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Resolution of fossil monocotyledonous roots to the natural taxa

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ABSTRACT

Bonde SD 2009. Resolution of fossil monocotyledonous roots to the natural taxa. The Palaeobotanist 58(1-3): 75-81.

Monocotyledons possess endogenously originated adventitious roots. Such permineralized roots occur abundantly in the Cretaceous and onward horizons assigned to the artificial genera *Rhizopalmoxylon* Gothan, *Aerorhizos* Chitaley, *Velamenorhizos* Barlinge and Paradkar and *Hygrorhizos* Trivedi *et al.*. Fossil roots reported so far have not been described with uniform terminologies which lack precision and delimitations of the tissues. Considering a need to have uniform terminologies in the description of permineralized roots, a system based upon Seubert's work has been proposed to describe the monocotyledonous roots.

Key-words—Monocotyledons, Permineralization, Anatomy, Roots.

प्राकृतिक टैक्सा के लिए एकबीजपत्री जड़ों के जीवाश्मों का वियोजन

एस.डी. बोंडे

सारांश

एकबीजपत्री अंत:प्रवर्धी रुप से उत्पन्न अपस्थानिक जड़ों को नियंत्रण में रखती है। ऐसी पर्मिनीकृत जड़ें कृत्रिम वंश *राइज़ोपामॉक्सीलॉन* गोथान, *एरोराइज़ॉस* चिताले, *वेलामेनोराइज़ॉस* बर्लिंगे एवं पराडकर तथा *हाइग्रोराइज़ॉस* त्रिवेदी एवं अन्य को निर्धारित क्रिटेशस एवं अग्रवर्ती संस्तर-स्थितियों में प्रचुरता से प्राप्त होती हैं। अब तक प्राप्त जीवाश्म जड़ें एक रूप शब्दावलियों से वर्णित नहीं हुई हैं जो कि ऊतकों की परिशुद्धता एवं परिसीमन का अभाव है। पर्मिनीकृत जड़ों के वर्णन में एक रूप शब्दावलियों की आवश्यकता पर विचार करते हुए, एकबीजपत्री जड़ों को वर्णित करने के लिए स्युबर्ट के शोध कार्य पर आधारित एक पद्धति प्रस्तावित है।

संकेत-शब्द—एकबीजपत्री, पर्मिनीकरण, शारीर, जड़ें।

INTRODUCTION

Monocotyledons constitute about 59,300 species assigned to 112 families comprising about 25 % of the angiosperms (Thorne, 2002). Anatomy of the monocotyledons has been investigated by large number of workers. However, their roots except those of palms have been poorly addressed (Haberlandt, 1914; D'Almeida & Ramaswamy, 1948; Surange, 1950; Fahn, 1954; Metcalfe, 1960, 1961, 1963, 1971; Cutler, 1969; Tomlinson, 1969, 1970, 1982; Ayensu, 1972; Ancibor, 1979; Tomlinson & Wilder, 1984 ; Keating, 2003).

ROOT ANATOMY OF EXTANT PALMS

Anatomy of roots in palms has been investigated by many workers. Mohl (1845, 1849) was the pioneer to describe the characteristic arrangement of the vascular tissues and their connections with the stem vascular bundles. He has also noted the presence of characteristic medullary bundles that occur in palms only. Karsten (1847) noted a single undifferentiated apical meristem. Naegeli (1858), Russow (1875), Falkenberg (1876), De Bary (1877), van Tieghem (1870), Olivier (1880) and Mangin (1882) made further additions to the root anatomy. Cormack (1896) noted polystelic condition in number of palms like - *Areca, Caryota, Corypha, Dypsis, Euterpe, Geonoma, Hyophorbe, Iriartea, Kentia, Livistona, Phoenix, Ptychosperma* and *Verschaffeltia*. Gillain (1900) noted three meristematic layers in the root apex of *Hydriastele* (*Kentia*) and analyzed the root structure in number of palms. Drabble (1904) investigated 67 species. Mahabale and Udwadia (1960) analyzed 37 adult palm roots and initiated the work on the resolution of the fossil organ genus *Rhizopalmoxylon* to the natural taxa. Tomlinson (1961, 1990) has studied the structural biology of palms along with the roots. Seubert (1996a, b, 1997, 1998a, b) made in-depth anatomical analysis of 159 genera based upon the ontogenetical and phylogenetical considerations adopted by Guttenberg (1960, 1968) and Hanstein (1870) and suggested the usage of a system of uniform terminologies in describing extant palm root.

