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FURTHER OBSERVATIONS ON THE DWARF SHOOTS OF *PENTOXYLON SAHNII* SRIV. COLLECTED FROM THE JURASSIC OF RAJMAHAL HILLS, INDIA

Dalsze obserwacje dotyczące krótkopędów *Pentoxylon sahnii* Sriv. zebranych w jurze Rajmahal Hills, India

ABSTRACT. Description is given of the external morphological characters as well as anatomy of the dwarf shoots of *Pentoxylon sahnii* collected from the Jurassic of Rajmahal Hills, Bihar. The vascular bundles are endocentric and provided with well developed secondary growth. Leaf traces originate in the same manner as in the long shoots and are provided with secondary xylem in the beginning. Association of the dwarf shoots with *Carnoconites* is discussed and comparison is made with that of *Ginkgo*.

INTRODUCTION

Srivastava (1946), Sahni (1948) and Mittre (1957) described dimorphic branches in *Pentoxylon sahnii* i. e. long shoots and dwarf shoots. The latter were covered with leaf bases while the former did not produce leaves. Sharma (1969, 73, 73a, 74) studied isolated, petrified stems, branches and dwarf shoots collected from Amarjola in the Rajmahal Hills and arrived at the conclusion that three types of branches were produced on *Pentoxylon sahnii* i. e. smooth surfaced long shoots, thin branches with sparsely placed leaves and the dwarf shoots covered with spirally arranged leaf bases (Sharma 1973a). He also distinguished them on the basis of the mode of their origin (Sharma 1974). However, for the present paper only the dwarf shoots have been chosen for description.

Srivastava (1946) described the external features as well as the anatomy of the dwarf shoot of *Pentoxylon sahnii*. He showed the presence of five, curved primary xylem bands forming the vascular system of the shoot; each is provided with mesarch protoxylem points. A similar kind of anatomy has been described

by Sahni (1948), Mittre (1957) and Stewart (1976). However, Stewart has shown the presence of only two mesarch protoxylem points in each bundle. Sharma (1973a) described the anatomy of the dwarf shoots collected from Amarjola and showed that the vascular bundles have well developed secondary xylem. The leaf traces were, however, shown to possess only the primary xylem. The present observations are based on some nicely preserved material and are showing differences from the earlier reports. Association of the dwarf shoots with the seed bearing organs of Pentoxyleae is also discussed.

The material was collected from the fossiliferous localities of Nipania and Amarjola in the Amarapara region of the Rajmahal Hills, Bihar. In the former the shoots are preserved in a silicified chert while in the latter they are found as isolated pieces in a ferruginous dark brown sandy rock. Cellular details are better preserved in the Amarjola material. The material was boiled in Canada Balsam prior to sectioning with the help of a wire bandsaw. Slides were prepared by the usual method of grinding and polishing processes and mounted in Canada Balsam.

DESCRIPTION

The dwarf shoots of *Pentoxylon sahnii* are ranging in thickness from 0·7 to 2·5 cm. The specimens collected from Nipania (Pl. I, figs. 1–3, 5, 8) are comparatively thicker than those from Amarjola (Pl. I, figs. 4, 6, 7). The length remains unknown as none of the specimens is complete. The majority of them are representing the middle portion. However, in the available specimens the length ranges from 1·0 to 5·5 cm. They are mostly straight and cylindrical (Pl. I, fig. 3). The bigger shoots may be slightly curved (Pl. I, fig. 1). All are covered with closely placed and spirally arranged leaf bases which may be of different shapes and sizes. In the dwarf shoots from Amarjola (Pl. I, figs. 4, 6) the leaf bases are rhomboid, comparatively bigger in size, $3{\cdot}0 \times 1{\cdot}1$ mm and 10–12 in a spiral. In the thicker specimens (Pl. I, fig. 7) leaf bases are semicircular, $1{\cdot}8 \times 0{\cdot}9$ mm in size and 18–20 in a spiral. In specimens collected from Nipania the leaf bases are nicely preserved and $3{\cdot}1 \times 2{\cdot}0$ mm in size. They are rhomboid with lateral extensions (Pl. I, fig. 8). The number of leaf bases per spiral ranges from 20–32. In some of the leaf bases vascular bundles are seen. They are 6–7, arranged in a row.

