

## THE AFFINITIES OF THE PENTOXYLEAE

A. R. RAO\*

Professor of Botany (Retd), Lucknow University, Lucknow-226 007, India

### ABSTRACT

The medley of characters found in the different components of the Pentoxyleae are discussed. It is pointed out that at the present state of our knowledge of the morphology and anatomy of this group, it is not possible to refer it exclusively to any known group of plants. It is also pointed out that in view of the mixture of characters it shows, it can be only regarded as an isolated synthetic group, showing some features in common with Pteridospermales, Cycadales, Bennettitales, Ginkgoales and Coniferales.

*Key-words* — Pentoxyleae, Pteridospermales, Cycadales, Bennettitales, Ginkgoales, Coniferales (India).

### सारांश

पेन्टॉक्सिली की सजातीयतायें—ए० आर० राव

पेन्टॉक्सिली के विभिन्न घटकों में पाये गये लक्षणों के संकुल विवेचित किये गये हैं। यह इंगित किया गया है कि इस समूह की आकारिकी एवं शारीर की वर्तमान जानकारी के आधार पर इसे पौधों के किसी भी ज्ञात समूह से सन्दर्भित करना संभव नहीं है। यह भी प्रदर्शित किया गया है कि लक्षणों के संकुल को देखते हुए इसे केवल एक विलगित-कृत्रिम वर्ग माना जा सकता है जो टेरिडोस्पर्मेल्स, साइकेडेल्स, बेन्निटाइडेल्स, गिन्कगोयेल्स एवं कौनिफरेल्स से कुछ सामान्य लक्षण प्रदर्शित करता हो।

**I**N 1948, Prof. Birbal Sahni instituted a synthetic group the Pentoxyleae for the reception of three petrified organ genera with unique and unusual anatomical features combining those of the Pteridosperms, Cycadales, Bennettitales and Coniferales. All these were from *Nipania* in the Rajmahal hills, Bihar.

*Stems* — *Pentoxylon sahnii* Srivastava and *Nipanioxylon guptai* Srivastava.

*Leaves* — *Nipaniophyllum raoi* (some of which were known till then as *Taeniopteris spatulata* McClelland).

*Female cones* — *Carnoconites compactum* Srivastava and *Carnoconites laxum* Srivastava.

*Male cone* — *Sahnia nipaniensis* was added to this list by Vishnu-Mittre (1953).

It may be pointed out that organic connection between these organs has not yet been convincingly demonstrated. But still, the disposition of these fossils in the

rock matrix, with reference to one another, and the presence of corresponding morphological and anatomical features in them suggest that *P. sahnii* probably bore the leaves *Nipaniophyllum raoi* and female cones *Carnoconites compactum* and male cones *Sahnia nipaniensis*. It is also likely that the little investigated *Nipanioxylon guptai* also bore leaves like *Nipaniophyllum raoi* and perhaps female cones, *Carnoconites laxum*; no male cones are known. A full description of these genera is given by Sahni (1948). Vishnu-Mittre (1953) and Rao (1974) have also described their morphological and anatomical characters briefly. So no attempt has been made to describe the structural features of these genera again. In this brief note the medley of characters found in the Pentoxyleae, which make comparison with other higher groups of the plant kingdom possible, have been discussed.

\*Present address: Guru Charna, No. 2, XI Main Road, 3rd Block East, Jayanagar, Bangalore-560011.

The stem *Pentoxylon sahnii* was dimorphic like those of the Coniferales or the Ginkgoales. The thick long shoots were covered by just a few leaf scars while the slender short shoots were densely covered with scale leaf and foliage leaf scars as in some cycads and conifers. The internal anatomy shows that the secondary wood had tracheids with uniseriate or biseriate pitting, contiguous and often hexagonal, as in the Araucariaceae of the Coniferae. The primary vascular bundles were in the form of 5 to 6 tangentially extended bands and protoxylem was possibly mesarch, as in some Pteridosperms. In later developmental stages these bands developed secondary xylem on both sides but more on the inner side than on the outer side. This resulted in 3-6, but generally 5, vascular steles in the long shoot, each with exaggerated secondary wood on the inner side—presenting a polystelic condition similar to those of the Medullosae. In fact Sahnii drew attention to this similar feature between *Pentoxylon* and *Medullosa*, and Srivastava in a way compared it with *Rhexoxylon* which is supposed to have Medullosae affinities. Delevoryas (1955) pointed out that centrepetally developed wood is also found in Medullosae. Stewart and Delevoryas (1956) stated that the “stem anatomy of members of the Pentoxyleae described from the Mesozoic of India by Sahnii, have much in common with the Medullosae stem structure and perhaps some affinity may exist”. Seward had suggested as far back as 1917 that leaves like those of *Taeniopteris* were probably borne on Medullosae stems. It may perhaps be significant that *Nipaniophyllum raoi*, the foliage of *Pentoxylon sahnii* was earlier known as *Taeniopteris spatulata*. This Medullosae or Pteridosperm affinity cannot be overlooked in spite of the wide difference in age.

The fleshy female cones *Carnoconites compactum* bear no comparison with any known group of gymnosperms. The numerous spirally disposed ovules were crowded in a sessile manner on the cone axis, the cones themselves being borne on peduncles arising from the short shoots. The mode of attachment of the thick bitegmic ovules is rather unique. The micropyles of the ovules face outwards. Bract and ovuliferous scales like those of

the Coniferae are absent, although the stem anatomy shows some conifer features. No interseminal scales as in the Bennettitales are seen although the stomatal and cuticular features and the male flower pattern, in some respects, correspond to those of the Bennettitales. The leaf anatomy presents some cycadean features but the female cone is in no way comparable to that of any member of the Cycadales.