PERMINERALIZED MONOCOTYLEDONOUS ROOTS

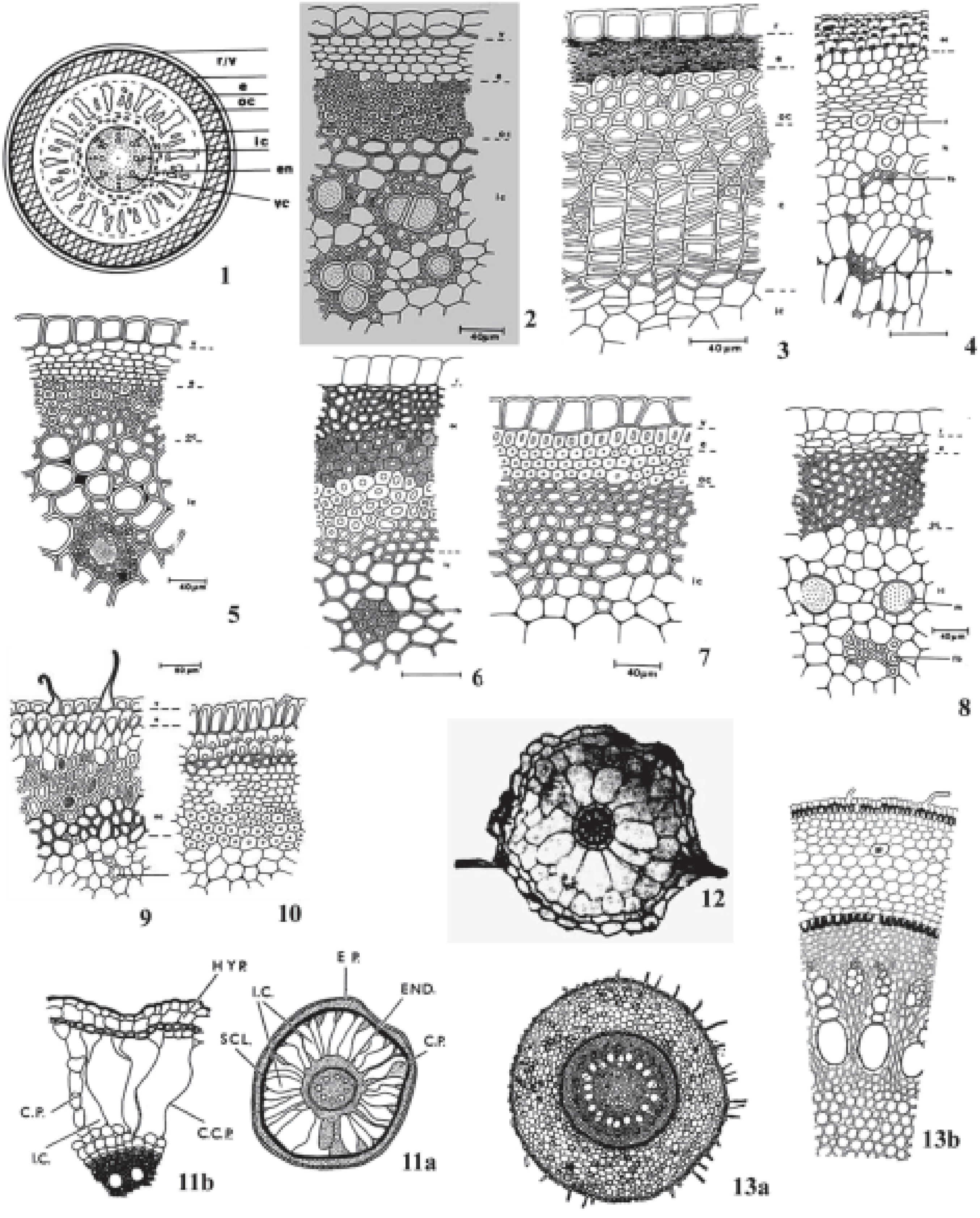
Monocotyledonous adventitious roots have been described from the Cretaceous and onward horizons. Majority of them are preserved due to permineralization, the most informative mode of preservation for the study of fossilized plants. In this process infiltration and permeation of the tissues occur by mineral charged water. Over a period of time, intracellular and interstitial precipitation of the dissolved mineral results in hardening within the plant and it effectively becomes solid rock. Thus, although the plant cell walls still consist of organic matter, they have been chemically altered and the intercellular spaces and cell lumens are filled with precipitated minerals (Schopf, 1975). The characters of the roots are ought to be present in them and the root anatomical details are available. It would be better to circumscribe the fossil forms into their nearest possible natural taxa.

