the identity of thousands of plant names. A herbarium acts as a source of information about plants - where they are found, what chemicals they have in them, when they flower, what they look like. Preserved plant specimens can be used to provide samples of DNA and to validate scientific observations. A herbarium is therefore of immense practical use and of fundamental importance to science. Individual plants or parts of plants, are preserved in various ways, stored and cared for over time so that current and future generations can identify plants, study biodiversity and use the collection in support of conservation, ecology and sustainable development. The curator of a herbarium is responsible for its long-term care, maintenance and development.

Herbaria across the globe provide a permanent record of the diversity of the Earth's flora. Herbarium plays an important role in the study of medicinal plants, study of botany, research and development of economically important plants, conservation of environment and ecology, and conservation of biodiversity.

E-herbarium

For making available all such detail information regarding plants electronically we had developed a website known as "e-herbarium" which provides an ease to cope well with lots of plants in a pleasant manner and having a user friendly interface with amazing photos and details such as plant classification, plant general characteristics, with other botany information. We can search plants in various ways such as standard search, detail search, search by name, search by voice, search by image, and also we can identify plants by answering different questions about the plants. The website offers lots of information similar to an encyclopedia. We can look for description of difficult scientific terms. It also provides administrative interface for managing the plant database. A user can contribute useful botany information to the system which is accepted only by administrator's approvals. The aim of our project is similar to develop a functional database that can be rapidly updated and that provides information for research, management and botanical species identification.

E-herbarium is established to increase the longevity of specimens. International loan programs enable a researcher to request specimens to be shipped in for study. This shipping contributes to the wear and tear of specimens.

If, however, digital images are available, images of the specimens can be sent electronically. These images may be a sufficient substitute for the specimens themselves, or alternatively, the researcher can use the images to “preview” the specimens, to which ones should be sent out for further study. This process cuts down on the shipping, and thus the wear and tear of the specimens, as well as the wait times associated with shipping. E-herbarium can also be used to increase public awareness of herbaria. Digital images of specimens can be added to the database to allow the public to further engage with the material.

E-herbarium project provides mainly, instant access, no damage to specimens, increased user interaction as numerous persons can work on same specimen simultaneously, and convenient access to information on descriptive details, geographical distribution, photographs, illustrations, manuscripts, published work, microscopic preparations, gene sequences and nomenclature through hyperlinks. Additionally several e-herbaria can be searched simultaneously.

Virtual Herbarium

In botany, a virtual herbarium is a herbarium in a digitized form. That is, it concerns a collection of digital images of preserved plants or plant parts. It is a text and photographic database of the specimens. Although our e-herbarium project is identical to a virtual herbarium, but is not limited to any specific herbarium and contains more features and functionality compared to it.

Materials and Methods

In software engineering, a Software Development Life Cycle is a division of software development work into distinct phases (or stages) containing activities with the intent of better planning and management. There are following six phases in every Software development life cycle model:

1. Requirement gathering and analysis
2. Design
3. Implementation or coding
4. Testing
5. Deployment
6. Maintenance

For development of the project we had followed all the phases of the SDLC and used some of the software tools which are explained as follows:

Software Tools for Project Development

For developing this website we had used Visual Studio 2008 as an IDE (Integrated Development Environment) tool, C# programming language with ASP.NET Framework for front end designing and Microsoft SQL Server 2005 Express Edition as a backend tool. C# is a multi-paradigm programming language encompassing strong typing, imperative, declarative, functional, generic, object-oriented (class-based), and component-oriented programming disciplines. ASP.NET is an open source server-side Web application framework designed for Web development to produce dynamic web pages. It was developed by Microsoft to allow programmers to build dynamic web sites, web applications and web services. By using C# with ASP.NET we can create dynamic web pages and handle databases efficiently with the implementation of object oriented programming principle.

Software Tools for Project

Deployment

After we had created the ASP.NET Web application project which is e-herbarium in Visual Studio, we deploy the project to a Web server where others can access the application. Deployment typically involves more than just copying the application’s files from one server to another. We might also have to perform additional tasks, such as the following:

Changing Web.config file settings that must be different in the destination environment, such as settings for debugging, or database connection strings.

Propagating data or data structures in databases that are used by the Web application.

Configuring IIS settings on the destination computer, such as the application pool, the authentication method, whether directory browsing is allowed, and error handling.

Installing security certificates.

Setting values in the registry of the destination computer.

Installing application assemblies in the global assembly cache (GAC) on the destination computer.

An extension to Microsoft Internet Information Services (IIS) that is named Web Deploy can automate most deployment tasks. Visual Studio provides tools that work with Web Deploy to make it easier to deploy a Web application project.

