FURTHER OBSERVATIONS ON SEWARDIOXYLON SAHNII GUPTA COLLECTED FROM THE MIDDLE JURASSIC OF RAJMAHAL HILLS, INDIA

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SUMMARY

A reconstruction of the vascular organization of the stem of *Sewardioxylon sahnii* is given along with the description of the manner of origin of leaf traces and the formation of the inner inverted ring of bundles in the main stele.

1. INTRODUCTION

The genus *Sewardioxylon* was established by GUPTA (1960) for the petrified cycadean stems collected from the fossiliferous locality of Amarjola in the Rajmahal Hills, Bihar. A detailed description was, however, published only recently by him (GUPTA 1971). The present author has prepared some more slides from the type specimen and included the description in his Ph. D. thesis (SHARMA 1967). On the basis of his studies the author has attempted a reconstruction of the vascular organization of the stem in the present paper besides, giving the manner of origin of leaf traces and formation of the inner inverted ring of bundles in the main stele.

2. DESCRIPTION

In the type specimen, pith as well as cortex are wide, parenchymatous and without mucilage canals. A vascular zone is comparatively narrow and made up of two equally developed rings of collateral, conjoint and open vascular bundles. In each ring there are nearly seventy bundles. Bundles of the inner ring are inverted and lying opposite those of the outer ring. Bundles of the two rings are separated by only few crushed parenchymatous cells; each bundle has its own cambium and phloem. Between the bundles wide and thin-walled pith rays are present which makes the wood manoxylic. Wood rays are absent. In the pith there are present numerous, irregularly scattered pith bundles which are either collateral or concentric. In the cortex there are numerous cortical bundles but these are arranged more or less in two rings and are always collateral with the endarch protoxylem.

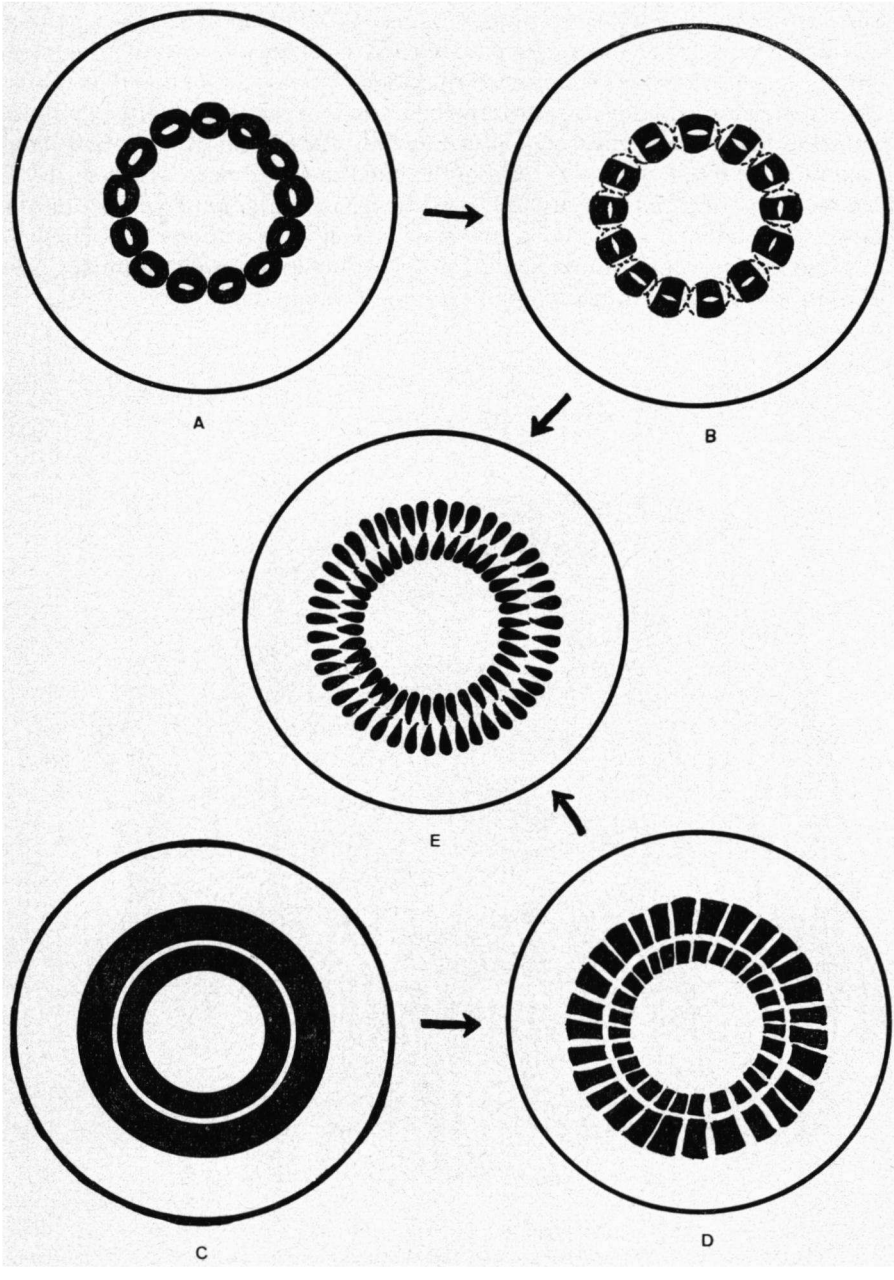
Origin of leaf trace: – Bundles in each ring of the main stele are travelling upwards in a zigzag way resulting from fusion with and separation from the adjacent bundles. It is from the points of fusion that the medullary bundles