Serial transverse sections have been cut out of a number of petrified specimens collected from Amarjola. Each section is provided with 5–6, well developed bundles (Pl. II, fig. 1). The bundles are either circular (Pl. II, figs. 2, 3; Fig. 1), $0{\cdot}95 \times 1{\cdot}1$ mm in diameter or elliptical (Figs. 2, 3), $1{\cdot}35 \times 0{\cdot}5$ mm in size. The primary xylem is 2–5 cells thick with 3–5 mesarch protoxylem points. Generally it is not preserved due to the extensive secondary growth and is seen as a crushed layer. The secondary growth is more on the centripetal side and may be differentiated into growth rings (Pl. II, figs. 3, 4). The secondary xylem

of the outer side extends laterally (Pl. II, figs. 3, 6; Fig. 1) and cuts off cortical bundles (leaf traces) on either side in the same manner as in the long shoots (Sharma 1969, 1973). The cortical bundles thus produced have secondary xylem (Pl. II, fig. 4). During their way through the cortex these bundles divide and redivide and lose their secondary xylem. So the outer portion of cortex possesses many smaller bundles arranged in groups of 4–7 bundles (Pl. II, fig. 2; Fig. 1). Each group passes into a leaf base. The amount of secondary xylem on the outer side in the main bundles is reduced gradually (Pl. II, figs. 5–7) due to the successive production of cortical bundles from their lateral sides. The ground tissue is parenchymatous with scattered patches of sclerotic cells. In the upper part of the shoot such cells are absent. The leaf bases are separated from the cortex by a periderm layer which is 3–4 cells thick.

DISCUSSION

In external morphology the dwarf shoots of *Pentoxylon sahnii* can easily be compared with those of *Ginkgo* and its fossil allies (Archangelski 1965). Like in *Ginkgo* they are covered with spirally arranged leaf bases and vary in

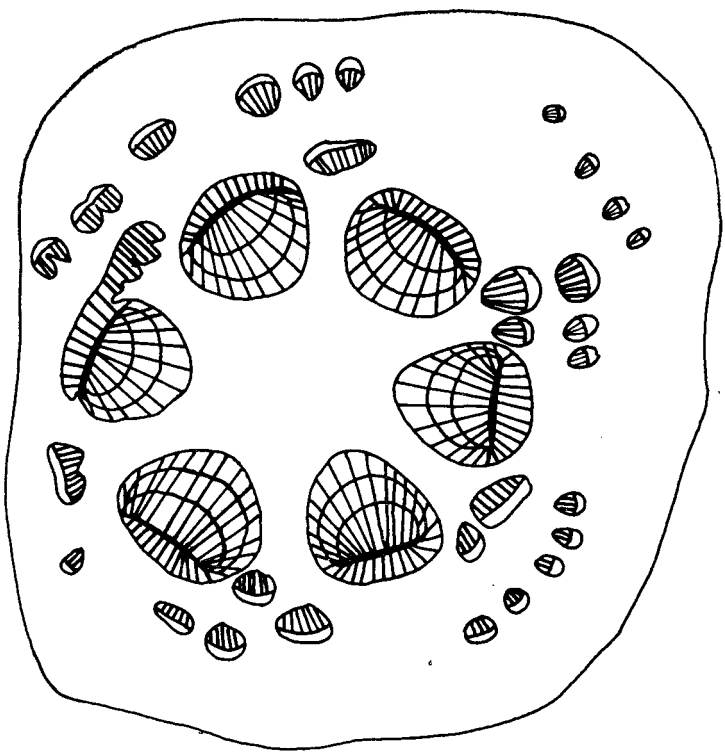

Fig. 1. *Pentoxylon sahnii*. Transverse section of dwarf shoot. Six circular main bundles and many cortical bundles; × 16

thickness as well as length. In *Ginkgo* sometimes from the terminal part of the dwarf shoot there may arise a long shoot or vice versa (Foster & Gifford 1959). Though such a feature has not been observed so far in *Pentoxylon sahnii*, yet the possibility cannot be ignored. The similarity in the gross general anatomy of the long shoots with the dwarf shoots, adds support to this presumption.