Working of The Web Application

In this website for consistent page layout we had used the concept of Master Page and Content Pages with

the means of ContentPlaceHolder Control. We had used different types of Stylesheets i.e. internal, external and inline for implementing different styles in the website. We had implemented the concept of programming redirection with the means of Query string. Even with this we had validated user input by using different validation controls such as RequiredFieldValidator, CompareFieldValidator, Validation Summary etc. With this we also had implemented the concept of Ajax for generating flicker free web pages. By using jQuery library we simplified the way to access the elements in the web pages, provide help in working with client-side events, enable visual effects like animations, and make it easier to use Ajax in the applications. For connecting the database to the frontend we had used ADO.NET entity framework with ASP.NET GridView and Repeater control. For providing security to the site's data we had provided authentication to the user by implementing ASP.NET Login controls. In this website users have also the facility to make the contribution to the website by providing additional information about the plant. In this website only the administrator has the right to update the plant's existing information or to add or remove any plant from the database.

Results and Discussions

We succeeded in developing the e-herbarium which is a flexible, dynamic, robust web application as a result of using ASP.NET a server-side Web application framework designed for Web development to produce dynamic Web pages with following advantages:

Web application exists in compiled form on the server so the execution speed is faster as compared to the interpreted scripts.

ASP.NET makes development simpler and easier to maintain with an event-driven, server-side programming model.

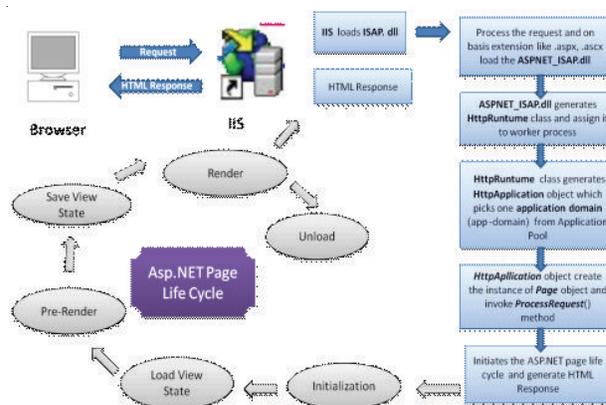
Being part of Framework, it has access to all the features of .Net Framework.

Content and program logic are separated which reduces the inconveniences of program maintenance.

ASP.NET makes for easy deployment. There is no need to register components because the configuration information is built-in.

Introduction of view state helps in maintaining state of the controls automatically between the post back events.

ASP.NET offers built-in security features through windows authentication or other authentication methods.



Execution of An Asp.net Web Page

ASP.Net Page Life Cycle:

When a page is requested, it is loaded into the server memory, processed and sent to the browser. Then it is unloaded from the memory. At each of these steps, methods and events are available, which could be overridden according to the need of the application. In other words, you can write your own code to override the default code.

The Page class creates a hierarchical tree of all the controls on the page. All the components on the page, except the directives are part of this control tree. You can see the control tree by adding trace="true" to the Page directive. We will cover page directives and tracing under 'directives' and 'error handling'.

The page life cycle phases are:

Initialization

Instantiation of the controls on the page

Restoration and maintenance of the state

Execution of the event handler codes

Page rendering

Understanding the page cycle helps in writing codes for making some specific thing happen at any stage of the page life cycle. It also helps in writing custom controls and initializing them at right time, populate their properties with view-state data and run control behavior code.

Following are the different stages of an ASP.Net page:

Page request, when ASP.Net gets a page request, it decides whether to parse and compile the page or there would be a cached version of the page; accordingly the response is sent

Starting of page life cycle, at this stage, the Request and Response objects are set. If the request is an old request or

post back, the `IsPostBack` property of the page is set to true. The `UICulture` property of the page is also set.

Page initialization, at this stage, the controls on the page are assigned unique ID by setting the `UniqueID` property and themes are applied. For a new request postback data is loaded and the control properties are restored to the view-state values.

Page load, at this stage, control properties are set using the view state and control state values.

Validation, `Validate` method of the validation control is called and if it runs successfully, the `IsValid` property of the page is set to true.

Post Back Event Handling, If The Request Is A Post Back (Old Request), The Related Event Handler Is Called.

Page Rendering, At This Stage, View State For The Page And All Controls Are Saved. The Page Calls The `Render` Method For Each Control And The Output Of Rendering Is Written To The `Outputstream` Class Of The Page's `Response` Property.

Unload, The Rendered Page Is Sent To The Client And Page Properties, Such As `Response` And `Request` Are Unloaded And All Cleanup Done.

Conclusions

An E-Herbarium Behaves As An Online Herbarium Available To The Users Across The World. It Works As A Website Which Gives A Similar Or More Helpful Approach Towards Study Of Plant Specimens.

E-Herbarium Can Also Be Used To Increase Public Awareness Of Herbaria. Digital Images Of Specimens Can Be Added To The Database To Allow The Public To Further

Engage With The Material.

