

Mucilage canals in the bennettitalean plant remains from the Rajmahal Hills, Jharkhand, India

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Structure and distribution of mucilage canals in pith, cortex and leaf bases in the stems of *Bucklandia* sp. and receptacles of seed bearing fructification *Williamsonia* are described. The canal is either a modified uniseriate row of parenchyma or a group of parenchyma and may be present in tangential rows in the secondary phloem of a *Bucklandia* stem. On the basis of study of mucilage canals evolution and relationship of the bennettitalean plants with other cycadophytes are discussed.

Key-words—Structure, Distribution, Canals, Mesozoic, *Bucklandia*, *Williamsonia*.

INTRODUCTION

THE canals exist in many groups of plants starting with the green alga *Euglena* in which a single, simple canal is present in the proximal portion of the body (Bold et al. 1987). Among bryophytes mucilage cavities are present in the thalli of some members of the Anthocerotales (Asthana & Srivastava 1991) and the retort cells of *Sphagnum* - stem also serve the purpose of canals (Campbell 1940). In pteridophytes mucilage canals and laticiferous ducts are known to exist in *Lycopodium* and *Regnellidium* respectively (Labourian 1952, Bierhorst 1971). The pair of parichnos which connect the cortex with the leaf base in extinct lycopods and *Isoetes* (Sharma et al. 1986) also form canals as a result of dissolution of transverse septae of thin walled parenchyma present on either side of the vascular trace (Eames 1936, Taylor & Taylor 1993). The carinal canals present in the internodal portion of stem of *Equisetum* and other calamitalean plants are also lycigenous in origin but do not have mucilage in them.

Among gymnosperms two kinds of canals are present i.e. mucilage/secretory canals and the resin canals. The former are characteristics of the cycadophyta (Pant 2002) while the latter are found in coniferophytes (Chamberlein 1935, Greguss 1955).

Mucilage canals are either solitary or occur in groups and store the product/secretion of the canal forming cells in them. Whereas, in the resin canal there is a distinct central canal surrounded by epithelial cells. The canal store the excretion/secretion of the epithelial cells.

In the present paper the structure and distribution of mucilage canals in the stem of *Bucklandia* and in the receptacles of seed bearing *Williamsonia* are described. Phylogeny is discussed on the basis of existence of mucilage canals between the bennettitalean and other cycadean plants.

MATERIAL AND METHOD

The material of *Bucklandia*-stems and receptacles of *Williamsonia* was collected from the well known locality of Amarjola in the Rajmahal Hills, Jharkhand (Bose 1953, Sharma 1967a, Sharma 1972). The material is soft and fragile and needs cooking in canada balsam prior to sectioning with a wire bandsaw. Slides were prepared by the usual technique of grinding and polishing methods and mounted in canada balsam (Sharma 1974a).

DESCRIPTION AND DISCUSSION

For the study of mucilage canals sections of the material have been prepared in different planes and

