

# PROFESSOR BIRBAL SAHNI'S CONTRIBUTIONS ON LIVING PLANTS

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IN its historical aspect science may be likened to a tree which is constantly branching as the sum total of knowledge grows larger and larger and a subdivision of the field becomes necessary. Occasionally, a bud of special vigour appears and gives rise to a branch so dominating and important that it changes the contour of the whole organic body. An event of this nature seems to have happened in Indian Botany when the young Sahni graduated from Lahore in 1911 and proceeded to England to study further in the Botany School of the Cambridge University. Coming under the influence of a great master like the late Prof. A. C. Seward, he learnt rapidly, gained much insight and experience in the morphology of living as well as fossil plants and started a flourishing school of research on his return to India, which is now well known all over the world.

It is commonly believed that Prof. Sahni was a palaeobotanist, and that it was his work in this field which brought him many distinctions like the Fellowship of the Royal Society and the Presidentship of the Indian Science Congress. While this is essentially true, those like the present writer, who came in personal touch with him, would at once agree that he was a botanist of very wide interests, eager to take advantage of every opportunity in advancing our knowledge of plant life. When I was told by Dr. R. V. Sitholey, a former pupil of Prof. Sahni and my own, and Secretary to the Editorial Committee of *The Palaeobotanist*, that Prof. T. G. Halle would review his work on the palaeobotanical side, and that I should review that on living plants, I, therefore, readily acceded to his request and set out to prepare this brief sketch.

Sahni's first paper entitled "Foreign Pollen in the Ovules of *Ginkgo* and of Fossil Plants" was published in the *New Phytologist* of 1915, only a few years after he reached Cambridge. Here he recorded the presence of pollen grains other than those of *Ginkgo* in no less than eight out of about a

dozen ovules of this plant obtained from Montpellier. Most of them showed the presence of two prothallial cells thus indicating their abietineous nature and one had germinated to form a tube twice as long as its own diameter.

Although an interesting observation in itself and quite indicative of the discerning power of the author, it is the latter part of the paper which specially revealed Sahni's critical insight even at that early stage of his career. He notes: "If a similar example were found in a fossil state, it would in all probability have led to a reference of the pollen grains and ovule to the same species." Further, "the mere fact of germination cannot be used in support of conclusions regarding the identity of fossil pollen-grains found enclosed in ovules".

Sahni's next paper, published in the *New Phytologist* of 1915, dealt with the anatomy of *Nephrolepis volubilis*, collected near Kuala Lumpur, Federated Malay States, by Prof. F. T. Brooks, at that time Lecturer in the Botany School of the Cambridge University. This is a very peculiar fern in which the enormously long stolons arising from the mother plant scale forest trees to a height of 16 metres. The lateral plants borne on them at intervals reach heights considerably above the mother plant which is rooted in the soil. Periodically the former are shed to the ground after which they produce their own roots. Sahni gave a detailed account of the anatomy of the stolon and the manner in which the basal protosteles of the lateral plants becomes modified into a dictyostele. Unfortunately no part of the mother plant was available to him and, therefore, a fuller account could not be given.

From *Nephrolepis volubilis* Sahni proceeded to a study of the vascular anatomy of the tubers of *N. cordifolia* (*New Phytologist*, 1916) which are formed as terminal swellings of short branches of the underground stolons. The influence of the size factor on internal structure was very evident in this case. The strand of the branch stolon

enters the base of the tuber as a solid proto-stele but rapidly expands in a funnel-like fashion, acquiring internal phloem, pericycle, endodermis and ground tissue. Eventually the expanded stele breaks up into a hollow network of tangentially flattened strands separated by gaps of irregular shapes and sizes. Towards the apex of the tuber the strands converge again to form a single protosteles.

An important point here is the breaking up of the stele and the formation of gaps without any influence from leaf traces which in normal fern rhizomes have been held to be the dominating factors in the evolution of a dictyostele.

Soon after the publication of his papers on *Nephrolepis*, Sahni submitted a dissertation for the Sudbury-Hardyman Prize on the "Evolution of Branching in the Filicales" which was published in the *New Phytologist* of 1917. In this he showed that as a rule the branches do not hold any regular position with respect to leaves and those cases where such a relationship is found, "this association is, in its evolutionary origin, a secondary phenomenon attributable to possible biological advantages, one of which may be the protection of the young bud".

New Caledonia shares with some other islands of the Pacific the possession of a large number of endemic species which are of great interest to the morphologist and systematist. Prof. R. H. Compton of South Africa, who visited these islands in 1914, collected a number of plants among which was also the rare and little known conifer *Acropyle Pancheri*. Originally named by Pancher as *Podocarpus pectinata*, then renamed by Brongniart and Gris (1869) as *Dacrydium Pancheri*, this plant was finally transferred by Pilger to a new genus of doubtful affinity. The generic name *Acropyle*, which he gave to it, refers to the so-called apical position of the micropyle although actually it is not quite so.

