PENTOXYLON FOSSIL

CHAPTER 7

Pentoxylales

- Introduction
- Characteristic Features
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Introduction

The name *Pentoxyleae* was proposed by Prof. Birbai Sahni in the year 1948 for a group of fossil plants discovered from the Jurassic horizon of the Rajmahal hills (Bihar) of India. These plants have been treated under a separate order by Sporne (1965). The order includes a number of stems (*Pentoxylon, Nipanioxylon*), leaves (*Nepaniophyllum*), pollen-bearing organs (*Sahnia*) and seed-bearing organs (*Carnoconites*). Sahni and Srivastava (1948) carried out extensive researches on the stems, leaves and seed-bearings organs. Vishnu Mittre described the pollen-bearings organs in 1953.

The members of this group are a unique combination of characters of *Bennettitales, Cycadales* and *Coniferales.* A few characters are peculiar to the group itself and hence it deserves a position as a separate order of the *Cycadopsida.* These have been found to occur in silicified petrification. Harris (1962) has also discovered them from New Zealand. He found only the seed-bearing organs.

Characteristic Features

The order is characterised by the following features :

1. The plants were probably shrubs or small trees. The habit is not known but the size and diameter of the stem, its branching and leaves reflect upon its shrubby or tree-like habit.
2. The branches were of two types : (*i*) long shoots and (*ii*) dwarf shoots.
3. The leaves were spirally arranged.
4. The stems were polystelic with 5 and 6 primary steles, hence the name Pentoxylae. Each stele has its own complete ring of cambium.
5. The development of secondary wood is exocentric.
6. The secondary medullary rays were uniseriate.
7. The leaves were simple, lanceolate and thick.
8. The venation was open, rarely reticulate.
9. The reproductive organs were unisexual. The female strobili looked like mulberries.
10. The male organs consist of a whorl of branched sporangiophores fused at the base into a disc. The sporangiophores bear microsporangia on its short branches.
11. The reproductive organs are borne terminally on short branches.
12. The tracheids have crowded, circular bordered pits on their radial walls.
13. The female reproductive organs lacked interseminal scales and consisted only of a thick central axis with ovules attached to it in a spiral manner.
14. The ovules were sessile.
15. The stomata were regarded by Sahni to be syndetocheilic by later Vishnu Mittre (1953) found that haplocheilic or cycadalean stomata also occur. So both the types were met with.

External Characters (Fig. 7.1)

Pentoxylon sahnii and *Nepanioxylon* are the two stem genera discovered from the Rajmahal hills in India. The stems were 3 mm to 2 cms across in the former species. It bore rhomboidal leaf scars and spirally arranged simple leaves. Short lateral shoots arose from the stem and the leaves were restricted to these shoots and were strap-shaped, simple, petiolate with entire margin and obtuse apex. There was distinct single mid-rib giving off lateral veins that ran outwards towards the margin and were parallel. The lateral veins were usually unbranched. Occasional dichotomies and reticulations have been noticed in rare cases. The reproductive organs were borne terminally on the short lateral shoots. The leaves were described under the name *Nipaniophyllum raoi.* They were later found attached to the shoots of *P. shanii*. These leaves were up to 7 cm long and one cm broad.

Anatomy (Fig. 7.1)

A cross section of the stem reveals five main primary steles, *i.e.*, the stem is polystelic. Each stele is a concentric structure having its own cambium that is uniformly active in young stems but in older stems, it produced more secondary tissue towards the centre so that the secondary wood became excentric. External to the cambium was primary phloem and primary xylem was in the form of an internal ring. The vascular strands run longitudinally and give off leaf traces. In addition to the 5 main strands there were 5 smaller strands alternating with them. According to Sahni, these were the strands of the lateral shoots. According to Vishnu Mittre, the number of primary strands varies at different levels along the length of the stem. Series of transverse sections cut at different levels

revealed that there were three strands in the lower region of the stem and 5 in the middle, whereas the number increased to six at the top. In *Nipanoxylon guptai* there was a single vascular cylinder near the base of the stem whereas the number increases to 5 to 7 at a higher level and the strands again coalesce at apex to form a single vascular cylinder again.