The permineralized monocotyledonous roots are mainly assigned to the artificial organ genus *Rhizopalmoxylon* Gothan assuming their affinities with the palms (Family–Arecaceae). However, these could belong to the other monocotyledons also. Felix (1883) reported the institution of the monocotyledonous organ

PLATE 1 →

1. Schematic transverse section (T.S.) of a palm root showing different tissues.
2. T.S. of root of *Calamus* sp.
3. *Phoenix reclinata* Jacq.
4. *Bentinckia nicobarica* Becc.
5. *Daemonorops* sp.
6. *Caryota mitis* Lour.
7. *Phytelephas* sp.
8. *Raphia australis* Oberm. & Strey
9. *Copernicia macroglossa* H. Wendl. ex Becc.
10. *Pritchardia beccariana* Rock
11. *Paspalum commessonii* Lam. (Gramineae) : a. Entire cross section, b. part enlarged showing very large intercellular spaces, thick walled pericycle and reduced vascular tissue
12. *Triuris* sp. (Family: Triuridaceae : Helobiae)
13. *Smilax herbacea* Linn.: a, Entire transverse section, b. part enlarged showing multilayered pericycle

r – rhizodermis, v- velamen, e– exodermis, c – cork, oc – outer cortex, ic– inner cortex, en–endodermis, vc – vascular cylinder, fb – fibre bundle, f – fibre, m–mucilage cell, scl–sclerenchyma, I.C.–intercellular cavity, C.P.–cortical parenchyma, E.P.–epidermis, END–endodermis.
1-10. after Seubert, 1996, 1997, 1998; 11. after Metcalfe, 1960; 12. after Tomlinson, 1982 & 13. after Jeffrey, 1917.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C.P.
C.C.P.
I.C.
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11a
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PLATE 1

genus for permineralized roots as *Rhizopalmoxylon* showing their affinities with palms. However, he did not provide the description or diagnosis and as such *Rhizopalmoxylon* Felix (*loc. cit*.) remained as *Nomen nudum*. Establishment of *Rhizopalmoxylon* became valid when Gothan (1942) provided its diagnosis and description. *Rhizopalmoxylon* Gothan possesses 13 species, viz., *R. glaseli* Gothan (1942), *R. bohlenianum* Gothan (1942), *R. libycum* Koeniguer (1970), *R. behuninii* Tidwell *et al.* (1972), *R . blackii* Tidwell *et al.* (1972), *R. scottii* Tidwell *et al.* (1972), *R. sundaram* Mahabale and Rao (1973), *R. huepaciense* Cevallos-Ferriz and Ricalde-Moreno (1995), *R. teguachiense* Cevallos-Ferriz and Ricalde-Moreno (1995), *R. borassoides* Awasthi *et al.* (1996), *R. angiorhizon* (= *Palmoxylon angiorhizon* Stenzel, 1904; Bonde *et al*. 2009), *R. macrorhizon* (= *Palmoxylon macrorhizon* Stenzel, 1904; Bonde *et al.* 2009) and *R. singulare* Bonde *et al.* (2009). In addition, a root comparable to *Nypa* from the Mohgaonkalan Intertrappean beds (Verma, 1974) and a borassoid root from Nawargaon Intertrappean sediments (Ambwani, 1981) have been reported.

Some of the fossil palm stems like *Palmoxylon rutherfordi* Stockmans & Williere (1943), *Palmoxylon* sp. Stockmans & Williere (1943), *P. sclerodermum* Sahni (Shukla, 1946), *P. surangei* Lakhanpal (1955), *P. kraeuselii* Rao & Menon (1966), *P. raoi* Menon (1968), *P. macginitie* Tidwell *et al.* (1971) and *P. sundaram* Sahni (Bonde *et al*., 2004) possess basal regions attached with the roots. In addition, roots of a scitaminean plant *Cyclanthodendron sahnii* Sahni and Surange (Sahni & Surange, 1953; Biradar & Bonde, 1990); *Sparganium* sp. (Mahabale, 1953); a cyperaceous rhizome *Scirpusoxylon indicum* Shete (1989); a viny araceous axis *Rhodospathodendron tomlinsonii* Bonde (2000); a pandanaceous rhizome *Pandanusoxylon kulkarnii* Patil and Datar (2002) and a liliaceous corm *Eriospermocormus indicus* Bonde (2005) have been described. In the light of the present system, reexamination of roots of these taxa will throw more light on the affinities with the natural taxa.