Digital Images May Be A Sufficient Substitute For The Specimens Themselves, Or Alternatively, The Researcher Can Use The Images To "Preview" The Specimens, To Which Ones Should Be Sent Out For Further Study. This Process Cuts Down On The Shipping, And Thus The Wear And Tear Of The Specimens, As Well As The Wait Times Associated With Shipping.

ASP.NET Is A Server-Side Web Application Framework Designed For Web Development To Produce Dynamic Web Pages.

Future Scope

To improve the image recognition algorithm which lets a user to upload an image on the website and the system will process that image and will match it with reference images in the database and sort the search results according to the images matched.

To enhance speech to text feature for increasing the accuracy of understanding voice of the user in the system.

To enrich database with as more information as possible.

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<http://apps.kew.org/herbcat/navigator.do>

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Research Article

A User Interface in e-herbarium for Automated Botanical Species Identification through image and voice based search

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Abstract : The present paper describes a Web application user interface for automated identification of botanical species in the field using search by image and search by voice features, developed for Department of Botany, B. N. Bandodkar College of Science e-herbarium project. Text based and voice based search are developed using ASP.NET framework built in libraries. In image based search, images are captured with a digital camera, smart phone or any other device and uploaded to the website. A computer vision component developed finds the best set of matching species, and we present the results in a user interface with zooming capabilities. Samples are matched with existing species or marked unknown for further study. A history of collected, samples along with collection context can be browsed for further study and comparison. The system has been designed for a field study or botanical research in the study of plant specimens. The present paper describes the implementation of algorithms and methodologies in the application in order to work properly and efficiently.

Key words: e-herbarium, botanical species identification, image and voice based search, asp.net with C#.

Introduction

As biodiversity and ecological research become more crucial, better tools for botanists must be developed. Of particular importance is the need to identify specimens in the field and associate them with an existing species or potential new species. In this process, data must also be collected for review and comparison. We are working together to develop a Web application user interface that support vision-based automated species identification. The goal of this overarching project is to radically change current practice, in which botanists use paper field guides and their own personal knowledge

to identify species. To confirm the identification, they must then compare the sample with a canonical specimen of the species, called a *voucher*. Vouchers are stored in academic or institutional herbaria and require travel to the herbaria or shipment of the vouchers to the remote locale for verification. For each identification task, this process is time consuming and requires the movement of unique and fragile voucher specimens, which may be lost or destroyed during transfer. Thus, botanical research is constrained by the identification task in the field and availability and access to botanical data.

A work published before, in which an ethnographic study (White *et al.*, 2006.) is performed as part of the design of several prototype augmented reality user interfaces to species identification. They introduced the term *virtual voucher* to describe a digital representation of the botanical reference specimen in conjunction with its contextual and characteristic data. This data includes additional imagery of

the whole plant and root systems, location and date of acquisition, name of the collector and of the identifier, regional information, articles about the specimen, and links to related specimens. The term more generally describes a holistic virtual representation of an object in the physical world.

Here we present a new Web application user interface prototype, (Figure 1).



Figure 1: Web application user interface prototype, showing the sorted results from automated species identification. Each leaf represents a virtual voucher.

Prior research has used mobile devices for recording data in field work, such as the PDA-based FieldNote (Ryan and Pascoe, 1999) system. More recently, ButterflyNet (Yeh *et al.*, 2006) has relied on a paper notebook with an Anoto digital pen, in conjunction with a small computer and camera to capture time stamped and barcoded images of specimens, thereby associating field notes with collected specimens. In contrast, our contribution is the development of a web user interface to an automated species identification system that combines collection and identification.

Materials and Methods

In software engineering, a Software Development Life Cycle is a division of software development work into distinct phases (or stages) containing activities with the intent of better planning and management. There are following six phases in every Software development life cycle model:

1. Requirement gathering and analysis
2. Design
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Get Started with Speech Recognition

A speech recognition application will typically perform the following basic operations [4]:

1. Initialize the speech recognizer.
2. Create a speech recognition grammar.
3. Load the grammar into the speech recognizer.
4. Register for speech recognition event notification.
5. Create a handler for the speech recognition event.

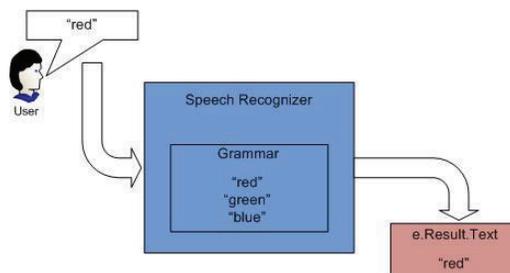


Image Matching Algorithm

The algorithm uses bitmap class and other built in library functions to compare images from the database. Bitmap class in dot net framework encapsulates a GDI+ bitmap, which consists of the pixel data for a graphics image and its attributes. A Bitmap is an object used to work with images defined by pixel data. It has various constructors, properties and methods which helped us in developing the algorithm.