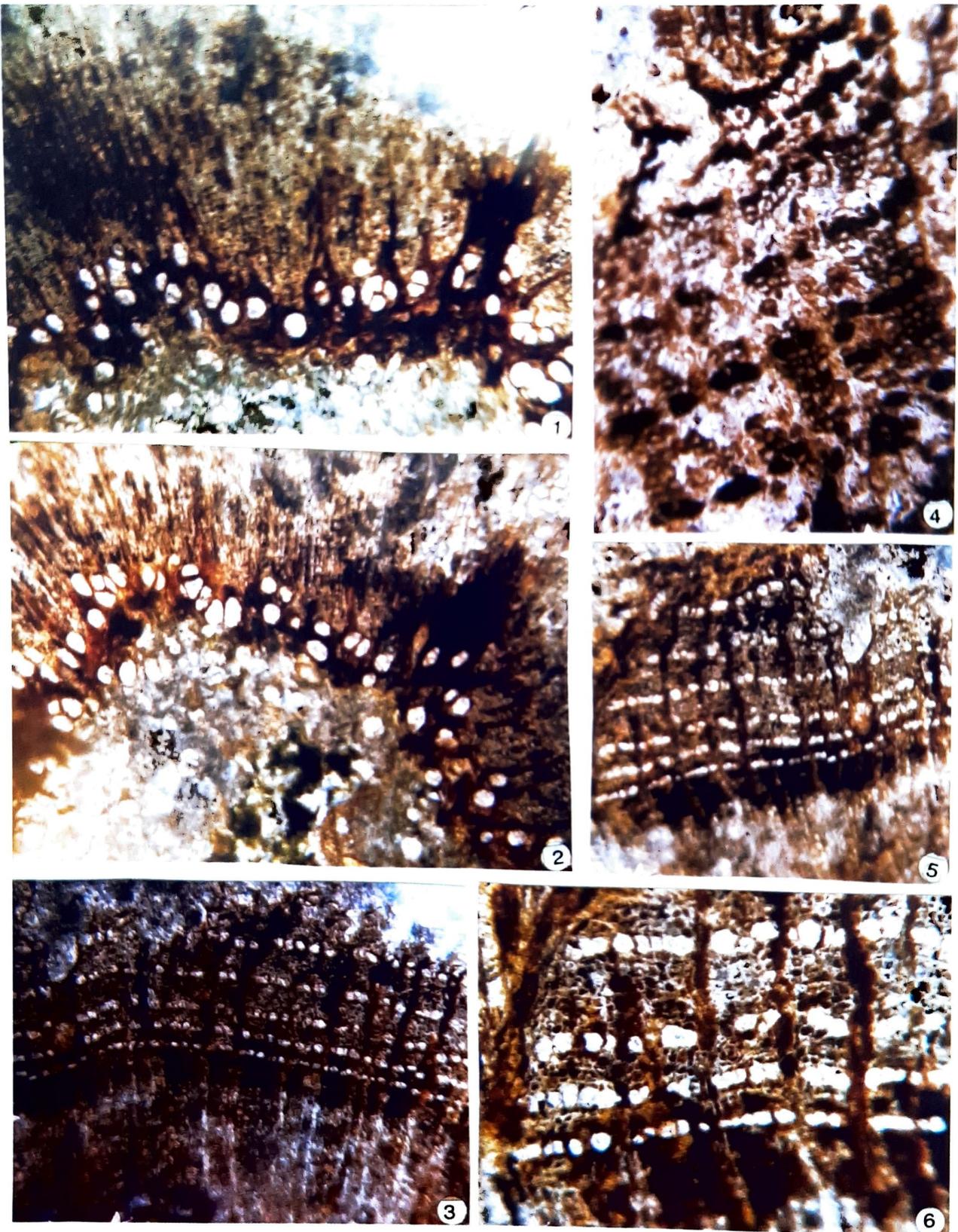


PLATE - 1

Bucklandia sp.

Figs. 1, 2. Cross sections of stem showing pith and compact secondary wood. Mucilage canals scattered in pith and specially in association with protoxylems. $\times 36$. 3, 5. Cross-section showing secondary phloem with tangential bands (5-6) of mucilage canals. Phloem rays distinct, secondary wood compact $\times 36$. 4. Secondary phloem with tangential bands of canals filled with dark inorganic contents $\times 60$. 6. Enlargement of a portion of fig. 5. Note tangential banks of canals and distinct phloem rays $\times 60$.

