P. K. K. Nair – the father of Indian palynology

A tribute

Parmeshwaran Krishnan Kutty Nair, fondly referred to as P. K. K. Nair (Figure 1) and considered as the father of Indian palynology is a colossal name among palynologists. He completed 85 years on 6 February 2015 and this note is a tribute to mark the occasion. Nair's major research contributions in palynology with special emphasis on the new principles, pollen morphology in relation to plant taxonomy and the triphyletic theory of the origin of angiosperms along with all other contributions on applications of pollen studies are highlighted here.

Making of a palynologist

Born on 6 February 1930 in Changanassery, Kerala, Nair completed his graduation from St. Berchman's College, Changanassery, topped in the postgraduate programme of Banaras Hindu University, Varanasi in 1952, with special paper in palaeobotany and started working in the Birbal Sahni Institute of Palaeobotany (BSIP), Lucknow. He completed Ph D in palaeobotany from Lucknow University in 1958, under the guidance of R. N. Lakhanpal with collateral support from Gunnar Erdtman of Sweden, a reputed scientist in world palynology. In 1958, Nair joined the National Botanical Research Institute (NBRI), Lucknow and worked for its betterment, mainly on environmental studies, garden planning and organization, pollen morphology, aerobiology, economic botany involving agriculture, eco-development, geology, plant systematics and evolution. Under his leadership, palynology started flourishing and reached great heights in India. His professional career spans over 38 years, working for the Government of India, as Founder Chairman of the Kaul Science Foundation in Lucknow and now the Founder Director of the Environmental Resource Research Centre (ERRC), Thiruvananthapuram. During his active research career, Nair was honoured with merit increments and merit promotions in CSIR–NBRI. After retirement, he was appointed as Emeritus Scientist of CSIR. He held various positions and responsibilities, including two years (1980–81) as Deputy Director on deputation at the Tropical Botanic Garden and Research Institute (TBGRI), Thiruvananthapuram.

Major contributions

New principle of palynology

The original principles of palynology, based on atmospheric pollen[1,2], were presented by Hyde and Williams[3,4]. Nair modified this concept and stated that the cycle of angiosperm flower included two alternate phases – the gametophytic and the sporophytic. The gametophytic phase was represented by pollen, when it starts developing, till pollination leading to fertilization and seed set. During this, pollen released from the anthers moves in various directions for pollination and

Figure 1. P. K. K. Nair.

forms the subject matter of palynological studies such as: (i) Aeropalynology and pollen allergy: the airborne pollen serves as indices of vegetational composition of a region and also causes allergy and hay-fever in human beings; (ii) Mellittopalynology and bee botany: the honey-bee collected pollen is used to feed the developing larvae in the beehive. This pollen also imparts properties to the honey manufactured here; (iii) Palaeopalynology: the airborne pollen falls on the ground and gets fossilized over a time period, which serves as an indicator of the past vegetation; (iv) Forensic palynology: pollen trapped in the body parts of victims of crime and the crime suspect is helpful in linking crime with the crime scene; (v) Copropalynology: pollen content of animal faeces provides evidence of their feeding habits. It is thus the gametophytic cycle of angiosperms which forms the principles of palynology.

Palynological renaissance, which started in 1952 with the contributions of Erdtman[5], and Faegri and Iversen[6], grew with the scientific activities of Nair and took a concrete shape in 1964, when he convened a symposium of palynology at NBRI. Following this symposium, promotion of palynology in India was phenomenal. Several centres of research activities emerged and the subject was introduced in the curricula of many universities throughout the country. Another symposium on agricultural palynology was soon convened by Nair at Tiruchirapalli in 1970, which enhanced its importance and scope, and the subject started proliferating and expanding. Keeping in mind Birbal Sahni's view that 'the scope of palynology in India is vast but trained workers are lacking', Nair also took up the challenge of creating manpower for palynology by guiding Ph Ds and training students in all spheres of palynology. He conceived that the science of palynology could not be only confined to pollen and spore morphology, but was also related to the reproductive cycle of plants which occurs in two phases – the pollen phase and the seed phase. The pollen phase has three stages – developmental, free life and fertilization stage. Developmental stage starts at initiation of flower morpho-system, and is directed towards protection of the pollen unit which is vital for reproductive success. Free-life stage has several dimensions based on the carrying agents like air, water, insects, etc and this opens new vistas of palynological science. Fertilization is finally achieved when the free pollen lands on stigma and germinates to produce pollen tube which carries sperms to the egg inside ovary, through the stylar canal. From this point of view of Nair, the very foundation of palynology got a new thrust with an integrated approach and as a result, India emerged as an academic school of its own for palynological science in the world.