arise, which on entering the pith travel obliquely upwards for an unknown distance. Deep in the pith these bundles divide and meet, forming a medullary vascular complex. Some of the pith bundles from the complex pass out into the cortex through the pith rays. In the cortex also these bundles divide and travel obliquely upwards for quite a long distance and finally enter the leaf bases. The cortical bundles are collateral with endarch protoxylem points. A number of such bundles enter into a leaf base and thus in *Sewardioxylon sahnii* the leaf supply is multilacunate like in most of the living cycads. The path of the leaf trace is peculiar in the present wood; it first enters the pith and then comes out into the cortex through the pith ray. On its way from the point of origin till it enters the leaf base the leaf trace divides several times and fuses with other traces both in the pith as well as in the cortex of the stem. A similar type of leaf supply is found in those members of living cycads which possess medullary bundles, for instance, *Macrozamia*, *Lepidozamia*, *Encephalartos*, *Microcycas*, and *Cycas revoluta* (GREGUSS 1961, 1968). Probably the cycadean stem genus *Fascisvarioxylon mehtae* Jain (JAIN 1964) described from the fossiliferous locality of Amarjola in the Rajmahal Hills also had a similar type of vascular supply to the leaf. GREGUSS (1966) and ZIMMERMANN & TOMLINSON (1969), while describing the anatomy of monocot plants, have shown the path of the leaf traces through the pith to be more or less similar to the one described in *Sewardioxylon sahnii*.

Origin of inner inverted ring of bundles in the main stele: – In *Sewardioxylon sahnii* there are two rings of vascular bundles which form the main stele of the stem. The bundles of the outer ring are endarch, those of the inner ring are exarch. Bundles of both rings are almost equally developed and lie opposite to one another. Such a peculiar type of arrangement of bundles in the main stele is still unknown elsewhere in the plant kingdom. It is now an almost accepted view that the anatomy of cycadean plants can be derived from that of the Medullosaceae as a result of tangential expansion of peripheral steles followed by lateral fusion (DELEVORYAS 1955, STEWART & DELEVORYAS 1952, 1956). By little modification in the anatomy of such medullosan stems, in which either a number of steles are arranged in a ring, as in *Medullosa solmsii* Schenk, or a continuous peripheral vascular cylinder is present, as in *M. stellata* Cotta, the vascular organization of *Sewardioxylon sahnii* Gupta can be derived. If in a Medullosa of the first mentioned type the lateral sides of each stele disappear and are transformed into parenchymatous pith rays, then the two rings of collateral vascular bundles of the present wood can be obtained. (*figs. A & B*). In the second case the outer and inner rings of the bundles of *Sewardioxylon sahnii* can be derived (*figs. C & D*) if the peripheral vascular cylinder disintegrate at regular intervals to form the pith rays.

GUPTA (1971) favoured the first possibility and derived the vascular cylinder of *Sewardioxylon sahnii* from medullosan stems like *Medullosa porosa* Cotta and *M. solmsii* Schenk; but a serious objection to this view is that it can not explain the zigzag path of the bundles of the main stele in the present wood. The second view is also a probability and requires confirmation.

Reconstruction of vascular organization: – On the basis of the study of trans-



Figs. A–E Two possibilities of the origin of the vascular cylinder of *Sewardioxylon sahnii* (E), either as a result of transformation of lateral sides of medullosan steles arranged in a ring into pith rays (A & B) or as a result of disintegration at regular intervals of a medullosan peripheral stele and formation of pith rays (C & D).

verse as well as longitudinal sections of *Sewardioxylon sahnii*, the present author has attempted the reconstruction of the vascular organization of this stem (*fig. F*). In the transverse section two rings of collateral, conjoint and open vascular bundles are seen which form the main stele of the stem. Cortex and pith are wide and have cortical and pith bundles, respectively. In the tangential longitudinal section the zigzag path of the bundles of the main stele is seen and the resulting long, multiseriate pith rays. In the radial longitudinal section the origin of medullary bundles from the main stele and formation of a medullary vascular complex can be observed. Some of the bundles from the complex pass out into the cortex through the pith rays and become leaf traces.