Results and Discussions

We succeeded in developing the User Interface in e-herbarium for Automated Botanical Species Identification which is a flexible, dynamic, robust web application as a result of using ASP.NET a server-side Web application framework designed for Web development to produce dynamic Web pages.

Conclusions and Future Work

We have successfully developed the interface for automated species identification in the field and we are currently improving the design. As testing for the project carried out, we came across some more improvements in the performance of the algorithm, and we will be improving the prototype with further field tests and to explore integration with ecological data.

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Section 3 :
Short Communications

Nursery Development

Compiled by Gazali Faiza Ismail

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Introduction

A nursery is a place where plants are cultivated, propagated and grown to usable size. The nursery can grow plants in open fields, in containers or in greenhouses. Nurseries comprise retail nurseries which sell to the general public, wholesale nurseries which sell only to businesses such as other nurseries and commercial gardeners, and private nurseries which supply the needs of institutions, private estates and clients. Nurseries can also be classified into 3 other types viz.

Volunteer nurseries wherein saplings are grown by volunteers

Educational nurseries are run in educational institutes where saplings are tended by students

Corporate nurseries are established in companies where saplings are grown within the premises.

Methods of Propagation

Plants may be raised from seeds or by vegetative methods of propagation. The important aspects of propagation are summarized below.

1. Raising plants from seeds.
2. Usage of vegetative propagation techniques such as cutting, budding, division and separation, grafting and layering.
3. Employment of tissue culture techniques.

Germination

Germination may be defined as the activation of dormant embryo, so as to initiate growth with the result that the embryo comes out of seeds in the form of a seedling.

The important conditions for fulfilling the germination of seeds are that the seed must be viable i.e. the embryo within must be alive and capable of germination; the internal conditions within the seed must be favourable for germination; and the seed must be subjected to appropriate environmental conditions with availability of water, temperature, oxygen and sometimes light in the required proportions.

The 3 types of germinations in plants are (1) Epigeal (2) Hypogeal and (3) Viviparous germination.

Nursery Techniques

Establishment: Nursery is developed gradually. The mother plants and seed propagated plants such as seasonal flower seedlings are raised for sale simultaneously. Important factors considered for establishing a nursery are agro-climatic conditions, soil types, soil pH, location, area, irrigation facilities, communication, market demand, availability of germplasm or mother plants, availability of expertise and skilled labour, etc.

Selection of site: The site selected for raising a nursery should preferably be located near marketing centres for the convenience of transportation of products with minimum damage.

Product choice: The product choice will primarily depend on the market demand in nearby areas. Varieties of various ornamental plants like shade loving foliage plants, flowering plants, creepers, plants suitable for parks, gardens and roadside plantations, offices, business houses, hospitals, residential buildings etc. may be propagated in the nursery. Planting materials such as seedlings of flowers, bulbs, corms, etc. may also be produced.

SOME POPULAR PLANT GROUPS FOR NURSERIES: Foliage and flowering plants, bulbous plants, ferns, cycads, palms, climbers, shrubs, trees, cacti and succulents are some of the popular plants raised in nurseries.

Management of Nursery

Collection and planting of mother plants: The plantation of mother plants is important in developing a nursery. The mother plants must be true to the type and variety. The plants should be appropriately labelled. Collection of exotic types is a continuous process.

Storage of soil and manure: Soil and compost/ manure must be stored in proper conditions during the dry months, for availability throughout the year.

Storage of propagated plants in nursery beds: The propagated plants are subjected to hardening in nursery beds. In general nursery beds are prepared under partial shade.

Manuring: Vigorous growth of plants with attractive foliage and flowers attracts buyers. Heavy manuring is not beneficial for storage of plants.

Watering: This has to be done according to needs of the plant. The nursery should have a water source of its own. Media of growth are also considered before watering.

Drainage: For good growth of plants, a good drainage system is essential. It is extremely important to ensure that water logging does not occur in and around the pots and beds.

Plant protection: Keen observation on attacks by different pests and diseases is required. Preventive measures are better and the necessary control measures should be taken immediately on observation.

Production of seeds: Production of seeds is a highly specialized job. The seeds should be produced with care. Quality of seeds determines the percentage of seed germination, vigour, vegetative and reproductive growth of the crop.

Harvesting: The seeds, bulbs, etc. need to be harvested at the proper stage. Only completely ripe seeds are ready for harvesting. Corms and bulbs are generally harvested when the leaves start yellowing or when they dry up. These are dug out carefully without imparting injury.

Storage: Seeds are stored in a cool, dry place or kept in desiccator. Living plants should be kept in shade. Bulbs, corms and tubers are stored in single layer over dry sand, flat wooden trays or racks in a well-aerated store room with low temperature and low humidity. Before storing, they may be treated with fungicides and insecticides.

