Multidimensional links in biodiversity research: An integrated exercise

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The advent of viable techniques for phylogenetic estimates together with evidences on their relationships on the basis of molecular biology have kindled an increased interest in systematic and biodiversity studies. The coming together of systematists, ecologists, developmental and molecular biologists as well as the biotechnologists would give an impetus to the study of biodiversity. Thus, the integration of basic and applied sciences will result in an effective understanding of the dynamics of biodiversity and help in overcoming the deterioration of the biological systems as well as the diverse environmental problems plaguing society.

AN increased awareness of the impact of science and technology on society over the last two or three decades has led to an increased realization of deterioration of the biological systems, which has assumed global dimensions. Technology has resulted in ecological changes at a very fast pace, and with our limited understanding of the functioning of ecosystems, the intensity of the implications pertaining to the loss of biodiversity – i.e. the loss of species, genes and ecosystems – has not registered.

Immense economic benefits accrue to man because of the prevailing biodiversity, therefore continued improvement of biodiversity, and hence the benefits will depend on new and enhanced resources from nature. At any given time, changes in biodiversity, i.e. the increase or reduction or maintenance of the diversity of genes, species or ecosystems will depend largely on human activities. Access to these resources will therefore depend on scientific knowledge of these resources through the studies of biodiversity to enable prediction of the most promising species, and choosing sites for prospective biological resources, which in turn will provide relevant information from the countless number of species.

The identification, recognition and emphasis related to this multifaceted discipline have assumed an increased relevance today, especially when such issues as environment, energy, global changes and sustainable development have become a part of basic education elsewhere in the world, aiming at an increased integration between basic and applied sciences. Furthermore, because of socio-economic changes, biological diversity has today come to occupy the central stage as it holds the 'key to the maintenance of the world'. It has emerged as a unifying discipline bringing together the ecologist, environmentalist, educationist and the economist, resulting in an interdisciplinary, multifunctional, problem-oriented education. Thus the essence of this education emphasizes relevance and quality to cope with issues like ecosystem dynamics, environment and climate changes, energy sources, biotechnology, global changes, and sustainable development at the local, national and global levels[1–3].

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Diversity of biotic interactions

Researches in biological diversity span through the themes of evolutionary biology, population and community ecology, as well as cover a continuum of pers-pectives of biodiversity from its genesis to its maintenance. On the basis of the understanding gained from the multidisciplinary interactions, a critical appreciation of the diverse issues involved, particularly of biological diversity existing at many different levels, will emerge. Many of the richest 'hot spots' in the tropical forests remain unprotected, so that meaningful conservation of the exploited areas has become imminent to enable maintenance of a high degree of biodiversity. The effects of climatic change on species and ecosystems with increased CO_2, changes in hydrological cycles, increased chemical loading of soils, changes in patterns of vegetation brought about by man and the like tend to have an added impact on the rate at which biodiversity is currently decreasing.

Species living in heterogeneous environments tend to show considerable phenotypic plasticity adding to the fitness of individuals in diverse environments. In heterogenous environments, there are adaptive advantages to the genomes that allow for environmentally induced expression of phenotypes[4]. Taxonomic diversity is critical because taxa are the units that contain genetic diversity and the units that make up ecological diversity, and therefore interest in the restructuring of evolutionary trees has resulted in cladistics. Phenotypic flexibility, genetic variation within populations, ecotypic variation, functional diversity, community diversity, gradient diversity, landscape diversity, besides species richness and diversity are the essential ingredients of biodiversity. Some species play a more significant role in the ecosystems than others as indicators of ecological processes or as keystone species influencing community structure[5], which are essential for ecosystem stability and diversity. Equally important are ‘species guilds’ which are taxonomically different but ecologically identical species[6]. Ecosystems flourishing at great heights in the forest canopy, often described as the ‘undiscovered continent’ or ‘powerhouses of the forest’[7], harbour ‘species guilds’ in countless numbers which are best known for the ecological services they offer, specially in the form of pollinators and biocontrol agents. Incorporating species into ecosystem function results in functional groups. Synthesis of ecological, behavioural, and evolutionary aspects of populations go a long way for a better appreciation of community biodiversity studies. In this connection mention may be made of the ‘biochemical cacophony’ of rain forests which poses a problem to potential insects, and evolutionary innovations in plant defenses and in insect feeding habits seem to have spurred their adaptive radiation. Escalation of plant defenses has resulted in increased diversity, and plant feeding has stimulated insect diversification with changes in chemical profiles exerting different behavioural interactions. The role of constitutive and induced plant defenses, and the significance of plant volatiles, insect pheromones and kairomones in the behavioural diversity of insects and their natural enemies have come to be regarded as essential components in our understanding of biodiversity.

