Pollen – the underestimated treasure of taxonomists

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Integration of the two disciplines of botany, viz. palynology and taxonomy is essential as it adds profound substance and accurateness in species discrimination and in resolving taxonomic complexities. Such an effort would minimize errors and modify taxonomy. I have suggested the possible practical expansion in the prevailing methods which are of utility in multidimensional taxonomic approach.

Linneaen taxonomy undisputedly forms the pillar of all plant-based research, taxonomy in particular. We are in a privileged position and fortunate enough to reap the harvest sown by the 'grandfather' of taxonomy. But it is now our turn to strive for the upliftment and modernization of the primitive methodologies, relying upon the conventional macromorphological parameters of species delimitation.

In support of views and suggestions of Krishnankutty and Chandrasekaran[1], I strongly uphold that 'SEM data on significant, minute taxonomic parts' should be couched in taxonomic information. Inquisitively, what are these minute parts of actual primary significance in taxonomy? Why are they important? How do they aid taxonomists? What are the possible shortfalls in adopting such studies? These are some pertinent queries. Here, I venture to illuminate these in terms of significance of pollen, the micromorphological unit of plants.

Incipient attempts to correlate pollen characters with taxonomic illustrations, commenced with the meticulous efforts of Francis Bauer, in the form of pencil sketches of the 'grains'[2], mostly published later in Brown's works[3]. Mohl[4] for the first time elucidated the importance of furrows on pollen walls in family diagnosis, and in palynological classification. Gradually and simultaneous to the modifications in the microscope, a breakthrough in this discipline occurred following excellent painstaking contributions of subsequent pioneer workers[5–9], and the pollen morphological features of many families of flowering plants were precisely resolved, reaching a culmination in the era of scanning electron microscopy (SEM). But, to our dismay, the vital applications of pollen morphology, as a tool in angiosperm systematics, faced digression and failed to achieve proper appraisal by taxonomists. Consequently, the value of this micro-unit, the asset of taxonomists, was eclipsed and vanished in the event of scientific modernization in the present times, mainly because (i) palynology, pollen morphology in particular, is often considered 'redundant' by modern botanists, (ii) a negative attitude prevails among herbarium curators to spare pollen material from their herbarium sheets for fear of damage, (iii) SEM of many laboratories is in a pitiable condition in the hands of under-trained users and (iv) there is a lack of manpower and basic infrastructure for pollen procedures in the taxonomic laboratories. It may be aptly emphasized here that pollen grains are as much a part of the plant, as various organs upon which taxonomy proliferates, but when these are willingly avoided by the taxonomists, the richest unit of heritage is disregarded, for in no other part of the plant are found packed in so small a space, several readily available phylogenetic characters.

The uniqueness of pollen features rests in the fact that the influences which determine their morphology are both hereditary and environmental (both internal and external). While heredity dominates the basic form of the pollen grain, the internal environment, viz. pollen ontogeny tends to control the number and arrangement of their germinal furrows and pores, and the external environment, viz. the pollination mechanism tends to modify their sculpturing. However, pollen features remain unaltered by atmospheric fluctuations. Hence 'pollen type' of the same species and of closely related species, growing in different ecological environments, tends to be alike, especially in their primary characteristics. It is on these principles that the role of pollen finds significance in the multidimensional concept of species.

It is therefore strongly accentuated that for solving taxonomic problems and simultaneously giving new life to the dwindled discipline of 'palynology'[10], the 'orphaned' pollen studies should be adopted by taxonomists globally as a 'first-aid'. The complexities of speciation are manifold and it is at this edge that plant taxonomists feel handicapped. Different species often portray similar morphological characters while morphological variations in many taxa are uncorrelated with speciation[11], and character analysis at such a juncture needs support of micromorphology. It is therefore suggested that taxonomists should expand their traditional deployment of plant morphological approach, based on dissecting microscopes, to encompass SEM-based pollen data. To implement this, bilateral taxonomic amendments are essential, first in classical herbaria and field schemes and secondly, in the depiction of mega-morphological features to embrace palynological evidence. The following modifications are suggested:

- Field trips for plant collection must be oriented to couple pollen collection, viz. 'polleniferous' material to develop indigenous pollen banks for ready use. For this, collection of sufficient mature buds of flowering plants is ideal. This would simultaneously avoid possible damage of precious herbarium specimens in retrieving pollen material.
- The collected buds are to be placed in 70% alcohol, to be preserved for short-term use, or they may be dried by the usual procedures and placed in paper packets for sustainable utility.
- Packets of 'polleniferous' material must be affixed in the suitable space along with the specimen and labelled accordingly. This would expedite the work of palynologists during material collection, and also provide sufficient material for palynological procedures involved in pollen studies, both light microscopy and SEM.
- The pollen reservoirs (packets and vials) must bear the same field number as the plant specimen.
- Revisionary studies and monographs must essentially include pollen descriptions.

- While erecting a new taxon, the pollen morphology with allied taxa should essentially be compared.
- Protologue should be supported with brief pollen morphology and/or palynogram (diagrammatic representation of the pollen)/pollen micrograph.
- Type specimens preferentially should bear a palynogram or pollen photographs, or at least a pencil sketch of the pollen.
- Loan/exchange of palynograms and scanning electron micrographs of pollen between different herbaria must be espoused for dissemination of information.
- Basic training must be imparted to taxonomists on pollen procedures and study of morphology.
- All taxonomic laboratories must be equipped with the minimum infrastructure for pollen analysis.
- Collaboration between taxonomists and palynologists should be encouraged.

Eventually, all taxonomists must strive for modernization at the first instance, by integrating pollen morphological criteria in their curriculum. They must realize the inter-relationship between the two subjects with the intention of supporting taxonomic data with palynological information. In the present sophisticated epoch of information technology, where taxonomists have undertaken the task of developing digitized 'virtual' herbaria, the implementation of SEM-based micro-morphological studies is not thorny. The venture would add a 'feather in the cap' of Linnean taxonomy and facilitate in solving intricate taxonomic problems, mainly at infra-specific levels. Our endeavour must be oriented to converge the two parallel disciplines, amalgamate and ameliorate them and develop a more reliable, authentic, standardized and intelligible taxonomy.

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Watershed development: how to make 'invisible' impacts 'visible'?

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The innovative and imaginative economic reforms, polices, programmes and investment portfolio have been internalized through various mechanisms of convergence. In this way the development process is evolving and dynamic in chasing efficiency, equity, social justice, reducing poverty, realizing sustainable livelihood and environmental services.

About 60% net sown area in India is rain-fed, supporting 87% pulses and coarse cereals, 77% oil seeds, 66% cotton as cash crop and 50% cereals. The entire 67.7 mha forests, grasslands, 80% mangoes and apples, all dry land and temperate fruits, 67% livestock and 40% human beings are distributed in the unirrigated agro-ecologies. During 1985–95, rain-fed regions witnessed higher agricultural growth rate of 4.01% compared to 2.90% in the irrigated areas. However, during the post-1995 liberalization, the growth in rain-fed agriculture[1] decelerated to almost zero, as against that of the irrigated region to 2.07%.

The Indian Planning Commission's Working Group on Natural Resources Management[2] has noted that, in spite of spending about Rs 192,510 million (US$ 4500 million) for watershed development in the rain-fed region of India, the results are 'invisible', and the treated areas have reverted to their 'original status'. Clearly, the development processes require a thorough examination.

The evolution of watershed development in India

The earlier pre-independence incarnation of the present-day watershed development consisted of preventing soil erosion in the catchments of River Valley Projects (RVPs) and various schemes on dry land agriculture, soil and moisture conservation. The objectives were empirical, thematic, commodity centric and lacked comprehensiveness of generating income, employment, equity, livelihood, and integrated as well as sustainable use of natural resources, including the soil capital. The community participatory process of developing all inclusive resources within a natural geo-hydrological unit of a watershed is being experimented since 1974 by different research and development endeavours. After 1982, NGOs, governmental organizations and donor-driven resources also jumped on the bandwagon of refining the watershed development projects. Centrality of the role of gender, poverty, landless, asset-less