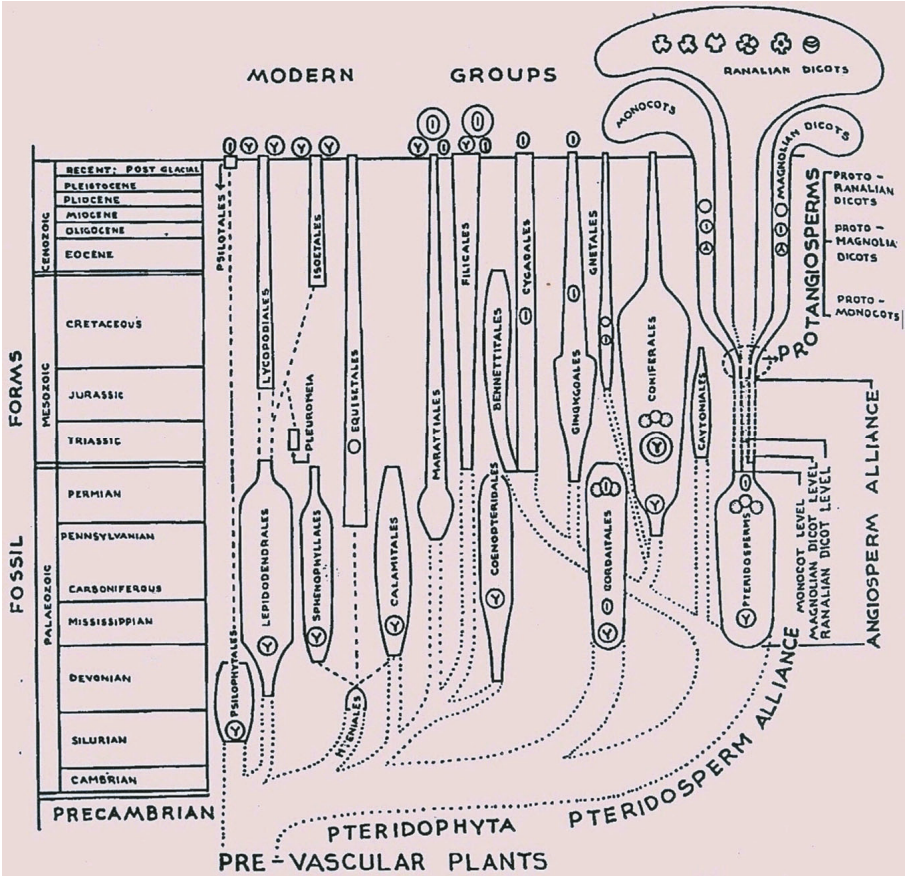

Figure 2. Schematic representation of the triphyletic theory of the origin of Angiosperma. Drawing by Nair.