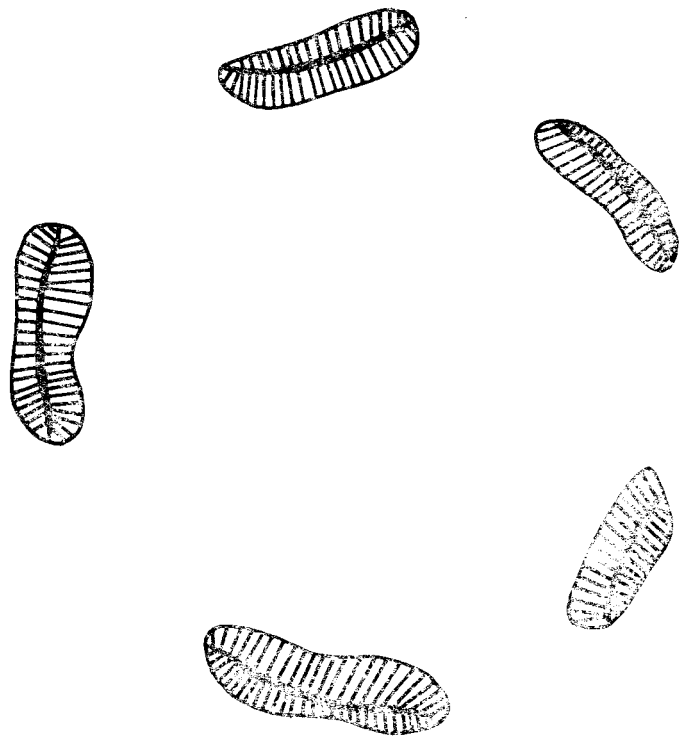

Fig. 2. *Pentoxylon sahnii*. Transverse section of dwarf shoot. Elliptical main bundles; × 16

On the basis of the origin of leaf traces, *Pentoxylon sahnii* was corelated with *Rhexoxylon piatnitzkyi* Archangelski and Brett (Sharma 1973a). The author also concluded that in *P. sahnii* there were produced two types of traces i. e. one with secondary xylem and the other without it. The former was found in the long shoot while the latter occurred in the dwarf branch. However, the present investigation differs a little from the previous one. Now it is noted that even in the dwarf shoot the leaf traces are provided with secondary xylem in the beginning. They lose their secondary xylem during their way through the cortex to the leaf base. The leaf traces arise as a result of detachment of the sides of the secondary xylem of the centrifugal part of the main bundles. A similar type of leaf trace origin is known in the long shoots (Sharma 1969, 1973). However, in the dwarf shoots the leaf traces arise much more frequently in comparison to the long shoots. That is why cortical bundles are much more numerous in the former in comparison to the latter.

Both seed bearing as well as male fructifications of Pentoxyleae, i. e. *Carnoconites* Sriv. and *Sahnia* Mittre respectively were described to be produced terminally on the dwarf shoots (Sahni 1948; Mittre 1953). However, the anatomy does not support this presumption. Srivastava (1946) described 7–9 bundles, Sahni (1948) figured 10 bundles, while Mittre (1953) reported 36–40 bundles in the basal part of the peduncule of *Carnoconites*. Mittre also