Hygrorhizos deccanii Trivedi *et al.* (1985) is a root comparable to *Hygrorhiza* (Family – Poaceae). *Velamenorhizos intertrappeanum* Barlinge and Paradkar (1978) is an aerial abortive root with velamen showing its affinities with Araceae, Arecaceae and Orchidaceae whereas *Aerorhizos harrisii* Chitaley (1968) is an aquatic root showing its resemblance with *Alpinia, Canna, Cyperus, Hedychium* and other aquatic plants. A doubtful root of *Eichhornia* (Family – Pontederiaceae) has also been reported (Patil & Singh, 1978; Awasthi *et al.*, 1996).

SYSTEM FOR RESOLUTION OF FOSSIL MONOCOTYLEDONOUS ROOTS

The fossil monocotyledonous roots reported so far have not been described with uniform anatomical terminologies. They lack precision and delimitations of the tissues particularly those of the extra stelar region. A system based upon Seubert's anatomical work on extant palms has been proposed to resolve the fossil monocotyledonous roots including the palms to their natural taxa (Seubert, 1996a, b, 1997, 1998a, b). It may throw some light on the phylogeny of monocotyledons in future (Pl. 1.1-13).

Monocotyledonous roots exhibit the following tissues from periphery to the centre. A. *Extrastelar region* - Rhizodermis / Velamen; Exodermis; Outer cortex; Inner cortex; and Endodermis. B. *Stelar region* – Pericycle; Sheathing layer of vascular tissue; Xylem and Phloem bundles; Pith and Medullary bundles.

Rhizodermis/Velamen—Appendages - Root spines – present/absent, pointed /blunt; root tubercles-spherical/bottle like; pneumathodes - present/absent; root hairs present/absent; lateral roots –few/dense, elongate/cylindrical; branching system - fewer, short/long , thick / thin .

Rhizodermis—Cells hexagonal/tangentially elongated/honey combed, expanded in either direction/irregularly expanded; cell wall thickened /unthickened.

Velamen—one/many layered; cell wall equally/moderately/strongly/unequally thickened , outer walls thicker than inner walls; root hairs present/absent.

Exodermis—Thickness one/many layered; cell walls moderately/strongly thickened; tannin contents present/absent.

Outer cortex—a. *Three zoned*, middle zone different from outer and inner parenchymatous zones ; pits on cell wall present/absent; raphides/tannin cells present/absent, isolated/in files; cell thickness unthickened/strongly thickned .

b. *Two zoned*, outer zone with thin walled cells, inner zone with thick walled cells.

c. *Homogeneous*.

d. Rhizodermis, exodermis, outer cortex absent / cork present.

Inner cortex—Homogeneous/three zoned; aerenchyma absent/weakly/strongly developed; air spaces small/large/quadrangular/radially elongated; very large in one/many rings; stone cells present/absent, solitary/forming hollow cylinder; fibres – present/absent; outline circular/irregular; solitary/forming bundles; fibre bundles – *Kentia* type/*Raphia* type .

Endodermis—Layers-one/many; cell wall unthickened/equally thickened/unequally thickened/'U' shaped thickened; casparian thickening present/absent.

Vascular cylinder—Eustelic/polystelic .

Pericycle—Layers one/several; fibre cells present/absent.

Sheathing layer—Sclerotic/parenchymatic.

Xylem / Phloem bundles—Size, shape; number.

Pith—Parenchymatic/sclerenchymatic.

Medullary bundles—Present/absent; number.

This system may prove to be the most feasible method to resolve the permineralized monocotyledonous roots to the extant taxa which may throw light on their phylogeny.

REFERENCES

Ambwani K 1981. Borassoid fossil palm root from the Deccan Intertrappean beds of Nawargaon, Wardha District, Maharashtra. Geophytology 11: 13-15.

Ancibor E 1979. Systematic anatomy of vegetative organs of the Hydrocharitaceae. Botanical Journal of Linnean Society 78: 237-266.