Of equal relevance are the taxonomical and functional aspects of community structure incorporated in food webs, which provide information on energy flow. Insect parasitoids and their hosts being an integral part of a complex web of multispecies interactions, such studies provide information on the mechanisms tending to promote the persistence of multispecies systems[8]. Long-term temporal aspects of biodiversity can be assessed only from phylogenesis, and evidence from phylogeny is available from molecular characterization. The potential of molecular phylogenies in revealing evolutionary radiation is immense in view of the rapid accumulation of molecular sequence data[9]. Tools of biotechnology have added to the pool of biodiversity through creating new genetic combinations not normally available in nature. Technological developments in the area of biodiversity have made possible the transfer of genes across species. This has revolutionized agriculture by opening up new opportunities that enable screening of a large number of plants and animals for their increased productivity and effectiveness against diseases, augmenting thereby opportunities for international trade in genetic resources[10].

Research priorities

The need for not only specialization in scientific knowledge and technological skills, but also on the legal and policy aspects has assumed importance in the studies of biodiversity, since, the new international legal framework on access to genetic resources provides countries with the opportunity to assert sovereignty over their genetic resources. The economic values of genetic resources are increasing owing to the fast changing field of biotechnology, thereby making it possible for biopros-pectors to analyse the genetic make up of any material using very minute quantities. This has become a priority area of research, consultation, and action by the developing countries. Further basic researches in universities on the diversity of organisms, including microorganisms which form the basis for biotechnological exercises, would help in an in-depth understanding of genetic and cellular mechanisms. This in turn would enable application of biotechnological principles to the improvement of society.

Another area requiring attention is inventory and identification of animal and plant taxa, notably the teeming millions of insects. Lack of this taxonomic knowledge affects the ecological, biogeographical and evolutionary studies. Comparing the biological attributes of a species of one region with another is an uncertain exercise and doubts over their exact identification may lead to questionable conclusions. The study of the discipline of hard-core taxonomy and its sustenance is a must for a meaningful approach for understanding the issues of biodiversity.

The preparation of proper inventories of the various biodiversity resources, their adequate monitoring and inclusion of proper computer-based information systems for such resources, and evolving strategies for conservation of species, are priority aspects in biodiversity studies. Mapping of tropical forests through remote sensing to cover large areas has become an inevitable aspect to be able to identify natural vegetation formations and assess the extent of loss of vegetation.

Some of the basic issues in conservation education are: (i) promoting a concern for the wide and indiscriminate use of natural resources; (ii) promoting an understanding of integrity, stability and beauty of the community of life, and (iii) initiating integrated efforts at solving multifunctional, problem-oriented exercises, besides continued monitoring for sustained utilization of research. In many parts of the world, the emergence of National Institutes of Biodiversity has been responsible for the generation, storage and communication of information on biodiversity. Integration of diverse networks of information, so as to be able to tackle natural and local issues, is among the major concerns for the build-up of such capacity for the future. As technology is faced with the need to overcome diverse environmental problems, restoration in terms of ecological services and crop productivity is also important, with restoration biology or ecological engineering holding the key for conservation in the next century.

Worldwide concern for the conservation of biodiversity for the benefit of present and future generations has resulted in a global biodiversity strategy which offers guidelines for the sustainable utilization of biological wealth. In this connection, the convention on Biological diversity held in Rio De Janeiro in 1992 relates to the conservation of biodiversity, sustainable use of its components, and equitable sharing of benefits arising from the use of genetic resources. The convention also calls for strengthening of 'natural capabilities through human resource development and institution building, promotion and establishment of joint research ventures and programmes for the development of skills and technologies'.

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