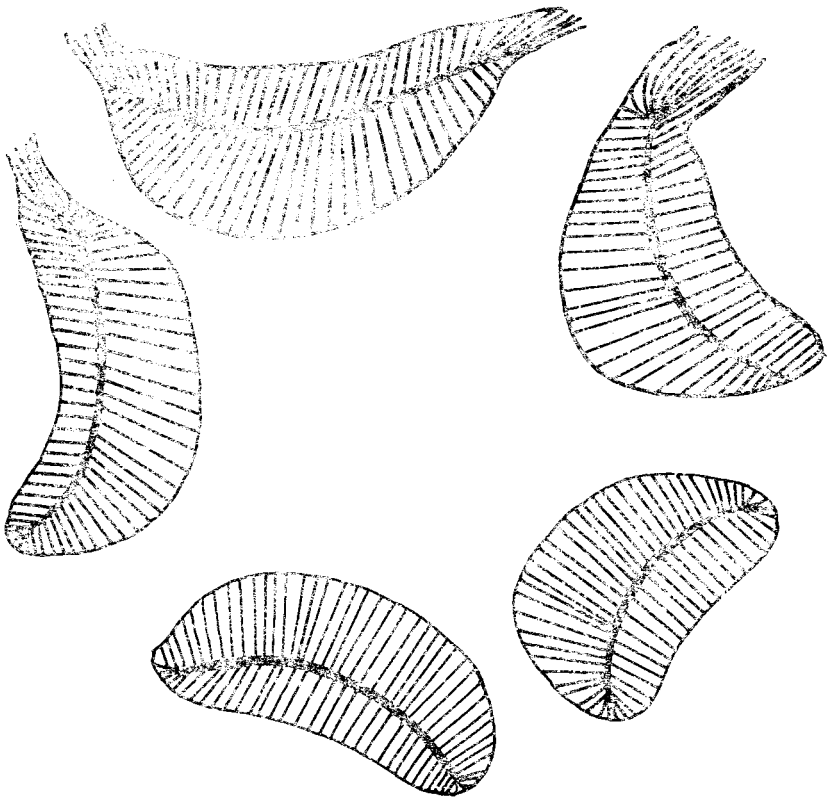

Fig. 3. *Pentoxylon sahnii*. Transverse section of dwarf shoot. Elliptical main bundles with originating leaf traces; × 16

described that the number is gradually reduced towards the distal end of the inflorescence axis to 10 or even less. According to Sahni (1948) the bundles were collateral and regular, while Mittre (1953) showed the bundles diploxylic and of irregular sizes. Each seed stalk received three bundles. Had the seed bearing fructifications been produced terminally on the dwarf shoots, the latter should not have shown such a fixed number (5–6) and regular arrangement of main bundles throughout the entire length (Sharma 1973a and the description given above). In other words for the production of 36–40 bundles found in the basal part of the peduncle of *Carnoconites*, the fission in the main bundles of the dwarf shoot should have started at a somewhat lower level and not exactly at

the terminal part. Secondly, there remains a big gap to fill in, the way of formation of collateral or diploxylic bundles without secondary growth of the peduncle of *Carnoconites* from the bundles of the dwarf shoot with well developed secondary xylem.

The present investigation also throws light on the polystelic concept of the vascular system of *Pentoxylon sahnii*. Recently, Stewart (1976) suggested that the vascular organization in Pentoxyleae and Medulloseae is monostelic and not polystelic as usually believed. He regarded the five or more bundles of *P. sahnii* as a result of fission from a single stele. If this is true then at the base or point of origin of a shoot the number of bundles should be less than 5 or 6 and the number must increase towards the distal end. But this does not occur and the number of bundles remain more or less constant throughout the length of the shoot. Neither do the bundles travel in a zigzag way nor do they divide so frequently as believed by him. Stewart's suggestion also fails to explain the occurrence of more secondary growth on the centripetal (endocentric) side found in Pentoxyleae.