Marketing: Marketing of plants and planting materials is a crucial part of the nursery business. The production of high quality bright and colourful, vigorous, true to the type and attractive plants and planting materials, free from pests and diseases is absolutely necessary.

Export: Export potential of nursery products is very high. Seeds, bulbs, tubers, cactii, flowering and foliage plants, unrooted cuttings and cut flowers are exported from India to many countries.

People who will not sustain trees will soon live in a world which cannot sustain people.

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Techniques of Herbarium

Compiled by: Shaikh Kashfiya Iqbal Ahmed

Department of Botany, B.N.Bandodkar College of Science, Chendani, Thane (W), Maharashtra

Introduction

The term “Herbarium” refers to a collection of pressed and dried plants that are kept as a botanical record. It is the basic reference source or ‘data bank’ for plant taxonomists, who are the professionals involved in classification, description and naming of plants. Herbaria not only contain vascular plants but also mosses, liverworts, algae and fungi.

Specimen Preservation

To preserve their form and colour, plants collected in the field are spread flat on sheets of newsprint and dried, usually in a plant press, between blotters or absorbent paper. The specimens, which are then mounted on sheets of stiff white paper, are labelled with all essential data, such as name, family, date and place found, brief description of the plant, altitude, special habitat conditions and name of collector. The sheet is then placed in a protective case. As a precaution against insect attack, the pressed plant is frozen or poisoned, and the case disinfected.

Collection Management

Most herbaria utilize a standard system of organizing their specimens into herbarium cases. Specimen sheets are stacked in groups by the species to which they belong and placed into a large lightweight folder that is labelled on the bottom edge. Groups of species folders are then placed together into larger, heavier folders by genus. The genus folders are then sorted by taxonomic family according to the standard system selected for use by the herbarium and placed into pigeonholes in herbarium cabinets.

Uses Of Herbarium

Herbarium has the following uses:

Herbaria are essential for the study of plant taxonomy, the study of geographic distributions, and the stabilizing of nomenclature.

Specimens housed in herbaria may be used to catalogue or identify the flora of an area.

Herbaria also preserve an historical record of change in vegetation over time.

They provide the comparative material that is essential for studies in taxonomy, systematics, ecology, anatomy, morphology, conservation biology, biodiversity, ethnobotany, and palaeo biology, as well as being used for teaching and by the public.

Basic Functions and Research

Basic functions of herbarium are as follows:

Discover or confirm the identity of a plant or determine that it is new to science (taxonomy); provide material for DNA analysis, house vouchers for photographs that can be used in lectures, web sites, and publications, provide information on rare or extinct species that can no longer be found in nature, allow for the documentation of flowering and fruiting times and juvenile forms of plants .

Education and Training

Herbarium has following applications:

Provide material for teaching (botany, taxonomy, field botany, plant communities; ethnobotany; agriculture; dendrology, forestry)

Promote appreciation of botanical diversity by making specimens available for viewing by students, researchers, and the public.

Provide internship and job opportunities for undergraduate and graduate students

Provide opportunities for students and young scientists to meet established scientists

Expose students to systematic research

Train local volunteers for specimen handling, scanning etc

Run educational courses for the public

References

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Molecular and Bioinformatics Techniques in Taxonomy

Compiled by Priyanka Jadhav

Department of Botany, B.N.Bandodkar College of Science, Chendani, Thane (W), Maharashtra

Introduction

Over the past few decades major advances have been made in the field of molecular biology. These, coupled with advances in genomic technologies have led to an explosive growth in the biological information generated by researchers. The different kinds of structural analysis has led to the formation of several databases. Molecular biology has expanded in several different but strongly related working fields viz., Genomics, Transcriptomics and Proteomics.

Genomics

By large scale-DNA sequence analysis, the mapping of genes of humans, animals, plants and microorganisms is done, which is known as Genomics. The large scale research on the function of genes as well as the manner in which hereditary compounds are stored in these genes is being translated into the functioning of the cell and the whole organism. Genomics is a set of technologies which have become indispensable in modern research.

Transcriptomics

Transcriptomics is the structural analysis of accumulated transcripts in a cell or tissue. Most research methods are setup to determine differences in expression between two cell cultures, such as an infected potato and a healthy potato. The genes that have a different expression in the two cultures can give more information about the defence of the potato plant.

Proteomics

Proteomics can be defined as the qualitative and quantitative comparison of proteomes under different conditions to further unravel biological processes. A new fundamental concept called proteome {PROTE in complement to a genOME} has recently emerged that should drastically help to unravel biochemical and physiological mechanisms of complex multivariate diseases at the functional molecular level.

Bioinformatics

Bioinformatics is the application of computer technology to the management and analysis of biological data. Bioinformatics is the study of biological data using information tools. The main task of bioinformatics is to

manage and analyse the biological data. Drug designing by the use of bioinformatics tools and software is on the rise. Bioinformatics helps in studying medicinal plants with the help of proteomics, genomics, transcriptomics and helps in improving the quality of traditional medicinal material.