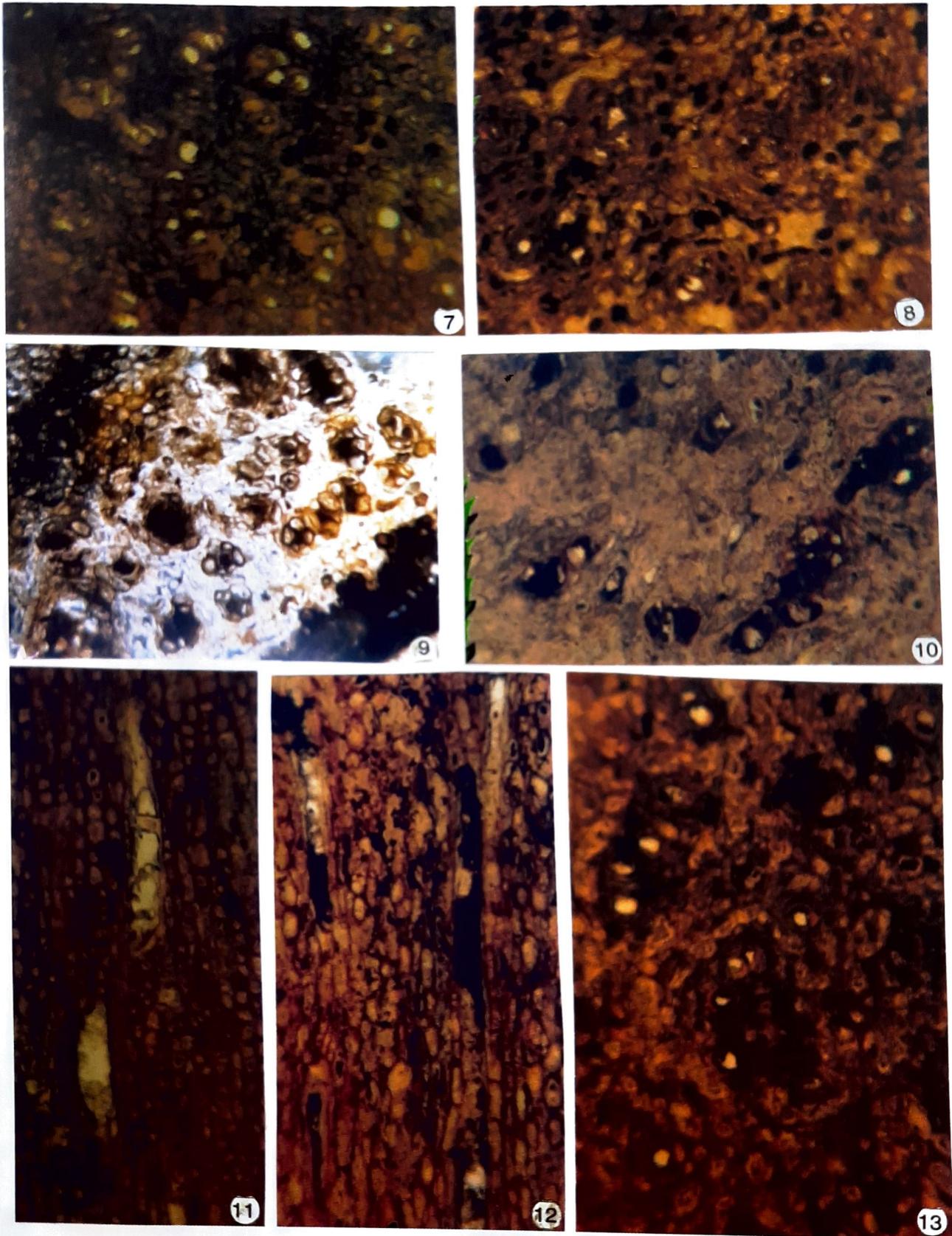


PLATE-2

Figs. 7. Cross section of *Bucklandia* stem, pith with mucilage canals in groups. Surrounding cells are modified and larger in size $\times 60$. 8. Cross section of receptacle of *Williamsonia*. The canal cells solitary or in groups, surrounding cells not modified $\times 60$. 9. Cross section of leaf base with peculiar kind of mucilage canals $\times 60$. 10, 13. Cross section of stem pith. Mucilage canals solitary and in groups either surrounding cells filled with dark contents or empty $\times 60$. 11, 12. Longitudinal sections through pith with uniseriate or biseriate canals; surrounding cells not modified. Canals are formed by dissolution of transverse septae. $\times 60$.

through stem, petiole, pinna, peduncle, receptacle etc. Petiole and pinna (leaf) of the bennettitalean plants are devoid of mucilage canals (Sharma 1967b, Rao & Achuthan 1968). The stem of *Bucklandia* and the receptacle of *Williamsonia* have the mucilage canals in their ground tissue i.e. pith and cortex (Sharma 1970a). In some of the specimens of *Bucklandia* the leaf bases also have mucilage canals (Sharma 1974b).

Stem: A cross-section of *Bucklandia* stem shows a well developed parenchymatous pith and a wide cortex with leaf bases at the periphery (Bose 1953, Sharma 1970b). In between the pith and cortex there is a distinct vascular zone made up of many collateral, conjoint and endarch vascular bundles arranged in a ring. The secondary wood is more or less pycnoxylic (Pl. 1, Figs. 1, 2) with differentiation of growth rings (Bose 1953, Sharma 1967b). Wood rays uni to multiseriate and parenchymatous. Protoxylem points are distinct and extended a little into the pith (Sharma 1974b). Similarly the secondary phloem is well marked from the cortical cells (Pl. 1, Figs. 3, 5, 6). Mucilage canals are present in the pith (Fig. 2), cortex, leaf bases and secondary phloem (Pl. 1, Figs. 3, 5, 6). In the pith the canals are scattered through out but crowded in the peripheral portion and specially in association with the protoxylem points (Pl. 1, Fig 1, 2). These are either solitary or in groups of 2-many (Pl. 1, Figs. 1, 2). In some of the *Bucklandia* stems majority of canals occur in groups of 2-5 or so and the adjacent cells of the pith are either unchanged in morphology (Pl. 2, Fig. 13) or these are modified and become larger in size (Pl. 2, Fig. 7), remain empty or are filled with dark inorganic contents (Pl. 2, Fig 10).

In the cortex of the stem the mucilage canals are comparatively lesser in number. These may be absent in the peripheral portion of cortex adjacent to the leaf bases. However, in some of the *Bucklandia*-stems the canals occur frequently in the leaf bases adjacent to the periphery of the cortex (Pl. 2, Fig. 9). These mucilage canals are peculiar in morphology. There is a central canal like cavity surrounding which are present 4 to many distinct circular cells (Pl. 2, Fig. 9). The central cavity is filled with an inorganic dark content. Otherwise in majority of *Bucklandia* stems

there are only a few mucilage canals per leaf base and these are mostly of solitary nature.