The material collected by Compton was rather fragmentary and poorly preserved, but Sahni was able to produce a fairly exhaustive work on the morphology and anatomy of this plant which was submitted to the London University as a part of his D.Sc. thesis in 1919 and published one year later in the *Philosophical Transactions of the Royal Society*.

Although Coulter and Chamberlain (1917) placed *Acropyle* in the Taxineae and the same procedure was followed by Chamberlain (1935) in his book on Gymnosperms, Sahni's work has made it clear that this genus is very similar to *Podocarpus* in the vegetative anatomy of the root, stem and leaf. Marked similarities also exist in the structure of the male cones, microsporophylls and pollen grains, the drupaceous character of the seed, and the organization of the female gametophyte and young embryo. The only important differences between the two genera are that in *Acropyle* the mature seed is nearly erect, the epimatium is fused to the integument even in the region of the micropyle, and the vascular supply of the ovule is much better developed than in *Podocarpus*. Taking the sum total of the characters, however, it was clear that *Acropyle* had to be classed in the Podocarpaceae, perhaps as one of its most highly specialized members.

In the theoretical part of the paper Sahni proposed a division of the Gymnosperms into two broad groups: (a) Phyllospems, with seeds borne upon the leaves; and (b) Stachyosperms, with seeds borne either directly upon an axis or upon a structure which is probably some modification of an axis. The Phyllospems included the Pteridosperms and Cycadales (also the Caytoniales), and the Stachyosperms included the Cordaitales, Ginkgoales, Coniferales, Taxales and Gnetales. The position of the Bennettitales remained doubtful owing to the uncertainty regarding the morphological nature of their ovule-bearing stalks.

As remarked by Florin (*Botanical Gazette*<sup>1</sup>, 1948) Sahni's view that these two groups constitute a natural assemblage receives considerable support from the results of recent researches on the morphology and phylogeny of the Palaeozoic and Mesozoic conifers.

In the year 1920 Sahni published another paper dealing with seed structure of *Taxus* and suggested that the Palaeozoic seeds *Cycadinocarpus*, *Rhabdospermum*, *Mitrospermum* and *Taxospermum*, all belonging to the Cordaitales, illustrated the general tendency which may have operated in producing the types of seeds found in *Taxus*, *Torreya* and *Cephalotaxus*. He further proposed that these three genera were sufficiently apart

1. *Bot. Gaz.* 110 (1): 31-39.

from the rest of the conifers to merit their being placed in a separate order Taxales. It is interesting to observe that recently Florin (*Botanical Gazette*, 1948) has accepted this view, which is a fine testimony to the shrewdness and insight of Sahni even during his pre-doctorate days.

Sahni's interest in the Taxales led him to cut some sections of the seeds of *Cephalotaxus pedunculata* in which he discovered the presence of an apical prolongation of the female gametophyte, which surrounded by a moat-like depression into which the archegonia open, props up the nucellar membrane somewhat like a tent-pole. Since the tent-pole is also found in several Cordaitalean seeds, he took it to be a further evidence of the close affinity between the two groups<sup>2</sup>.

In 1924 Prof. Sahni, then Head of the Department of Botany at the Lucknow University, was elected President of the Indian Botanical Society which had been founded only three years earlier as the result of his own efforts and those of Profs. W. Dudgeon (Allahabad), S. R. Kashyap (Lahore) and K. Rangachari (Madras), none of whom is with us any more. The subject of Prof. Sahni's presidential address was "The Ontogeny of Vascular Plants and the Theory of Recapitulation". Although formulated for all living organisms, the theory of recapitulation had so far derived its chief support from the zoological side. Sahni took pains to show that an equally convincing case could be made out for it on the botanical side. He cited numerous examples from ferns to support his contention, but did not fail to draw upon the gymnosperms and angiosperms and even the algae and bryophytes, and made a contribution which is fully indicative of his scholarliness and powers of reviewing facts.

The brilliant discoveries of Kidston and Lang and the great resemblances between the Psilophytales and Psilotales inspired Sahni into some studies on the latter. In 1923 he published a short paper entitled "On the Theoretical Significance of Certain So-called Abnormalities in the Sporangio-phores of *Psilotum* and *Tmesipteris*" based on some material of these plants collected from New Caledonia by Prof. R. H. Compton.

2. Tent-poles have also been reported in other gymnosperms, such as *Taxus* (DUPLER, 1917), *Saxegothaea* (DOYLE & LOOBY, 1939), *Ephedra* (MAHESHWARI, 1935), but their exact significance remains doubtful.