The leaves designated *Nipaniophyllum raoi*, originally known as *Taeniopteris spatulata* McClelland (Rao, 1943) show a mixture of Cycadean and Bennettitalean features. The stomata present a syndetocheilic appearance—although this may be marked by secondary division of the subsidiary cells. The internal anatomy of the leaf showed cycadean features, in its diploxylic vascular bundles, the winged petiole and the slightly sunken stomata. But the bundles themselves are arranged in an arc in the petiole and not in a typical Cycadean pattern. Prof. Sahnii has aptly said “in their vascular anatomy as well as their epidermal structures the leaves represent a generalized cycadophyte type with no exclusive affinity with either the Bennettitales or the true cycads”.

A rather confusing feature is that *N. raoi* leaves have not been found yet in actual organic connection with *P. sahnii* although leaves like them cut in transverse sections are found surrounding the short shoots, and sometimes the long shoots also of *P. sahnii*. Some exactly similar types of leaves have haplocheilic type of stomata. From transverse sections only it is difficult to say which one of these types of leaves were the ones borne on *P. sahnii*. It is not unlikely that these leaves had perhaps similar anatomical features while their epidermal features were dissimilar. This is mentioned here to bring home the fact that categorical assignment of affinities cannot be made sometimes, in the absence of complete morphological data.

The male flowers *Sahnia nipaniensis* are neither completely Bennettitalean nor completely Cycadean but show characters of both groups. For example, the general pattern of the flower is Bennettitalean. But they do not show the circinate vernation of the erect part of the flower nor their pinnate branching, so characteristic of the Bennettitales. The filiform branched microsporophylls were originally regarded as



united into a disc at the base, but recent finds of the flower show that the sporophylls were free from each other and were arranged in a spiral phyllotaxis. The unicellular pyriform sporangia measuring  $120 \times 70 \mu\text{m}$  contain boat-shaped, monocolpate pollen grains. In these two features these are comparable with the living Cycadales.

The structural features of *Nipanioxylon guptai* and *Carnoconites laxum* are imperfectly known and are therefore not discussed here.

It will thus be seen that the different genera of the Pentoxyleae cannot be assigned exclusively to any known Gymnosperm Group. At the same time they are not totally unlike any group of gymnosperms. The most obvious and intriguing feature is that they present a combination of characters belonging to the Pteridosperms, Coniferae, Ginkgoales, Cycadales and Bennettiales. One may be tempted to infer that this is a unique group showing characters of different gymnospermous groups. Therefore Prof. Sahni rightly regarded them as "belonging to some unknown new and synthetic group of gymnosperms" occupying an isolated position. Investigations carried on this group within the last thirty years have not in any way further clarified our knowledge of the exact affinities of this group. Further work on the detailed morphological and anatomical features of the different members of the groups may in course of time throw light on its position and relationships.

Several questions arise from a study of the Pentoxyleae-imperfect though the study of this group is at present. Did this group

arise from any geologically earlier group of plants, say like the Pteridosperms with which it seems to share so many characters? Did it then in course of evolution incorporate in itself the characters of the other gymnosperm groups referred to above? Did this group give rise to any other groups of plants in course of time? Meeuse (1961) suggested "a more or less direct descent of the Pandanaceae and some related monocotyledons from the Pentoxyleae". He has based his conclusions on the basis of similarities found in this group and the Pandanaceae.

These similarities centre round general morphology, leaf morphology and anatomy, stem structure, construction of the male flower and its pollen morphology. The structure of the female flower, inflorescence, the ovule and seed coat characters also according to Meeuse offer a number of comparisons. This aspect of its affinity also needs a critical study.

It is perhaps futile to further discuss the affinities of this important and fascinating group of gymnosperms until we know more morphological and anatomical details about its constituent members. These facts can only be obtained in a extensive and intensive investigation of the group as suggested by Rao (1976) and then properly assessed.

In conclusion it must be admitted that in the light of our present knowledge, the Pentoxyleae cannot but be regarded as representing an isolated synthetic group of gymnosperms sharing characters with the Pteridosperms, Cycadales, Bennettiales, Ginkgoales and Coniferales.

## REFERENCES

- DELEVORYAS, T. (1955). The Medullosae — their structure and relationships. *Palaeontographica*, **97B**: 114-117.
- MEEUSE, A. D. J. (1961). The Pentoxyleae and the origin of monocotyledons. *Proc. K. ned. Akad. Wet.*, **60**: 543-549.
- RAO, A. R. (1943). The structure and affinities of *Taeniopteris spatulata* McCl. *Proc. natn. Acad. Sci.*, **13**: 333-355.
- RAO, A. R. (1974). Pentoxyleae, pp. 201-209 in K. R. Surange *et al.* (Eds)—*Aspects and Appraisal of Indian Palaeobotany*. Birbal Sahni Institute of Palaeobotany, Lucknow, India.
- RAO A. R. (1976). Problems in the Pentoxyleae. *Palaeobotanist*, **25**: 393-396.
- SAHNI, B. (1948). The Pentoxyleae: A new group of gymnosperms from the Rajmahal Hills of India. *Bot. Gaz.*, **110**: 47-80.
- SEWARD, A. C. (1917). *Fossil Plants*, **3**. Cambridge.
- STEWART, W. N. & DELEVORYAS, T. (1956). The Medullosean Pteridosperms. *Bot. Rev.*, **22**: 48-80.
- VISHNU-MITRE (1953). A male flower from the Pentoxyleae with remarks on the structure of the female cones of the group. *Palaeobotanist*, **2**: 75-84.