PENTOXYLALES

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Contents:

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1. Systematic Position of Pentoxylales:

Sporne (1965) has rightly stated that “the correct phylogenetic placing of the Pentoxylales is a most fascinating problem”. Birbal Sahni (1948) had already expressed almost similar views:

We are faced with a real difficulty when we try to ascertain the place of the Pentoxyleae”…….”While in their seed attachment they are clearly stachyosperms (Coniferophytes), and they also have a coniferous type of secondary wood, their stomatal structure is fundamentally bennettitalean, the vascular anatomy of their leaves is truly cycadean, and the general anatomy of the stem is unique” (Sahni, 1948).

According to him, Pentoxyleae “occupy a unique and rather isolated position”.

Vishnu-Mittre (1957) opined that if characters of stems, leaves, and male and female reproductive organs are compared, Pentoxyleae exhibits close affinities with Cycadales. The group (Pentoxylales) “should thus be given an equal rank amongst the Bennettitales and the Cycadales”.

Rao (1974) has also expressed almost similarly. Because definite organic connections between the discovered organ genera of Pentoxylales has not so far been established or completely proved, this fascinating topic should be kept pending “till more structural data about them and their mutual organic connections are discovered”.

2. Discovery of Pentoxylales:

This group has been discovered and named as **"Pentoxyleae"** by well-known Indian Palaeobotanist Professor Birbal Sahni (1948). This is a group of some fossil plants described from Rajmahal Hills in Amrapara District (Santhal Parganas) of Eastern Bihar (India) revealing their existence in Jurassic Period.

Sahni (1948), while introducing this group, remarked: **"……Some discoveries in size help or appear to help in solution of the old standing problems, others and these are perhaps the most interesting, seems to create new difficulties in our path."**

True to his words, Professor Sahni's discovery of Pentoxyleae has created many new problems to the taxonomy of gymnosperms, as well as has become a threat to our understanding of the evolution of gymnosperms.

While Pentoxyleae exhibits certain characteristics, not shown by members of any other group of gymnosperms, this also shows a combination of features characteristic of the Bennettitales, Cycadales and Coniferales.

Lam (1952) suggested that Pentoxylae should be given a rank equivalent to Bennettitales and Cycadales in the Gymnospermous classifications. Sporne (1965) has treated this group as an order under the name "Pentoxylales".

Harris (1962) also discovered some members (Carnoconites cranwelli) of this group from New Zealand. B P. Srivastava (1946) and Vishnu-Mittre (1953, 1957) are some of the major Indian contributors on Pentoxylales.

Stems, leaves and male and female reproductive organs of this group have been described under following names:

Stems: Pentoxylon and Nipanioxylon

Leaves: Nipaniophyllum

Pollen-bearing organs: Sahnia

Seed-bearing organs: Carnoconites.

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3. Distinguishing Features of Pentoxylales:

1. Extinct Mesozoic plants found in Jurassic period.

2. Although the exact habit of these plants is not clearly established, these were probably shrubs or very small trees.

3. Long and short shoots were present on these plants.

4. Short shoots had spirally arranged leaves and terminally located reproductive organs.

5. Leaves were thick, simple, lanceolate, and had diploxylic leaf trace.

6. Stomata were formerly thought to be syndetocheilic, but now they are considered to be haplocheilic. 7. Leaves possessed open venation.

8. Stems were polystelic. Basinger et al. (1974) opined that “it may be more appropriate to call each stele as vascular segment or sympodium”.

9. Wood of Pentoxylon was pycnoxylic and resembled Araucaria.

10. Ovules were sessile.

11. Female reproductive organs were like stalked mulberry, consisting of about 20 sessile seeds attached to central receptacle and surrounded by stony layer and then fleshy outer layer of integument uniting them.

12. Male reproductive organs or microsporophyll’s form whorl of branched micro-sporangiophores.

13. The micro-sporangiophores were fused basally into a disc-like structure.

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4. Stem Genera of Pentoxyleae:

(i) Pentoxylon Sahnii:

Pentoxylon sahnii and Nipanioxylon guptai are the stem genera of “Pentoxyleae”. The stems of Pentoxylon sahnii attained a diameter from 3mm to 2 cm. The stem has always been reported in association with the leaves called Nipaniophyllum.

Presence of five steles in a cross- section of the stem has been the main reason for giving the name Pentoxylon to the genus. Many short lateral shoots or dwarf shoots were also present on the stem.

Five steles (Fig. 7.1) occupied greater part of the stem in a cross-section. Each stele had its own cambium. The cambium was uniformly active in the young stems, but at

maturity more secondary tissue developed towards the centre, and thus the secondary wood appeared eccentric.

Primary phloem and primary xylem were present towards outer and inner sides of the cambium, respectively. Six steles have also been observed by Sahni (1948), although rarely. According to Vishnu-Mittre (1953) the number of steles varied along the length of the stem.

