Plant taxonomy

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The very foundation of biological sciences is based on the primary knowledge regarding diversity of life forms, their characterization and classification in the process of resolving the evolutionary lineage. With the postulation of the 'origin of species' by Charles Darwin, the conceptual foundations of classification changed course with 'Darwinism' as a directive principle. In line with the fast pace of progress in biological sciences, particularly genetics and molecular biology, 'Neo-Darwinism' took shape, and today we know what genes, gene sequences in chromosomes, and genetic combinations mean in the origin of species, and the advantages of the new knowledge in genetic manipulations in producing biota with desirable traits. However, the 'species concept' as the core foundation for classification, remains unaffected. Nevertheless, microtaxa and even populations associated by ecological and geographical locations, have gained a new meaning and identity, with the result that biodiversity defined to cover species, genes and ecosystems, has become the foundation for 'new taxonomy'. In this process, the genuineness and authenticity of taxa at micro-levels have become vital in product development and bio-improvement. It is in this context that working taxonomy (applied taxonomy) has gained the focus of attention of those concerned in quality-control operations and resources management.

SINCE time immemorial, the origin of life and its ramifications attracted the thinking process of academics, and has concretized to emerge into a scientific discipline, namely 'evolutionary biology'. Biodiversity through time and space provides the panorama of the genesis and diversification of various life forms, their interdependence, and the link between life and life-support systems, triggering a holistic approach to knowledge-building focused on various aspects of human affairs.

The discovery of biodiversity of plants and animals, their origin and diversification may perhaps be attributed to Charles Robert Darwin (1809–82) through his observations and analysis of Nature, following his travel around the world in the ship *HMS Beagle*. He made the momentous scientific postulation that variation and natural selection were the twin phenomena associated with the 'origin of species' (1859) and that survival of the fittest carried life forward. The postulation survived debate for over three centuries, but got modified by the impact of new knowledge on cell biology in particular and biology in general. The science of life is focused today on 'biodiversity', involving species, genes and ecosystems signifying the importance of Darwinism as the core directive principle in evolutionary biology. Records of the geological past, and the composition as well as pattern of geographical distribution of life forms provide the scenario of diversity and change associated with climatic zones, ranging from the equatorial tropics to temperate alpine heights and to the poles. This suggests the pertinent need to circumscribe bioforms, and to gain knowledge on lineage of one from the other, by which the 'species' has been notified and acknowledged as a basic unit or taxon in biological classifications. In effect, the foundation of taxonomy, laid by Linnaeus (1707–78), with the formulation of binomial nomenclature to characterize and name the species, was strengthened by Darwinism.

The 'green earth concept' gives the projection that the plants form the dominant element of life on earth, in spite of the current scientific understanding of plant–animal–earth cycle as the undefined principle of life on earth. It is therefore appropriate to consider plants as the base for presenting the theme on taxonomy as a fundamental directive component in applied biology in the 21st Century and ahead.

Plant taxonomy – a perspective

In evolving plant classification, the 'species' has been the basic taxonomic unit associated into various categories, in the ascending order: genera, tribes (and sub-tribes), class (subclass) and phyla, on the basis of visible morphological relationships[1–4], mainly focused on the flower system. Over the years, new knowledge generated from studies in cytogenetics, molecular biology and ultra structure, chemistry and biochemistry, ecology and a spectrum of other areas, led to the emergence of 'new taxonomy', as reflected in the modern approaches to phylogenetic systems of angiosperm classification[2,5–7]. In fact, Takhtajan[2,7] was influenced by Darwinism, and noted that Darwin equated 'affinity' with evolutionary relationship, 'natural' with 'ge-

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neological', systematic groups with geneological 'units', and considered the system of hierarchical relationships to be the result of 'evolution'. Compounding the various systems are the views and proposals made by an array of specialists engaged in monostructural research, each propounding his own theory based on limited information. Thus, taxonomy is in a state of complexity, and it is time that a standard system is globally accepted, to which any information may be collated or added, so that a new foundation for plant taxonomy is laid, and which will give taxonomy the importance it deserves, in education, research and practice[8,9].

Pollen and spore morphology and phylogenetic taxonomy

With the flower as the fundamental base for all systems of plant classification, and the new knowledge generated on the morphology of pollen[10–15], the male partner in fertilization biology[16], together with information in plant biology, a significant new approach in phylogenetic taxonomy has emerged as the one by Takhtajan[2,7] and also by Cronquist[5,6] among others[9]. Taking the plant kingdom as a whole, the pollen in flowering plants was preceded by spores in the flowerless plants as reproductive entities. The pollen and spores having similar structures in terms of protection of the genome by the resistant and non-destructive outer wall (exine) and of its diagnostic characteristics to identify the mother plant, the phylogenetic lineage presented by them may be considered a natural one, the essential aspects of which are presented here.

The protective coat (exine) being a phenotype reflective of the genotypic characteristics, the reproductive unit formed of spores and pollen provides a picture of hereditary lineage in plants[11,14]. Being a product of the meiotic process, the spore–pollen genome is a genetic pool with phenotypic expression in the exine providing a relatively reliable basic direction in evolutionary biology and phylogenetic taxonomy.