Applications Of Bioinformatics

Processing raw information obtained from bench work done by researchers.

Tradition of genes using computer programmes like GENEMARK for prokaryotes and GENESCAN for eukaryotes.

Predicting protein sequence using computer programmes.

Identifying regulatory sequences such as enhancers and UAS using computer programmes.

Deriving phylogenetic relationships amongst different organisms.

Taxonomy

Taxonomic designations increasingly rely on similarities in deoxyribonucleic acid {DNA} sequences. As DNA mutates at a known rate, the more alike the DNA sequence are for two types of organisms, the more recently they diverged from a shared ancestor. By considering such data on pairs of species, biologists can construct evolutionary tree diagrams that depict how existing organisms are related to one another. In this way, taxonomy in the modern sense reflects evolution.

Nucleotide

The nucleotide database is a collection of sequences from several sources, including Genbank, Refseq, TPA and PDB {Protein Data Bank}. Genome, gene and transcript sequence data provide the foundation for biomedical research and discovery.

Batch Entrez

We can use Batch Entrez to upload a file of GLS (Genetic Local Search) or accession numbers from the nucleotide or protein databases, or upload a list of record identifiers from other Entrez databases. Batch Entrez will check for duplicate identifiers when reporting results from a list that you have imported. When retrieving a list of

nucleotide accessions, you must select the specific component database from which the accessions or GLS were saved. For nucleotide , choose either the core nucleotide , the EST{Expressed Sequence Tag] or the GSS(Genome Survey Sequences) selection from the database menu.

If you have a mixed list of nucleotide accessions or UIDS (User Interface Design System) , you will need to run the Batch Entrez search three times. Select the database from the pull-down menu , core nucleotide , EST and GSS separately. In all cases , be certain to select the correct database for uploaded identifiers when using Batch Entrez , to ensure the expected records. e.g. if you have saved a list of protein GLS , be sure to select the protien database.

- i. Create a file with a list of GL or accession numbers and save it locally.
- ii. Select the database from which the list of accessions or

UIDs originated.

- iii. Use the Browse button to select the filename containing the list of UIDs from your system directory.
- iv. Press the Retrieve button and you will see a list of document summaries.
- v. Select a format in which to display the data for viewing, and/or saving.
- vi. Select Send to File to save the file.

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We are thankful to



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Section 4 :
Reports
Pre - Conference Workshops

NATIONAL CONFERENCE ON
NEW AND EMERGING TRENDS IN BIOINFORMATICS AND TAXONOMY NETBT 2015
FIRST PRE-CONFERENCE PREPARATORY WORKSHOP

TUESDAY 12TH AUGUST 2014

PATANJALI SABHAGRUHA

B.N.BANDODKAR COLLEGE OF SCIENCE

PROGRAMME

SPEAKER	TOPIC	TIME
Inaugural Session		
National Anthem		
Dr.(Mrs.) MK Pejaver	Convener's Inaugural Address	3.00 PM
Dr. R.P Athlaye	Scientific meets organized at B.N. Bandodkar College	3.10 PM
Dr. Moses Kolet	Organizing Secretary's Address	3.15 PM
Scientific Technical Session		
Dr. Moses Kolet, Associate Professor, Dept. of Botany, B.N.Bandodkar College of Science.	The Legacy of Scientific Nomenclature	3.20 PM
Dr. (Mrs) Unnati Padalia, Associate Professor, Dept. of Microbiology, K.J.Somaiya College, Mumbai.	Taxonomic Systems in Microbiology	3.35 PM
Dr. (Mrs.) Sunita Chahar Head, Department of Botany, Ratnam College, Mumbai.	Taxonomy of Arbuscular Mycorrhizal Fungi	4.15 PM
Dr.(Ms.) Urmila Kumavat Asst. Professor, Dept. of Botany, B.N.Bandodkar College of Science.	Chemotaxonomy of Plants	4.55 PM
Presentations by Students		
Ms. Priyanka Jadhav T.Y.B.Sc. Botany	Molecular and Bioinformatics Techniques in Taxonomy	5.20 PM
Ms. Shraddha Thosar T.Y.B.Sc. Botany	The Ashoka: An Historical Account	5.30 PM
Ms. Farheen Bagdadi F.Y B.Sc.(CBZ)	Dispersal of Spores in Fungal organisms	5.40 PM
Valedictory Session		
Ms. Chetna Shetty	Vote of Thanks	5.50 PM
National Song		
Students Interaction with Invited Guests and Speakers		5.55 PM

REPORT

FIRST PRE-CONFERENCE PREPARATORY WORKSHOP

NEW AND EMERGING TRENDS IN BIOINFORMATICS AND TAXONOMY NETBT 2015

I have immense pleasure in presenting the report of the first pre-conference workshop of the National Conference on New and Emerging Trends in Bioinformatics and Taxonomy NETBT 2015. The workshop was conducted on Tuesday 12th August 2014 in Patanjali Sabhagruha in B.N.Bandodkar College of Science. This was the first amongst the two pre-conference workshops preceding the National Conference NETBT 2015 which is scheduled to be held on 14th and 15th of January 2015 in Thorale Bajirao Peshwe Sabhagruha on V.P.M.'s Jnanadweepa, Thane College Campus. The pre-conference workshop was attended by over 150 students and members of the staff, from Degree and Junior college, scientists as well as non-teaching members of faculty from our own as well as various colleges and institutions in the vicinity, all of whom actively participated in the proceedings and added vibrant colours to the event.