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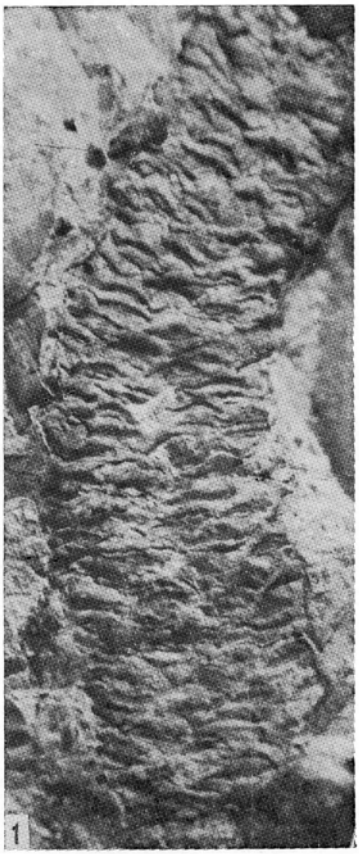
STRESZCZENIE

DALSZE OBSERWACJE DOTYCZĄCE KRÓTKOPĘDÓW *PENTOXYLON SAHNII* SRIV. ZEBRANYCH W JURZE RAJMAHAL HILLS, INDIA

Podano opis zewnętrznych cech morfologicznych jak również budowy anatomicznej krótkopędów *Pentoxylon sahnii* Sriv. zebranych w utworach jurajskich Rajmahal Hills, Bihar. Wiązki naczyniowe są endocentryczne i posiadają dobrze rozwinięty przyrost wtórny. Wiązki liściowe rozpoczynają się w ten sam sposób jak w długopędach i są opatrzone na początku drewnem wtórnym. Przedyskutowano fakt znajdowania tych krótkopędów razem z owocowaniami *Carnoconites* oraz porównano je z krótkopędami *Ginkgo*.

Plate I

1–8. *Pentoxylon sahnii*. Dwarf shoots showing external morphology. 1, 2, 3, 5, 8 collected from Nipania; 4, 6, 7 collected from Amarjola; × 2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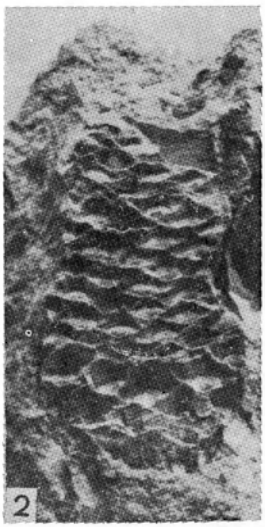
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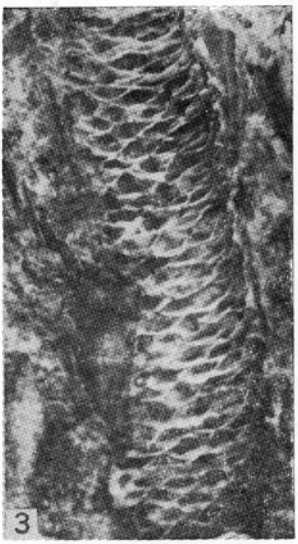
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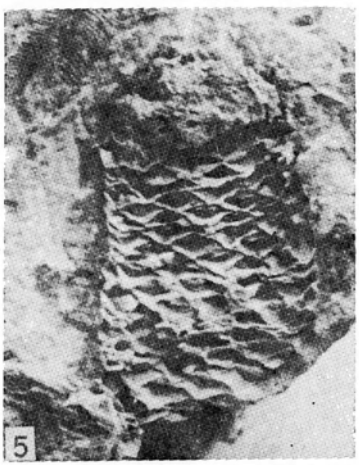
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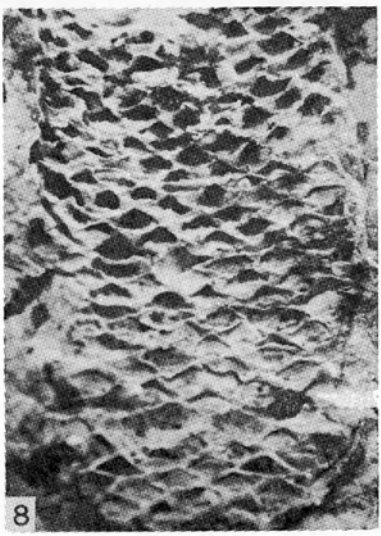
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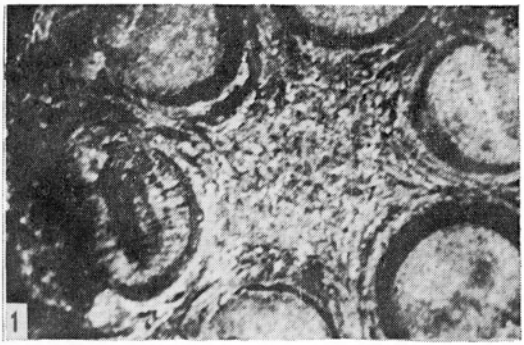
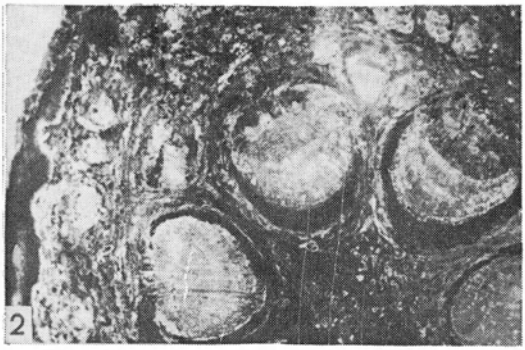
Plate II