He concluded that the sporangiophores of the Psilotales are not forked sporophylls but axial organs comparable with the branched sporangium-tipped axes of the Psilophytales.

This short paper was followed by a larger and more detailed contribution published in the *Philosophical Transactions of the Royal Society* (1925) in which Sahni gave a very complete account of the morphology and anatomy of the rare species, *Tmesipteris Vieillardii*. The erect and terrestrial habit and presence of medullary xylem in the stem distinguish this plant from the more common *T. tannensis* which grows as a pendant epiphyte and is devoid of any xylem elements in the pith. Sahni correctly compared the medullary xylem of the former with the central cauline xylem in the steles of *Asteroxylon* and *Lycopodium* and concluded that the Psilotales, especially *Tmesipteris*, offered a closer resemblance to the Devonian genus *Asteroxylon* than had been suspected up to that time.

Another piece of work started by Sahni at Cambridge but completed only after his return to India (in collaboration with his pupil A. K. Mitra) deals with the anatomy of some New Zealand species of *Dacrydium*. As a result of this study one of these species, *D. Bidwillii*, had to be transferred to the genus *Podocarpus*. Another, *D. laxifolium*, was found to be peculiar in the absence of all traces of xylem parenchyma and of resin or mucilage canals in the stem, leaves or ovules. The article is concluded with a criticism of the view that *Podocarpus* is the most primitive member of the Podocarpaceae. The authors express the opinion that *Dacrydium* is the more primitive genus which gave rise on the one hand to *Podocarpus* (by inversion of the ovule) and on the other hand to *Acropyle* (by increasing succulence and fusion of the epimatium with the integument)<sup>3</sup>.

During his younger days Prof. Sahni was very fond of long treks in the hills. Once in 1908, when he was yet a college student, and again in 1920, soon after his return from Cambridge, he set out on a walking tour from Lahore to Ladakh via Chamba and the Bara Lecha. About 8 miles from Chamba was the village of Khajiar with a beautiful meadow and lake set in the midst of a

3. This view is open to modification and revision. As Florin (*Svensk Bot. Tidskr.* 1940) has pointed out, *Acropyle* shows some significant resemblances with section *Dacrycarpus* of the genus *Podocarpus*.

dense forest at a height of about 6,400 ft. above sea level. A curious feature of the lake is a small island thickly overgrown with tall reeds and gliding over the water like a sailing vessel before a breeze. Sahni was naturally attracted by the sight of this island and presented his observations in a paper entitled "A Note on the Floating Island and Vegetation of Khajiar, near Chamba in the N.W. Himalayas" (*Journal of the Indian Botanical Society*, 1927), which again speaks of his great power of taking advantage of every situation and pursuing any idea with keenness and determination. Although the facts outlined by him were inadequate for a reconstruction of the precise origin or history of the floating island, there seems to be no reason to doubt his view that there once arose around the lake an extensive reed fen of which the islet was the only persisting relic, detached like the "Plav" of the Danube described by M. Pallis in the *Journal of the Linnean Society* of 1916.

During his memorable voyage of the "Beagle" Captain Fitz Roy discovered a new monotypic conifer named *Fitzroya patagonica*, some material of which was passed on to Sahni by Prof. A. C. Seward during his Cambridge days. This he studied in co-operation with T. C. N. Singh on his return to India (*Journal of the Indian Botanical Society*, 1931). Besides some peculiarities in the anatomy of the leaf they described the three curious gland-like organs which are found in this plant at the apex of the female cone alternating with the last whorl of scales. Their exact morphological nature still remains problematical. The authors called attention to their superficial resemblance with naked nucelli (i.e. ovules devoid of integuments) but wisely refrained from any further commitment on their homologies.

While searching for flowers on a young *Ginkgo* tree at Lahore in 1920, Sahni noticed some abnormal leaves shaped like the ascidia found in *Ficus Krishnae*<sup>4</sup> and certain garden varieties of *Codiaeum variegatum*. The two lower margins of the triangular lamina, which in a normal leaf converge into the petiole, were bent over and fused on the upper side so as to make a funnel. While no morphological significance was attributed

to this abnormality, Sahni (*Journal of the Indian Botanical Society*, 1933) quoted numerous instances of the occurrence of similar ascidia in several Mesozoic and Tertiary species of *Ginkgo*, *Ginkgoites*, *Ginkgodium* and *Baiera*. He ends the paper with a cryptic note: "It is indeed strange how these peculiarities sometimes tend to persist through geological time."