Fructification : The central receptacle of bennettitalean fructification *Williamsonia* shows mucilage canals. A cross section through the receptacle indicates a wide parenchymatous pith and a well developed cortex. The vascular ring is narrow consisting of inverted bundle (Sharma 1970a). In the pith the mucilage canals are narrow, mostly solitary or in small groups (Pl. 2, Fig. 8). These are not much differentiated from the cortical cells. Similar to the stem, in the receptacle also the cortex is either devoid of canals or only a few solitary canals are seen scattered in the inner portion of the cortex. From the periphery of receptacle arises a compact layer of fertile and sterile scales. These scales are devoid of canals.

Longi to canal sections cut through the stems and receptacles show the origin of canals from the parenchyma cells as a result of dissolution of the transverse septae (Pl. 2, Figs. 11, 12). The participating cells are either uniseriate or multiseriate, empty or filled with dark contents (Pl. 2, Fig. 12). Adhering cells of the pith or cortex are typical thin walled regularly placed parenchyma (Pl. 2, Figs. 11, 12). Sharma (1970b) and Sharma and Bohra (1977) described the structure of phloem of the bennettitalean and pentoxylean plants. According to them the phloem is made up of sieve cells and phloem parenchyma. In the secondary phloem the parenchyma are produced in tangential rows. Phloem rays are either narrow (Pentoxyleae) or flared and wide (Bennettitales). In some *Bucklandia* sp. the secondary phloem makes a continuous ring surrounding secondary xylem with 1-3 cells wide phloem rays (Pl. 1, Figs. 3, 5, 6). In place of parenchyma bands it may have tangential bands of mucilage canals (Pl. 1, Figs. 3, 5, 6). These canals resemble closely with the mucilage canals present in the pith of the *Bucklandia* stem (Pl. 1, Figs. 1, 2) in shape, size and mode of preservation. More or less a similar type of arrangement of phloem parenchyma is described in the stem of *Pinus* by Fahn (1987). There are 4-6 such bands of mucilage canals in the secondary phloem of the *Bucklandia* stem described in this paper (Pl. 1, Figs. 3, 5). The bands are not at equal distance

from the secondary xylem. The first two bands are little closer than the outer bands. Majority of canals of the tangential bands are empty but at some places in the phloem ring these are filled with dark inorganic contents (Pl. 1, Fig. 4) of unknown nature. The sieve cells are comparatively narrower cells and are produced in a regular sequence from the cambium (Pl. 1, Figs. 4, 6).

According to Eames and MacDaniels (1947), Easu (1965, 1977) and Fahn (1987) among gymnosperms the secondary phloem in Cupressaceae has alternate bands of fibres and sieve cells whereas in *Pinus* sp. there are tangential bands of parenchyma along with sieve cells and scattered albuminous cells in the secondary phloem. The present report of tangential bands of mucilage canals in the secondary phloem of *Bucklandia* stem is thus an interesting finding.

The sub division cycadophyta of the gymnosperms is divided into four classes i.e. Pteridospermopsida, Cycadopsida, Bennettitopsida and Pentoxyllopsida. Plants of Pentoxyllopsida do not have mucilage canals. Whereas, Medullosales of pteridosperms, Cycadales and Bennettitales (including Cycadeoidales) have mucilage canals in their vegetative organs. In *Medullosa* stem and associated petiole *Myeloxylon* there are numerous narrow, solitary secretory canals (Taylor & Taylor 1993, Stewart & Rothwell 1993). Among Cycadales mucilage canals are present in stem, petiole, leaflets (in some taxa like *Macrozamia*) and micro and megasporophylls (Pant 2002). The canals are mostly solitary and scattered or may be arranged in regular sequence. In Bennettitales and Cycadeoidales the canals are found in stem, peduncle and receptacle of seed bearing fructifications. In these organs the canals are restricted to pith and cortex and they occur either solitary or in groups (Bose 1953, 1968, Sharma 1967, 1970a, 1970b, 1974b). There are no canals in the petiole and leaflets of the bennettitalean plants (Bose & Banerji 1981). The present study of occurrence of mucilage canals in the secondary phloem of the stem of *Bucklandia* is a new record. An evolutionary sequence may be drawn from Medullosales with scattered narrow, solitary secretory canals to regularly arranged solitary mucilage canals of the cycads to

scattered or regularly arranged, solitary or in groups of mucilage canals of the Bennettitales. In Medullosales the canals are found in radial bodies, (stem, petiole) and leaflet. In Bennettitales again the canals are restricted to radial organs i.e. stem peduncle and receptacle. It means the canals did not appear or enter the appendicular structures in the Bennettitales and restricted only to axial organs. However, the occurrence of canals in the leaf bases of some specimens of the *Bucklandia*-stem represents relics of their presence in the petioles of Medullosales and the Cycadales.

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