Pollen spore morphology

Nair's principle that pollen is a vital 'special cell' unit with attributes of an exine which is both protective and diagnostic, gave new dimension to pollen morphology[7]. According to him, the features of pollen aperture were primary, exine ornamentation secondary and exine strata, grain size and shape tertiary, in the order of their conservative value and functional priorities. He gave new terms and expressions for characterization of these features, highlighted the significance of acetolysed pollen preparations against those unacetolysed, and demonstrated the value of the scanning electron microscope (SEM) in gaining insights into the fine structure of the exine surface patterns for detailed comparative morphology. These findings set new initiatives on morphological standards for application of pollen morphology in the characterization of genetic resources, as an index in plant ecology and environmental stress conditions, and in screening plant populations. He also suggested that the pollen–spore unit was an index of the evolutionary progression in angiosperm flowers through the cryptogams at mega and micro levels and even down to the level of populations, and pioneered the association of pollen morphological studies in floristics, taxonomy, biosystematics and associated areas. His extensive studies on pollen morphology of angiosperm taxa generated a pollen key to aid in drawing significant taxonomic conclusions, viz. separation of Nelumbonaceae, with three-colpate grains from Nymphaeaceae with monocolpate grains; separation of lower taxa levels – *Caltha palustris* var. *palustris* with three-colpate pollen from *C. palustris* var. *alba* with pantoporate pollen, as well as in cultivar taxonomy where application of pollen morphology was best exemplified in the case of *Gloriosa*, *Amaranthus* and *Cocos nucifera*, by virtue of results from SEM and in circumscribing the ecotypes of *Oryza melampuzhaensis*. Nair also generated knowledge on the pollen flora of the western Himalaya with the prime objective of identifying fossil pollen of peat and lignites and their pollen equivalents in present-day plants, in order to establish the vegetational history of Kashmir.

Evolutionary biology – the triphyletic theory of evolution of angiosperms

As a consequence of original thinking on pollen resource and biodiversity in the Indian subcontinent, Nair[8] enunciated the triphyletic theory of evolution of angiosperms in 1969, as a vital clue to unravelling the mystery of origin and evolution of the angiosperms. Taking plant kingdom as a whole, he illustrated that spores in lower cryptogams, the algae, were amorphous with no fixed morphology for comparison, while in higher cryptogams, including bryophytes, pteridophytes and in primitive spermatophytes, the gymnosperms, these were trimorphous with trilete or trichotomocolpate, monolete or monocolpate and alete or inaperturate pollen/spore types.

The most highly evolved angiosperms were polymorphous having varied apertural forms in their pollen grains. Based on apertural evolution, Nair observed that bryophytes formed the baseline of organized structural features in spore morphology, with three spore types – trilete, monolete and alete. In higher groups, the pteridophytes have the same three types as in bryophytes, but the general homosporous condition (with no sex differentiation) was deviated in Hydropteridineae with heterospores (large female megaspores, small male microspores). The next higher order, gymnosperms, also possessed three forms, but here the proximal position of aperture (in tetrad) became distal and in the highest order, angiosperms, the subclass Magnoliideae had the same condition as in gymnosperms, while in monocotyledons, the trimorphous forms dominated, but with many derivatives. In subclass Ranunculiideae and other subclasses of dicotyledons, pollen was characterized by new apertural features, being tricolpate and their derivatives, but with lack of occurrence of trimorphous condition of the lower plant groups. Evidently, the archaegoniates, cryptogams and gymnosperms were trimorphous, and this situation continued up to subclass Magnoliidae of angiosperms and partly to the monocotyledons, but all dicotyledons (other than Magnoliideae) were polymorphous. He therefore suggested that angiosperms originated and evolved along three directions – the Magnolian stock represented by subclass magnoliideae of Cronquist, 1964; the Monocot stock, and the Ranalian stock represented by subclass Ranunculiideae and other subclasses of dicots. Further, the angiosperms and gymnosperms originated and evolved concurrently from cycadofilicales and with decline of gymnosperms in the Cretaceous period, angiosperms became dominant and continue to be so even today (Figure 2). It was also observed that gymnosperms and angiosperms originated together at the level of Cycadofilicales and evolved parallely, while subclass Ranunculideae of dicotyledons had its primitive base in the tricolpate Ranunculaceae and diversified at the level of order Rosales, during the late Cretaceous period of geological history[9].