The spores and pollen are haploid, derived from the diploid as a general rule, at least in the flowering plants. Five groups of characters, namely germinal aperture, exine ornamentation, exine strata, grain size and shape in the order of their importance have been notified for describing the exine, and the various character combinations provide an entity to a particular taxon[12]. It is in the bryophytes that a definite structural feature is first seen, resolved into three forms, namely trilete, monolete and alete, and described as a trimorphous situation, with the aperture occurring in a proximal position (as seen in the tetrad). The trimorphous condition continues to occur in the entire pteridophytes.

At the level of origin of the flowering plants, to begin with, the gymnosperms the position of the aperture changes from proximal to distal, but still is trimorphous in terms of form (trichotomous, monocolpate, inperturate).

In the angiospermous group of flowering plants, the trimorphous situation suddenly changes into a polymorphous condition, with the origin of many new apertural forms, differing in number, position and character (NPC), but inclusive of the trimorphous forms characteristic of the pre-angiosperms. It is therefore imperative that the haploid spore–pollen lineage by itself is suggestive of the evolutionary pathways of plants.

The trimorphous combination is a stable pre-angiospermous feature and therefore the occurrence of such a feature in the angiosperms can be taken as a reasonable measure of primitivity. Considering the taxonomic system of Takhtajan[2,7], the subclass Magnoliidae of class Magnoliopsida, composed of the families Magnoliaceae, Piperaceae, Chloranthaceae, Aristolochiaceae and Nymphaeaceae (barring *Nelumbo*, which has been placed in Nelumbonaceae) is totally trimorphous, the class Liliopsida beginning with the subclass Liliidae (monocots), contains trimorphous and their derivatives, while the subclass Ranuculidae (of class Magnoliopsida) consists of totally new forms with a polymorphous feature (trimorphous being totally absent). The above situation led to the enunciation of the 'triphyletic theory'[12,13,16], to explain the origin and evolution of the angiosperms, which had remained an abominable mystery.

According to the triphyletic theory[12,13,16,17], the angiosperms (Magnoliophyta) originated together with the gymnosperms[11,18], and evolved along three lines namely the 'Magnolian' stock (equivalent to subclass Magnoliidae), the 'Ranalian' stock (equivalent to subclass Ranunculidae and other subclasses of class Magnoliopsida) and the 'Monocot' stock (class Liliidae). The above facts substantiate the correlation between a recognized phylogenetic system of classification[5,7] and pollen–spore evolution, and is indicative of the merit of approaching taxonomic circumscription, through the linking of character combinations, wherever and whenever possible, particularly with regard to reproductive materials in which natural selection is at its best, as an imperative need in species survival and succession[10,19–24].

Sporae dispersae

The pollen and spores (microfossils) preserved in sedimentary rocks do not have any physical connection with the mother plant (macrofossils) that they belonged to, and therefore are collectively placed under 'sporae dispersae'[22]. While the characterization of such material is based on the standards for the present-day plants, the classification is almost always artificial, except for geologically recent materials, in which taxonomic identification is possible. All the same, it is significant that 'sporae dispersae' among the various plant fossil components may be one material which reflects the near continuity of evolutionary lineage of plants to the largest extent in consideration of its non-destructive feature by the environmental hazards during the process of fossilization. Further, these materials provide important information on palaeobiodiversity, palaeoecology, palaeogeography and palaeoclimate, all having well-established applications in geoprospecting[21], evolutionary biology apart[11,13,25].

Applied taxonomy

The new taxonomy takes into consideration the application of taxonomy in the wake of the advances in biological sciences as a whole. The resource-based economic regime is now in place, in which taxonomy is an integral component in terms of biodiversity protection, remediation, ecodevelopment, product development and quality evaluation. The importance of characterization of genetic resources for selecting materials of quality and authenticity in plant improvement and utilization, is most significant with regard to industrial raw materials and medicinal resources. India is one of the 12 mega-diversity regimes of the world, but is faced with destruction and decay of the vital regimes, occurrence of rare and endangered taxa, degeneration of forests and soil, destruction of the wild wealth, and eco-degeneration (Kerala has become a threatened ecoregime on the world map). It is time that rarity becomes a situation of abundance. The situation warrants appropriate attention for conservation, afforestation and eco-development, taking note of the livelihood pattern of the native societies in particular. For all these, exploration and identification of taxa for biorestoration and ecosystems development form important pre-requisites. The advantage offered by biotechnology, will serve to curtail the ongoing biodiversity loss and to revitalize the degenerating land systems, in which process the communities may be able to develop their own economic wealth from raw materials to finished products.

Coming to environment-based activities, environmental impact assessment has become an obligatory component of development. It is in the section of hydropower generation that taxonomy and biodiversity evaluation and management have become important. Taxonomy is equally significant in areas like agroforestry, mitigation of pollution, tourism development, social forestry needing an appropriate approach, among the other areas of socioeconomic advantages.

Concluding remarks

The totality of information on genes, species and ecosystems of biota, biodiversity in essence, is relevant in the current and future context of global requirements of the human society, with link and dependence between people having wide geographical and cultural divisiveness and natural resources.

In achieving success in sustainable development, economy and ecology, the primary activity in research protocol is taxonomy for authenticated product development and materials management. The implementation of knowledge-based development activities ought to be streamlined, in which working taxonomy will have a vital role. Participation of people being a vital component of development, the imperative need is to evolve qualified human resources empowered to provide quality services with science and technology as the directive principles. Even high-level education in institutions needs to be improved; this calls for new initiatives, of which taxonomy ought to be an area of focus, but is being neglected due to the ignorance about its importance in achieving the hopes and aspirations of the people in the emerging world order.

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