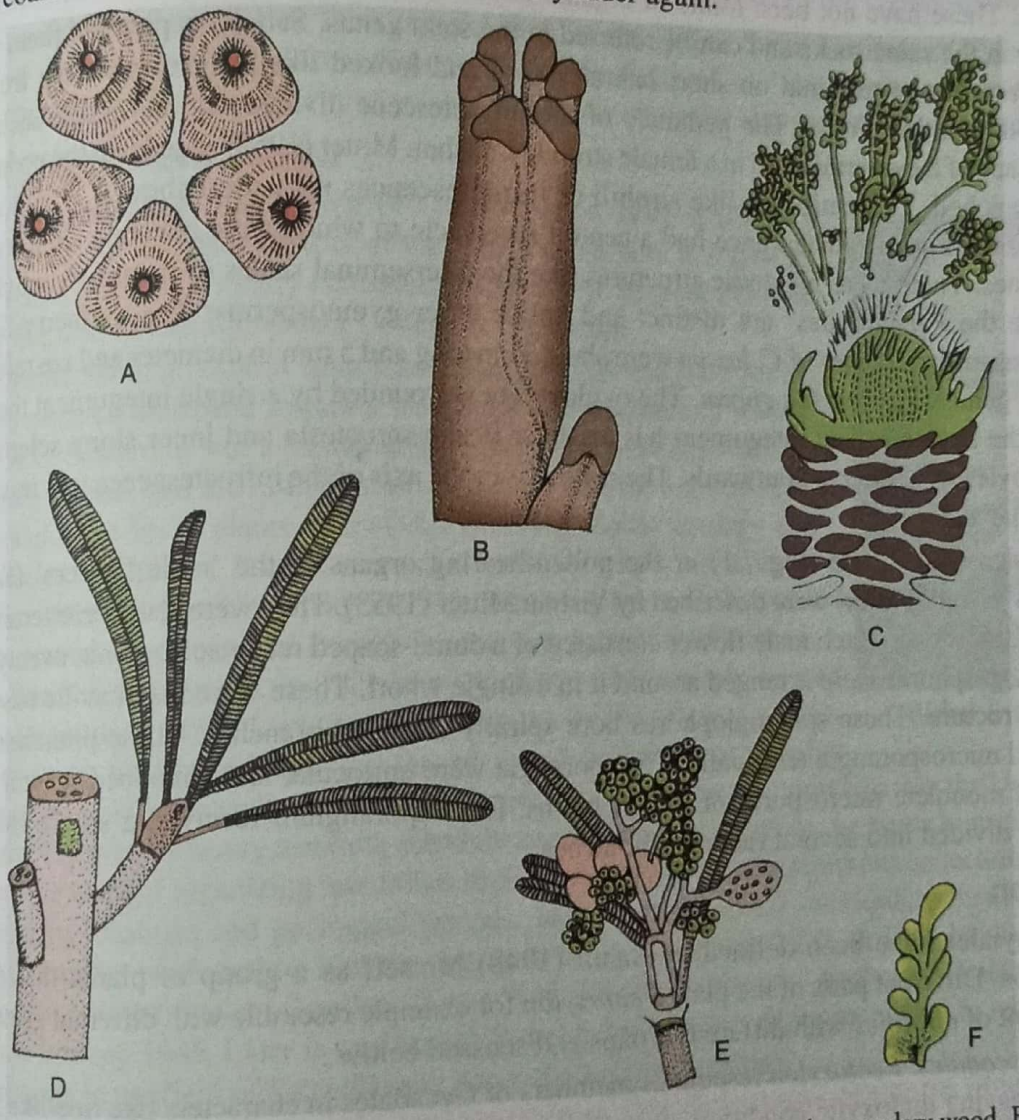


Fig. 7.1 *Pentoxylales* (A—F). A. Five steles of *Pentoxylon sahnii* showing excentric secondary wood. B. Trunk of *P. sahnii* C. Reconstruction of *P. sahnii* bearing a dwarf shoot and leaves. D. The male organs of *P. sahnii* borne at the tip of a branch. E. The mulberry-like female strobili (*Cornoconites compactum*). F. A microsporophyll.