While most university men in India look upon the summer vacation as a time of rest and pause in some hill station, this was hardly so with Sahni. He used to spend this time botanizing in Kashmir, Almora, Lansdowne and other places in the Himalayas. Away from the din and bustle of Lucknow and the pressing duties of his office, it was in these summer months that he used to do much of his thinking and planning, writing of manuscripts, and even active work at the microscope. During one of these visits to Lansdowne, Garhwal (Western Himalayas), he made some interesting observations on the fruits and seeds of *Viscum japonicum* Thunb., now called *Korthalsella opuntia* Merr. This is a very common parasite in the lower Himalayas on *Quercus incana* and at Lansdowne there is hardly an oak tree which is free from one or more bunches of it. The minute obovoid fruits ripen in the rainy season during the month of July and the seeds are ejected with some force to a distance of two feet or more. Microscopic examination revealed that this is due to the occurrence of a viscid layer in the fruit which swells in the presence of moisture and causes an all-round internal pressure on the seed which is relieved only by a rupture of the fruit at its apical end and a shooting out of the seed in manner comparable to the discharge of a bullet. Prof. Sahni very kindly passed on some material of this plant to me for a more detailed investigation and refers to this in his paper published in the *Journal of the Indian Botanical Society* of 1933. This work, I am glad to say, is now nearing completion and will be published elsewhere in due course.

In 1935 Sahni wrote a short but interesting paper entitled "The Roots of *Psaronius*, Intra-cortical or Extra-cortical? A Discussion" in which some very interesting observations were recorded on the anatomy of the roots of *Asphodelus tenuifolius* (see also MEHTA, 1934; and PANT, 1942<sup>5</sup>) which is

4. There is a legend in India that Lord Krishna drank milk from the leaf-cup of this plant.

5. *Jour. Ind. Bot. Soc.*, 13 & 22.

a common weed in north India during the winter season. Unlike other monocotyledons this plant has a main root which persists like that of a dicotyledon. The younger roots grow vertically downward through the cortex of this root which becomes greatly distorted. This is made possible by the activity of a peripheral cortical cambium which gives rise to several layers of periderm. The younger rootlets contribute to the girth by the formation of peripheral periderms of their own but these periderms are developed only on their outer sides, where they are in contact with the main periderm. In a full-grown plant a transverse section of the root presents a baffling appearance with as many as a hundred or more intra-cortical roots packed around the centrally placed stele of the main root. These roots are usually so densely crowded that the original cortex of the main root is practically all crushed and disorganized. At the lower end of the plant the roots are seen breaking through the sheathing periderm, either singly or in thongs of two or more, which themselves become resolved into their constituents at still lower levels.

What significance these observations have in our understanding of the anatomy of *Psaronius* is for palaeobotanists to judge but Prof. Sahni felt that the compact root zone seen around the stele is a part of the stem itself being formed by the presence of many roots growing down through the cortex.

The paper on the anatomy of the roots of *Asphodelus* was perhaps the last of Sahni's major contributions to plant morphology, and although his interest in living plants never faded, his own studies henceforth were devoted almost exclusively to palaeobotanical, geological and archaeological investigations. Even so he inspired many a young man in India into studies on living plants. No reference to him would, therefore, be complete without a brief mention of the work of some of his pupils in this line.

While Professor of Botany at the Banaras Hindu University for a few months, Sahni

encouraged N. K. Tiwary, himself a very senior botanist in India, to work on the origin of the polyembryonate condition in *Eugenia*. At Lucknow the first to come under his fold were S. K. Pande who has worked actively on the morphology and biology of the liverworts for upwards of twenty-five years; T. C. N. Singh, now Professor of Botany at the Annamalai University, who interested himself in the anatomy of ferns; and the late S. K. Mukherji who later went abroad and specialized in Ecology and Soil Science. K. M. Gupta, now Professor of Botany at the Dungar College, Bikaner, worked on the anatomy of some homoxyloous woods and described the mode of reproduction in a moss, *Physcomitrellopsis indica*, collected by Sahni from Banaras; and K. N. Kaul, Professor of Botany at the Agricultural College, Kanpur, sought to classify the palms on the basis of the structure of the ground tissue of the stem<sup>6</sup>. In addition, H. S. Rao, now at the Forest Research Institute, Dehra Dun, contributed an important paper on the structure and life-history of *Azolla pinnata*, which was, no doubt, inspired by Sahni's great interest at that time in the fossil history and past distribution of Hydropterideae; N. P. Chowdhury (1937) made a detailed study of the anatomy of some Indian species of *Lycopodium*; D. D. Pant (1942), now at the University of Allahabad, produced a detailed account of the anatomy of the roots of *Asphodelus tenuifolius*; and Bahadur Singh has given an interesting account of the embryology and anatomy of *Dendrophthoe falcata* which is in course of publication.

In flesh and blood Sahni is no more with us, but the torch he lighted during the last thirty years now burns more brightly than ever and the foundation of a research institute after his name will always be a reminder of the great man who brought it into existence.

6. Work on the anatomy of palms is now being continued by T. S. Mahabale at the Royal Institute of Science, Bombay.