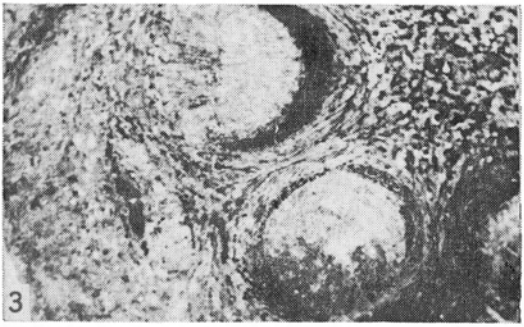
Pentoxylon sahnii. Transverse sections of dwarf shoots

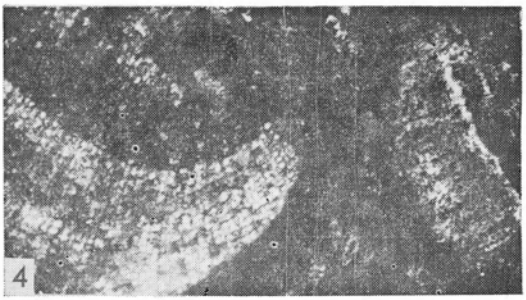
1. Six bundles surrounding the pith; × 24
2. Many cortical bundles and the main bundles; × 24
3. Two main bundles and a cortical bundle; × 24
4. An inner cortical bundle with secondary xylem; × 72

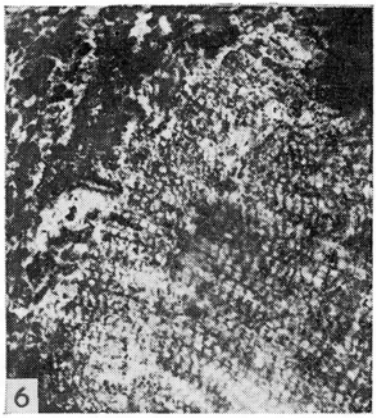
5, 6, 7. Main bundles showing gradual loss of the sides of the outer secondary xylem as a result of production of leaf traces; × 72

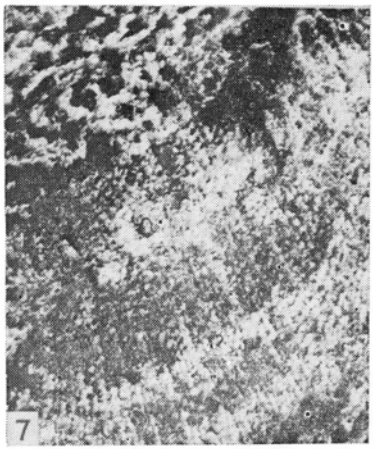












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