Economic and applied palynology

Application of pollen in agriculture is as old as 717 BC, as depicted through stone carvings (Figure 3). Nair suggested that since pollen application in the improvement of agricultural crops and plants of medicinal and economic value is inevitable, handling of pollen mass should be developed with scientific evaluation of its qualities. Since pollen grains are repositories of significant male-specific characters such as vigour, disease resistance, male sterility, etc. quality pollen selection of male parent is a prerequisite in the plant breeding process. Further, as pollen morphology reflects genotype constitution of the species, it is also indicative of pollen biology, from development to fertilization, and hence pollen morphology can aid in the selection of the right species during crop improvement. This was explicitly demonstrated by Nair in *Arachis hypogea*, *Cajanus cajan* and *Gloriosa superba*. The fungal disease in *Zea mays* in North America was overcome through breeding with pollen of *Zea perennis*, its wild relative from Mexico. Thus pollen index value in breeding programmes opened new vistas in pollen biotechnology. While exploiting the use of insects, particularly honey bees, in enhancing crop pollination, Nair found that honey bees get attracted to plants in two steps – they select the primary site on the petal surface having secretary glands and then seek the main nectar site at the ovary base. Significance of pollination by bees in plant improvement, therefore depends on field knowledge of the pollination process, pollen and nectar availability and pollen–stigma interaction for evolving artificial pollination strategies. Nair also provided a picture of diversity in bee pasturage through pollen spectrum of honey and elucidated that pollen composition of honey reflects natural bee forage ecosystem. Such studies therefore, are useful in specifying the source and standardization of honey. While illustrating pollen germination, Nair showed that *Luffa aegyptica* flowers open when the sun sets, and pollination and pollen tube germination are completed during night. He also unfolded the germination potential of pollen at different phenological stages in racemose flowers, which revealed that pollen of flowers in the middle stages of development was most potent and useful for storage in pollen banks and that pollen from the most mature

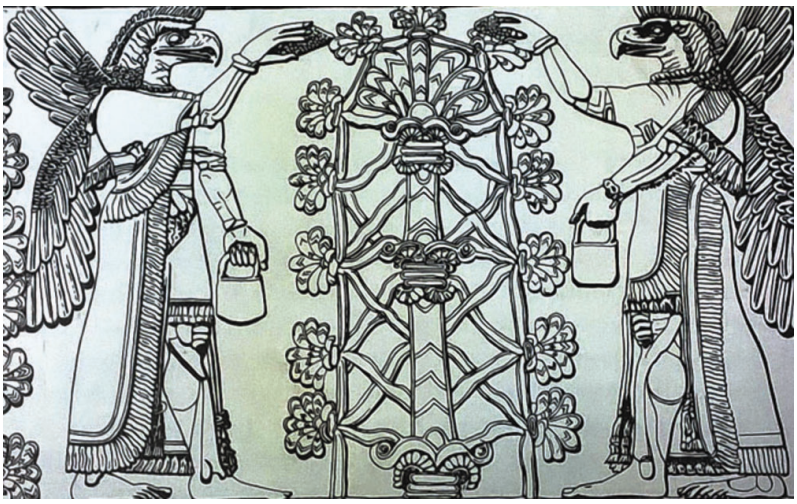

Figure 3. Assyrian winged beings pollinating date palms (after an original in the Leiden Museum of Antiquities).

anther was as good in fertility potential as that of unopened flowers; hence storage of mature anthers would conserve and ensure purity of pollen mass during breeding. He further confirmed that presence of intermixed pollen and fungal spores on the stigma surface after pollination inhibits pollen germination on live stigma, and proved experimentally that growth and proliferation of *Aspergillus* on the pollen mass resulted in loss of pollen viability[10]. This gave a new impetus to ensure pollen germination during plant breeding programmes.

While conceiving that information on aerospora of a particular habitation is prerequisite in diagnosis and treatment of bronchial allergy, Nair illustrated the aerospora of Lucknow which gave fresh thrust to aeropalynological studies in India. An all-India coordinated project on aerobiology, sponsored by CSIR, was launched under his leadership and its consolidated results were published in a book entitled *Airborne Pollen, Spore and other Plant Materials of India*[11]. These studies had an impact on industrial production of antigens for diagnosis and treatment of allergy and promoted pharmaceutical research. Nair also highlighted the native uses of *Typha* pollen for food and of *Cycas* pollen as medicine, particularly in view of its mass production in these plants. He further demonstrated that pollen content in floral drugs of both indigenous and modern medicines was an index in pharmacognosy and helped in ascertaining drug quality.