The secondary xylem was pycnoxylic, *i.e.*, the wood was very compact. This is a coniferous character. The tracheids were quite like those of the living *Araucaria* and possessed circular bordered pits that may be uniseriate or biseriate and were present on the radial walls. The secondary medullary rays were also uniseriate and ranged in height from one to five cells. The secondary wood developed more towards the centre. The secondary wood shows growth rings but it cannot be definitely stated whether they represent annual rings.

The leaf traces are typically cycadalean because they posses vascular bundles with both centrifugal and centripetal xylem (diploxylic). Six strands entered each leaf base. They arose singly from the steles. Regarding stomata Sahni (1956) stated them to be syndetocheilic like those of the *Bennettitales*, but Vishnu Mittre (1957) observed them to be of both types. He also observed haplocheilic stomata on the leaf. So in this character *Pentoxylales* combine both Benettitalean and Cycadalean features.

Reproductive organs

Two species of seed-bearing organs have been described by Sahni and Srivastava from the Jurassic horizon of Rajmahal hills. These are *Cornoconites compactum* Srivastava and *C. laxum* Srivastava. These have not been found in organic connection with the stem genus *Pentoxylon* but they occur in the same rocks and can be referred to the stem genus. Sahni has pictured them in his reconstruction, to be terminal on short lateral shoots and looked like stalked mulberry fruits or annonaceous multiple fruits. The peduncle of the infructescene divided into several branches or pedicels. Each of these terminated in a female strobilus. Vishnu Mitter (1953) stated that the peduncles were unbranched. The mulberry-like strobili or infructescences measured about 1.8 cm long in *C. compactum*. Each infructescence had a central receptacle to which were attached about twenty sessile ovules. There were no sterile structures like the interseminal scales or megasporophylls. In this feature the *Pentoxylales* are distinct and unlike other gymnosperms. The mulberry-like or annonaceous infructescenes of *C. laxum* were about 3 cm long and 5 mm in diameter and are referable to the stem genus *Nipanoxylon guptai*. The ovules were surrounded by a single integument that was free from the nucellus. The integument has an outer fleshy sarcotesta and inner stony sclerotesta. The micropyles were directed outwards. The cone axis or the axis of the infructescence was traversed by 5 vascular strands.

The microsporangiate (Fig 7.1) or the pollen-bearing organs or the 'male flowers' (*Sahnia nipaniensis* Vishnu Mitter) were described by Vishnu Mitter (1953). They were also borne terminally on short lateral shoots. Each male flower consisted of a dome-shaped receptacle. About twenty-four microsporangiophores were arranged around it in a single whorl. These were fused at the base into a discoid structure. These sporangiophores bore spirally arranged branches. These branches bore pear-shaped microsporangia terminally. The sporangia were unilocular and contained several boat-shaped and monolete microspores or pollen grains. Each sporangium received a single vascular bundle that divided into several radiating branches.

Discussion

Pentoxylales have been defined by Sahni (1948) himself as a group of plants that defies classification. Different parts of the plant *Pentoxylon* for example resemble with different groups. A brief account of *affinities* with different groups is discussed below :

With Cycadales. Pentoxylon resembles members of Cycadales in characters like tree-like habit, leaf traces having diploxylic condition, unisexual reproductive organs, microsporangia not uniting in synangia with monocolpate boat shaped microspores. In having polystele stem with pycnoxylic wood and simple leaves, *Pentoxylon* differs from Cycadales. While the seed bearing organ in *Cycadales* is leaf borne (phyllospermous), it is stem borne (stachyospermous) in *Pentoxylae*. Moreover integument is free from nucellus in Pentoxylae.

With Cacadeoidales. The Pentoxylae shares the character with Bennettitales (Cycadeoidales) are : the microsporangiophore arrangement, bisymmetrical ovules and thick sclerotesta. However Pentoxylae differs in polystelic stem and lack of interseminal scales between ovules.

With Medullosaccae. In having polystelic condition, *Pentoxylon* closely resembles with *Medullosa*. However in *Medullosa* the stele is centrifugally developed while in *Pentoxylon* it is centripetally developed. The reproductive structures too differ. While in *Pentoxylon*, these are stachyospermous, in *Medullosa* these are phyllospermous.

With Conifers. Pentoxylae resemble conifers in having pycnoxylic wood with trachieds having bordered pits. In both the groups dimorphic shoots are present. However, in several other characters both differ.