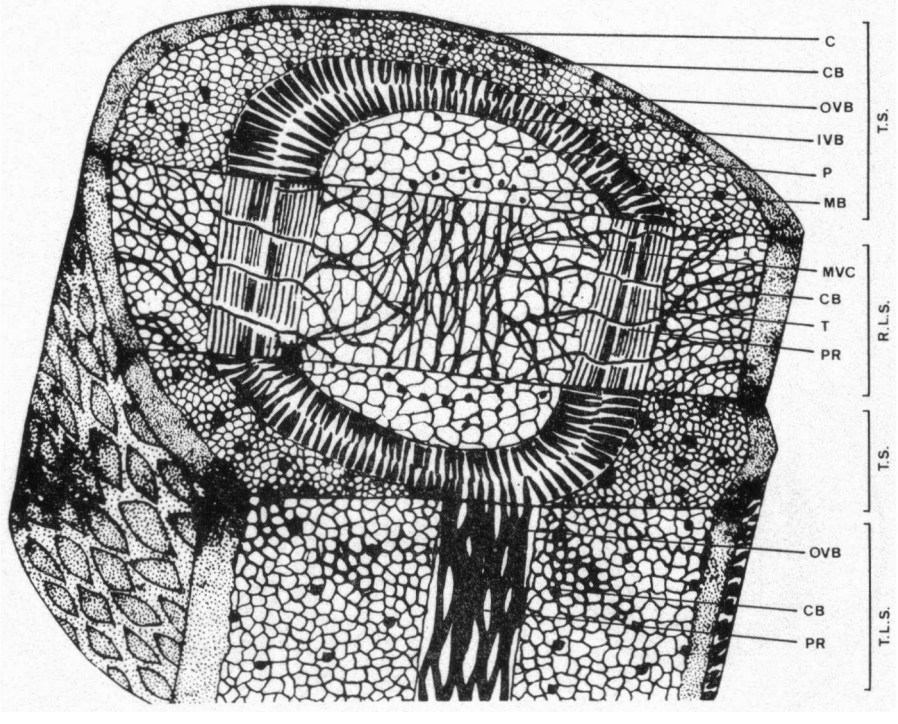


Fig. F. A reconstruction of the vascular organization of the stem of *Sewardioxylon sahnii* Gupta, as seen in transverse section, radial longitudinal section and tangential longitudinal section. (C = Cortex, CB = Cortical bundle, OVB = Outer ring of vascular bundles, IVB = Inner ring of vascular bundles, P = Pith, MB = Medullary vascular bundle, MVC = Medullary vascular complex, T = Tracheids, PR = Pith ray, T.S. = Transverse section, R.L.S. = Radial longitudinal section, T.L.S. = Tangential longitudinal section)

3. DISCUSSION

WORSDELL (1906) derived the monostelic condition found in the stems of living cycads from the conditions in Medullosaceae by means of phyletic fusion of peripheral steles and by gradual loss of centripetal xylem. This view has been favoured by a number of botanists like DELEVORYAS (1955), STEWART & DELEVORYAS (1952, 1956), etc. Whatever may be the mode of formation of vascular organization in *Sewardioxylon sahnii*, certainly this plant shows affinities with Medullosaceae on the one hand and with Cycadaceae on the other hand and possesses primitive anatomical characters like the presence of a large number of bundles forming the main stele and an equal development of centripetal and centrifugal xylems. The discovery of *Fascisvarioxylon mehtae* Jain has further helped in understanding the anatomy of *Sewardioxylon sahnii*. In the former, bundles of the inner ring are comparatively less developed than those of the outer ring and are sometimes absent. Thus *Fascisvarioxylon mehtae* shows a reduction of centripetal xylem and a tendency towards the formation of a monostelic condition. So, on the basis of the present study, a line of evolution can be drawn from Medullosaceae to the cycads through intermediate forms like *Sewardioxylon sahnii* and *Fascisvarioxylon mehtae*.

SCOTT (1896, 1923) however, did not attach importance to the presence of circum-medullary bundles (inner inverted bundles) and considered such anomalies as the result of injuries and of no phylogenetic value. He derived the anatomy of cycads from *Lyginopteris*-like plants. Though this view was also favoured by a number of workers like DE FRAINE (1912), BANCROFT (1914), ARNOLD (1953) etc., in the stem of *Sewardioxylon sahnii* the presence of circum-medullary bundles (inner inverted bundles) is a constant feature and certainly related to the phylogeny of the plant.

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