There were present five much smaller bundles just alternating with the main bundles of the stem i.e. five steles. Each such bundle had a large amount of secondary wood. These were probably the leaf trace bundles.

Medullary rays of the main steles were uniseriate, and they lacked ray tracheids, wood parenchyma and resin canals. The secondary wood resembled greatly with that of Araucaria. Uniseriate or bi-seriate bordered pits were present on the radial wall of tracheids.

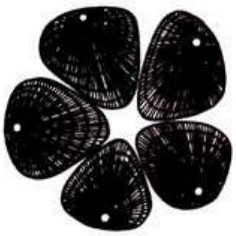

Fig. 7.1. *Pentoxylon sahnii.* T.S. stele. (after Sahni)

(ii) Nipanioxylon:

This stem genus of Pentoxyleae was discovered from the village Nipania and hence named Nipanioxylon. Village Nipania is in Rajmahal Hills, near Dumarchir in the Amrapara district (Santhal Parganas) in Bihar (India). Nipanioxylon differed from Pentoxylon in possessing larger number of bundles (steles) and less developed secondary growth in the stem. Nipanioxylon resembled Pentoxylon in other details.

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5. Leaves of Pentoxyleae:

Nipaniophyllum:

The leaves have been described under the name Nipaniophyllum raoi. They were found attached with the shoots or Pentoxylon sahnii. They were originally described under the name Taeniopteris. They were present on the short lateral shoots (Fig. 7.2). Each leaf was simple, petiolate, strap-shaped, and possessed a well-developed mid rib with many

parallel lateral veins. Branching has not been observed in lateral veins.

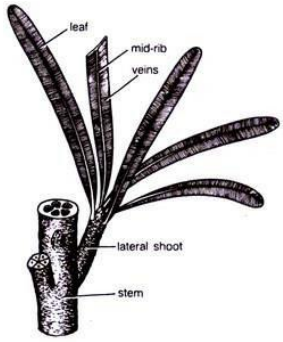

Fig. 7.2. *Pentoxylon sahnii*. Reconstruction of stem and leaves (*Nipaniophyllum raoi*). (after Sahni).

Similar to cycads, the leaf traces had centripetal and centrifugal xylems, thus exhibiting diploxylic condition. Sahni (1948) reported the presence of syndetocheilic stomata in Nipaniophyllum but Vishnu-Mittre (1953) also observed the presence of Cycadalean type of haplocheilic stomata.

Later on, Sharma (1969) and Bose et al. (1985) observed that arrangement of stomata was anomocytic as in Cycads and most other gymnosperms. Vascular bundles in Nipaniophyllum were mesarch.

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6. Seed-Bearing Organ of Pentoxyleae:

(i) Carnoconites:

The female cones or seed-bearing organs have been described under the name Carnoconites. Two species (C. compactum and C.laxum) have been described. Both these species have, however, not been reported in organic connection with the stem genus Pentoxylon but from the same rocks.

Seed-bearing organs (Fig. 7.3) were forked and found attached terminally on the lateral dwarf shoots. They were mulberry-like, and attained a length of about 1.8 cm in Carnoconites compactum and 3 cm in C. laxum. They were, however, narrower in C. laxum.

About 20 sessile ovules were seen attached on the receptacle, and there were no inter-seminal scales. Any sporophyll-like structure was also not reported. In-spite of these facts Sahni (1948) used the word ‘cone’ for these structures. The ovules were covered by a single integument. The nucellus was free from the integument.

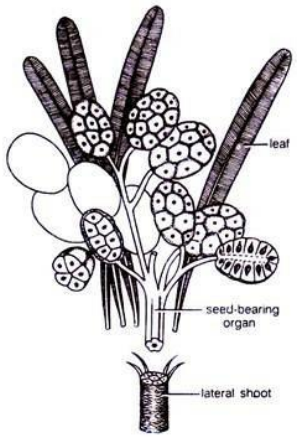

Fig. 7.3. *Carnoconites compactum*. Female cones. (after Sahni).

(ii) Sahnia Nipaniensis:

The probable microsporangiate or male organs of Pentoxyleae were named as Sahnia nipaniensis by Vishnu-Mittre (1953). They were present terminally on the shoot, and fused basally in a shallow disc (Fig. 7.4). Vishnu-Mittre (1953) reported as many as 24 such pollen-bearing organs.

Each microsporophyll possessed many pear-shaped, unilocular sporangia. The terminal position of the sporophyll was also occupied by a sporangium (Fig. 7.5). Several monocolpate and boat-shaped pollen grains were present in each microsporangium.

Fig. 7.5. *Sahnia nipaniensis*. A detached microsporophyll. (after Vishnu-Mittre).

The sexine of the pollen wall is homogeneous while its nexine is present in the form of thin dark zone. In the region of aperture, the sporoderm is highly folded. Taylor & Taylor (1987) observed a few lamellae in the region of aperture. Other details of the male flowers are not yet fully known.