The workshop started with the inaugural session, preceded by the national anthem. The Convener, Dr. (Mrs.) Madhuri Pejaver welcomed all participants in the inaugural address. Vice-Principal Dr. R.P Athalye briefed the gathering on the legacy of Bandodkar College of Science in successfully organizing university, state and national level scientific events and meets. The Organizing Secretary, Dr. Moses Kolet drew attention to the necessity of pre-conference workshops, their potential importance and value to student learners as perceived by Vidya Prasarak Mandal, Thane; in his address, which merged into the scientific technical session wherein the legacy of scientific nomenclature, the core theme of the National Conference was discussed in brief.

The first invited guest speaker, Dr (Mrs.) Unnati Padalia, Associate Professor of Microbiology, K.J Somaiya College, Mumbai, an ardent researcher, research guide, mentor and a very popular teacher, enthralled the august gathering with her talk and presentation on various systems of nomenclature followed in microbiology and recent technological and allied developments in the domain. The talk touched upon knowledge explosion in current times and coping skills of the young generation.

The next guest speaker, Dr (Mrs.) Sunita Chahar, Head of the Department of Botany, Ratnam College, Mumbai, a dedicated research guide in the field of mycology, informed the audience about recent developments in the taxonomy of Arbuscular Mycorrhizal Fungi, popularly referred to as the AM Fungi. Our own faculty Dr. (Ms.) Urmila Kumavat concluded the scientific technical session with a wonderful presentation on the chemotaxonomy of plants.

The scientific session of invited guest speakers was followed by presentations by students. One of the main objectives of conferences and pre-conference workshops organized in our college is to provide and make available suitable and congenial platforms for student learners where they can present their concepts, ideas and work. Three such presentations featured in this session. Scheduled in the first slot was Ms. Priyanka Jadhav a student of T.Y.B.Sc. Botany, who gave a well-prepared and studied presentation on various modern molecular and bioinformatics techniques used in taxonomical studies. Ms. Shraddha Thosar, also from T.Y.B.Sc. Botany class presented her work covering Indian mythological and historical aspects of the Ashoka tree. Ms. Farheen Bagdadi, a student of F.Y.B.Sc. CBZ group gave a presentation on spore dispersal mechanisms in some fungal organisms. All the talks and presentations were well- received by the august gathering which could be gauged from the lively interaction with the speakers.

The valedictory session concluded with the vote of thanks by Ms. Chetna Shetty followed by our national song. The entire schedule of the pre-conference workshop commenced and concluded in the prescribed time allotted for the event. The organizing team and committee is thankful to Vidya Prasarak Mandal, Thane and Bandodkar College administration for providing encouragement, state-of the –art infrastructure, opportunity and support; and all the enthusiastic student and staff participants, speakers, guests and our very own staff and student volunteers for making the event a grand success. The next and second pre-conference workshop is scheduled to be held on Saturday 13th December 2014 in Patanjali Sabhagruha, B.N.Bandodkar College of Science.

Dr. Moses Kolet

Organizing Secretary, NETBT2015

B.N. Bandodkar College of Science

NATIONAL CONFERENCE ON
NEW AND EMERGING TRENDS IN BIOINFORMATICS AND TAXONOMY NETBT 2015
SECOND PRE-CONFERENCE PREPARATORY WORKSHOP