Nair's critical investigations on fossil pollen of Karewas in Kashmir revealed that fossilized pollen was double in size of its equivalent living pollen, which indicated ongoing oxidation/alkalinity in the sedimentary system. His studies on terrestrial aerospora system and the Arabian Sea revealed that *Cocos nucifera* pollen gets transported to more than 25 km from the coast, which revealed the possibility of using it as an index of air movement. These findings are of much utility during oil exploration, where demarcation of the ancient coastline is made with the help of fossil pollen by drawing isobotanical lines, a procedure adopted all over the world. The diversity in pollen morphology of *C. nucifera* pertaining to different ecological zones became helpful in unfolding the ecological adaptations in different coconut varieties of Southeast Asia, and in *Oryza* pollen a well-adapted apertural system was discovered as an evolutionary character to curtail loss of short-lived pollen viability, under stress in aquatic environment, a phenomenon unique in the whole plant kingdom.

Nair's contributions as an organizer

Being the Founder of the Palynological Laboratory at NBRI and of the Palynological Society of India with activities involving organization of seminars, symposia, national conferences, presenting awards and above all, publication of the *Journal of Palynology*, amply testify Nair's organizational activities and their national and international impact, as result of which, India gained pride of place in the formation of the International Federation of Palynological Science, in 1968, Nair as its first Vice President. With Nair as the key figure, the networking and integration of palynological science in its new perspective conceived that pollen, the male reproductive unit, is the core unit of reproductive machinery and evolutionary process of the plant kingdom. Under Nair's leadership, concrete proposal for a National School of Palynological Science also emerged and he became the founder editor of journals such as *Advances in Pollen-Spore Research*, *Glimpses in Plant Research* and *New Botanist*, to promote the development palynological science in India. Nair was instrumental in managing all national palynological activities and chaired many international and national conferences. He has published more than 250 research papers and 24 books. More than 30 research students obtained their Ph D degrees under his able guidance. He was bestowed with the prestigious Birbal Sahni Centenary Award in 2009. While continuing to work at Environmental Resources Research Centre, Thiruvananthapuram, Nair is currently engaged in studying pollen grains of spice crops.

1. Potonié, R., *Arb. Inst., Paläobot. Petrogr. Brennsteine*, 1934, **4**, 5–24.
2. Wodehouse, R. P., *Pollen Grains. Their Structure, Identification and Significance in Science and Medicine*, McGraw Hill, New York, 1935.
3. Hyde, H. A. and Williams, D. A., *New Phytol.*, 1944, **43**, 49–61.
4. Hyde, H. A. and Williams, D. A., *Nature*, 1945, **155**, 265.
5. Erdtman, G., *Pollen Morphology and Plant Taxonomy. Angiosperms*, Stockholm, Sweden, 1952.
6. Faegri, K. and Iversen, J., *Text-Book on Modern Pollen Analysis*, Einar Munksgaard, Copenhagen, Denmark, 1950.
7. Nair, P. K. K., *Pollen Morphology of Angiosperms – A Historical and Phylogenetic Study*, Barnes and Noble, New York, 1970.
8. Nair, P. K. K., *Grana*, 1979, **18**, 141–144.
9. Nair, P. K. K., *Evol. Biol*., 1974, **7**, 127–137.
10. Nair, P. K. K. and Khan, H. A., *Nature*, 1963, **200**, 1335–1336.
11. Nair, P. K. K., Joshi, A. P. and Gangal, S. V., Airborne pollen, spores and other plant materials of India: a survey: report of the All India Co-ordinated Project on Aerobiology, CSIR Centre for Biochemicals, Delhi, 1986.

ARTI GARG

Botanical Survey of India,
Central Regional Centre,
10, Chatham Lines,
Allahabad 211 002, India
e-mail: kad_arti396@yahoo.com