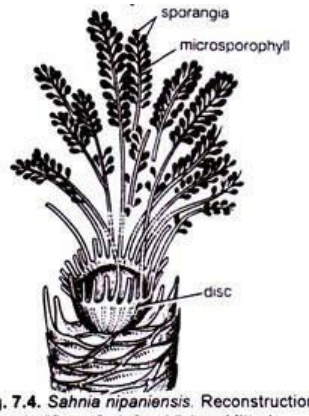

Fig. 7.4. *Sahnia nipaniensis*. Reconstruction of male "flower". (after Vishnu-Mittre).

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7. Affinities of Pentoxylales:

Some of their possible affinities are discussed below:

Affinities with Cycadales:

The two groups (Pentoxyleae and Cycadophytes) resemble each other in:

(i) possession of direct leaf trace in Pentoxyleae and seedlings of some cycads,

(ii) leaf traces anatomy in showing diploxylic nature of their vascular bundles,

(iii) haplocheilic stomata,

(iv) vestigial polystely in the seedling stages of some modern cycads,

(v) nature of wood and pittings,

(vi) possessing more or less similar kind of pollen grains, and

(vii) structure of their seeds and peduncles.

However, vascular bundles in Pentoxylon are not arranged in the Cycadean manner. There is also no similarity between the polystelic condition of Pentoxylon and mature modern cycads.

Affinities with Conifers:

Some of the characteristics, in which Pentoxylales resemble with conifers, include the presence of:

(i) Pycnoxylic wood,

(ii) Tracheids with circular bordered pits arranged in uniseriate or bi-senate manner,

(iii) Uniseriate wood rays, and

(iv) dimorphism in the stems of Pentoxylon sahnii and several conifers.

However, the general anatomy of the stem of Pentoxylales is not at all coniferous as mentioned also by Sahni (1948). Pentoxylales are totally stachyospermous (i.e. both the male and female organs were borne on stems, rather than on leaves) while conifer ales are partly phyllospermous and party stachyospermous.

Affinities with Medullosaceae:

Pentoxylales also resemble with members of family Medullosaceae of Palaeozoic Pteridospermales (e.g. Medullosa) in possessing a polystelic primary vasculature in their stems. The secondary wood of Pentoxylon was pycnoxylic, character also encountered in some species of Medullosa.

The two groups also resemble each other in their mode of branching as well as nature of their steles. Coniferous type of pittings were present in the stems of Pentoxylon and some species of Medullosa.

Affinities with Bennettitales:

Under mentioned are some of the resemblances between Pentoxylales and Bennettitales:

1. Presence of syndetocheilic stomata, in addition to haplocheihc ones.

2. Diploxylic nature of the vascular bundles.

3. Whorled micro-sporangiophores.

4. Superficial resemblances between male flowers of both the groups.

5. The manner in which the ovules were borne in Pentoxylales was similar to that of Bennettitales. However, the inter-seminal scales, found in members of Bennettitales, were absent in Pentoxylales.

6. Stachysporous nature of their male and female organs, i.e. instead of leaves, these organs were borne on the stems.

7. Both the groups share several common characters in their dwarf shoots.

8. Presence of direct leaf trace also brings the two groups quite close to each other.

However, the polystelic condition of the stems of Pentoxylon and Nipanioxylon has no similarity with that found in Bennettitales. In Pentoxyleae, the sporangiophores were erect, radial structures without any sterile part.

They were spirally branched and possessed sac-like unilocular microsporangia. On the other hand, in Bennettitales these structures were completely different. They had circinate dorsiventral pinnate sporophyll with a sterile and synangium-bearing portion.

Affinities with Some Other Groups:

While stem dimorphism of Pentoxylon sahnii is a Ginkgoalean feature as also a coniferous one, the diploxylic vascular bundles of Pentoxylales are also seen in Cordaitales as also in Bennettitales. Meeuse (1961) observed several resemblances between Pentoxylales and Pandanus (a member of family Pandanaceae of Monocotyledons) and opined that “Pandanaceae and some related monocotyledons” have descended directly “from Pentoxylales”.

Features Unique to Pentoxylales:

The mulberry-like female cones or infructescences of Pentoxylales (Carnoconites compactum) with over twenty sessile ovules attached to a central receptacle is a unique feature of this group.

Furthermore, these infructescences had neither any inter-seminal scales, nor anything that could be called a sporophyll, a unique feature again. The sporangiophores of Pentoxylales had spirally arranged branches and the sporangia were unilocular as well as terminal.

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8. Conclusion of Pentoxylales:

In view of the above mentioned unique features, (e.g. wood similar to that of a conifer, leaf and pollen grains like that of cycads and cycadeoids, and ovulate cones not reported in any other gymnosperms) as well as resemblances of Pentoxylales with several groups of plant kingdom, Sahni’s (1948) remarks that Pentoxyleae **“occupy a unique and rather isolated position”,** or Pentoxyleae “is a group of plants that defies classification”, still hold good.

This group, of course, belongs to gymnosperms, but to establish its phylogenetic relationships a lot more is still to be done.