With Angiosperms. The group Pentoxylae has been compared with *Pandanus* by Moeuse (1961). Both *Pentoxylon* and *Pandanus* are erect or suberect, dioecious plants with cylindrical stems bearing terminal tufts of strap shaped leaves and fleshy seeds.

The female infructescence with cone-like organisation and without any sterile appendages or megasporophylls is a character unique to Pentoxylales. The sporangiophores with spirally arranged branches bearing terminal and unilocular sporangia is also a character unique to Pentoxylales. These interesting features, in addition to those stated above, stamp the group of the Gymnosperms.

It would be interesting to learn that emblem of the Birbal Sahni Institute of Palaeobotany, Lucknow named after Prof. Birbal Sahni is based on *Pentoxylae* – the group instituted by Prof. Sahni. The internationally acclaimed journal *The Palaeobotanist* also carries the same emblem.

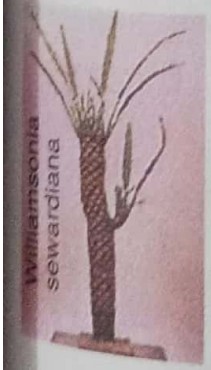
PROFESSOR BIRBAL SAHNI

Prof. Sahni was born on the 14th of November, 1891 at Bhera, a small town in the Shahpur District of the West Punjab now in Pakistan. Birbal Sahni received his early education at Lahore. In the year 1911, he left for England to join Emmanuel College at Cambridge.


Birbal Sahni

Birbal Sahni graduated from Cambridge in 1914 and soon settled down to research under the inspiring leadership and guidance of Professor Sir A.C. Seward. It was a relationship deeper and more exquisite than between a teacher and his disciple that stimulated him for a meaningful understanding of fossil plants, knowledge of living plants, geology and other related disciplines. For his researches on fossil plants he received the D.Sc. of the London University in 1919. Returning home in the same year, he served as professor of Botany for one year each at the Universities of Banaras and Punjab. In 1921 he took charge of the newly opened Botany Department of the Lucknow University, as its first Professor. Charisma of Professor Birbal Sahni as a teacher noted for brilliance, lucidity and illustrative skills became a legend and inspired a number of young minds to join the University of Lucknow. Despite his heavy teaching schedule and other preoccupations, he threw himself heart and soul into the work of organizing researches in palaeobotany and made enormous collections of fossils from various localities and geological periods. In recognition of his outstanding merits the Cambridge University conferred on him the degree of Sc.D. in the year 1929. In 1936 he was elected a Fellow of the Royal Society, London. It was Prof. Sahni who founded Institute of Palaeobotany at Lucknow in Sept. 1946. Later it was named Birbal Sahni Institute of Palaeobotany to recognize his contributions in the field of Palaeobotany particularly Gymnosperms.

The set of four stamps issued by the Department of Posts to commemorate the fiftieth anniversary of the Birbal Sahni Institute of Paleobotany in Lucknow, Uttar Pradesh, depict the richness and variety of plant fossils.



Williamsonia sewardiana - A model of the extinct plant Williamsonia sewardiana which thrived in Rajmahal, Bihar about 140 million years ago. This model is based on the reconstruction envisaged by Prof. Birbal Sahni.

Pentoxylon - An important discovery of Prof. Birbal Sahni is the extinct plant group named Pentoxylae from Nipania in Dumka district, Rajmahal Hills, Bihar (age 110-114 million years). Reconstruction of plant with leaves, stem, flowers.


Pentoxylon

Glossopteris - The tongue-shaped leaf Glossopteris, represents a unique group of extinct vascular plants (age : Permian, 250-280 million years). During this period India occupied a position south of equator close to South Pole as a part of a very large continent which included South America, Antarctica, Africa and Australia, called Gondwanaland. This vegetation was responsible for the precious coal reserves in peninsular India.

Birbalsahni divyadarshanii-Fossil of an enigmatic flower-like organ of the extinct plant named after eminent Indian Palaeobotanists — Prof. Birbal Sahni and Prof. Divya Darshan Pant, discovered from Hura Coalfield, Santhal Pargana, Bihar (age 250-280 million years).