SATURDAY 13TH DECEMBER 2014

PATANJALI SABHAGRUHA

B.N.BANDODKAR COLLEGE OF SCIENCE

PROGRAMME

SPEAKER	TOPIC	TIME
Inaugural Session		
National Anthem		
Dr.(Mrs.) MK Pejaver	Convener's Inaugural Address	2.00 PM
Scientific Technical Session		
Dr. Lal Sahab Yadav Department of Botany, CHM College, Ulhasnagar.	Isolation, Taxonomic Study and Conservation of some Rare Fungi from Unusual Habitats: Fungi from Forest Floor	2.05 PM
Dr. (Mrs) Ujwala Bapat, Director, Blatter Herbarium and HOD Department of Botany, St. Xavier's College, Mumbai.	Scientific Technique of Herbarium (Talk accompanied with Demonstration of Dry Herbarium Technique)	2.30 PM
Dr. Amol Patwardhan Department of Zoology, K.G. Sonaiya College, Mumbai.	Taxonomy of Beetles and Insects	3.30 PM
Presentations by Students		
Ms. Vaishnavi Harad S.Y.B.Sc. (Botany Zoology Group)	Sheep Breeding and Rearing	4.15 PM
Ms. Kashfiya Shaikh T.Y.B.Sc. Botany	Techniques of Herbarium	4.25 PM
Ms Saima Mujaver T.Y.B.Sc. Botany	The World's Largest Flower	4.35 PM
Ms. Faiza Gazali T.Y.B.Sc. Botany	Similarities in Nature Nursery Development	4.45 PM
Valedictory Session		
Ms. Chetana Shetty	Vote of Thanks	4.50 PM
National Song		
Students and Past students Interaction with Invited Guests and Speakers		5.00 PM

REPORT

SECOND PRE-CONFERENCE PREPARATORY WORKSHOP

NEW AND EMERGING TRENDS IN BIOINFORMATICS AND TAXONOMY NETBT 2015

I have great pleasure in presenting the report of the second pre-conference workshop of the National Conference on New and Emerging Trends in Bioinformatics and Taxonomy NETBT 2015. The workshop was conducted on Saturday 13th December 2014 in Patanjali Sabhagruha in B.N.Bandodkar College of Science. This was the second of the two pre-conference workshops preceding the National Conference NETBT 2015 which is scheduled to be held on 14th and 15th of January 2015 in Thorale Bajirao Peshwe Sabhagruha on V.P.M.'s Jnanadweepa Campus also known as Thane College Campus. The pre-conference workshop was attended by over 170 students and members of the staff, from Degree and Junior colleges, scientists as well as non-teaching members of faculty from our own as well as various colleges and institutions in the neighbourhood, all of whom actively participated in the proceedings of the evening and added colour and dynamism to the event.

The workshop started with the National Anthem and convener's address. The first invited guest speaker, Dr. Lal Sahab Yadav, a budding mycologist who has initiated a Fungal Culture Collection and Identification facility at CHM College, Ulhasnagar, enlightened the audience on various aspects of taxonomy of fungi. His talk touched upon exploration of fungi from unique habitats.

The second invited speaker Dr. (Mrs.) Ujwala Bapat, Director, Blatter Herbarium, and Head of the Botany Department, St. Xavier's College, Mumbai, explained the essential and historical role of Blatter Herbarium in taxonomy and Botany. Various aspects of Herbaria were dealt with in detail.

The next speaker, our own alumnus, Dr. Amol Patwardhan, a popular teacher and mentor from K.J Somaiya College, Mumbai, enthralled the gathering on various aspects involved in the taxonomy of insects. He also touched upon beetles, his area of specialization, during his talk.

The session of invited guest speakers was followed by presentations by students. One of the important objectives of conferences and pre-conference workshops organized in our college is to make available suitable and congenial platforms for student learners where they can present their concepts, findings, ideas and work. Five such presentations featured in this session. The first presentation featured Ms. Vaishnavi Harad, a student learner from S.Y.B.Sc. Botany-Zoology group, who presented her paper on rearing and breeding of sheep. The second paper presenter, Ms. Kashfiya Shaikh from T.Y.B.Sc. Botany class presented her compilations on the techniques involved in preparation of herbarium specimens. The next presentation by Ms. Saima Mujaver also from T.Y.B.Sc. Botany class featured the world's largest flower, *Rafflesia*. The next two papers on 'Nursery Development' and 'Similarities in Nature' were presented by Ms. Faiza Gazali, a student of T.Y.B.Sc. Botany.

The presentations were followed by a very informative practical demonstration of 'Techniques of Preparation of Dry Herbarium Specimens' by Shri Praveen Kale, Asst. Curator, Blatter Herbarium, Mumbai and Ms. Rashmi Sharma, research scholar. The session ended with Vote of Thanks by Ms. Chetana Shetty followed by the National song. It was proposed to organize a lecture series on relevant topics just before the National Conference which is scheduled on 14th and 15th January 2015.

Dr. Moses Kolet

Organizing Secretary, NETBT2015

B.N. Bandodkar College of Science

Pre-Conference Lecture Series

A Pre-Conference Lecture Series was conducted from

Friday 9th January to Saturday 10th January 2015

Friday 9th January 2015	Dr. (Mrs.) Kalpita Mulye & Dr. Jayshree Pawar	Microbial Taxonomy
	Dr. Mrs M. Saha	The Evolutionary Basis of Bioinformatics: An Introduction to Phylogenetic trees
Saturday 10th January 2015	Dr. Aruna Rai	Floral Biodiversity of the Western Ghats
	Dr. Vaishali Somani	Taxonomy of Rotifers

Organizing Secretary, NETBT2015

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