Awasthi N, Mehrotra RC & Khare EG 1996. A borassoid palm root from the Deccan Intertrappean beds of Wardha District, Maharashtra with critical remarks on fossil roots of *Eichhornia*. Geophytology 26: 57-61.

Ayensu ES 1972. Anatomy of the Monocotyledons - VI. Dioscoreales. Clarendon Press, Oxford, 182p.

Barlinge SG & Paradkar SA 1978. Fossil aerial abortive root and the role of velamen. *In:* Dnyansagar VR, Deshpande PK & Padhye MD (Editors)—Recent Trends and Contacts between Cytogenetics, Embryology and Morphology: 583-587. New Delhi.

Biradar NV & Bonde SD 1990. The genus *Cyclanthodendron* and its affinities. *In:* Douglas JG & Christophel DC (Editors)—Proceedings of the 3rd International Organization of Palaeobotany Conference, Melbourne 1988: 51 -57. A-Z Printers, Melbourne.

Bonde SD 2000. *Rhodospathodendron tomlinsonii* gen. *et* sp. nov., An araceous viny axis from the Nawargaon Intertrappean beds of India. Palaeobotanist 49: 85-92.

Bonde SD 2005. *Eriospermocormus indicus* gen. et sp. nov. (Liliales: Eriospermaceae): first record of a monocotyledonous corm from the Deccan Intertrappean beds of India. Cretaceous Research 26: 197-205.

Bonde SD, Chate SV & Gamre PG 2009. *Rhizopalmoxylon singulare* sp. nov. – coralloid palm roots from the late Cretaceous Deccan Intertrappean beds of Nawargaon, India. Palaeobotanist 58: 57-65.

Bonde SD, Gamre PG & Mahabale TS 2004. Further contribution to *Palmoxylon* (*Cocos*) *sundaram* Sahni: Structure of the rooting base and its affinities. *In:* Srivastava PC (Editor)—Vistas in Palaeobotany and Plant Morphology: Evolutionary and Environmental Perspectives. Professor D.D. Pant Memorial Volume: 229-235. U. P. Offset, Lucknow, India.

Cevallos-Ferriz SRS & Ricalde-Moreno OS 1995. Palmeras fosiles del norte de Mexico. Anales Instituto Biologia Universita Nacional Autonoma Mexico, Series Botanica 66: 37-106.

Chitaley SD 1968. On *Aerorhizos harrisii* gen.*et* sp. nov. from India. Journal of the Indian Botanical Society 47: 7-12.

Cormack BG 1896. On polystelic roots of certain palms. Transactions of the Linnean Society, London., Series 2, 5 : 275-286.

Cutler DF 1969. Anatomy of Monocotyledons - IV. Juncales. Oxford University Press, London, 357p.

D'Almeida & Ramaswamy CS 1948. A contribution to the study of the ecological anatomy of the Indian Cyperaceae. Botanical Memoirs, University of Bombay 1 : 1-80.

De Bary HA 1877. Vergleichende Anatomie der Vegetationsorgane der Phanerogame und Farne. Leipzig.

Drabble E 1904. On the anatomy of roots of palms. Transactions of the Linnean Society, London., Series 2, 6: 427-490.

Fahn A 1954. Anatomical structure of Xanthorrhoeaceae Dumort. Botaical Journal of Linnean Society 55: 158-184.

Falkenberg P 1876. Vergleichende Untersuchungen uber den Bau der Vegetationsorgane der Monocotyledon. Stuttgart.

Felix J 1883. Die fossilen Holzer Westindiens. Sammlung Palaeontologie Abhandlungen, Series I: 1- 27.

Gillain G 1900. Beitrage zur Anaomie der Palmen und Pandanacean Wurzel. Bot. Centralbl. lxxiii. : 337-345, 369-380, 401-412.

Gothan W 1942. Uber Palmenwurzelholzer aus der Brunkohle von Bohlen (Sachsen). Zeitschrift fur Geschiebeforschung und Flachlandsgeologie 18: 2-14.

Guttenberg H von 1960. Grundzüge der Histogenese höherer Pflazen, I. Die Angiospermen . In Handbuch der Pflazenanatomie, Bd. 8, Teil 3. Berlin, Stuttgart.

Guttenberg H von 1968. Der primare Bau der Angiospermenwurzel . In Handbuch der Pflazenanatomie, Bd. 8, Teil 5. Berlin, Stuttgart.

Hanstein J von 1870. Die Entwicjlung des Keimes der Monokotylen und Dicotylen Botan. Abh. a.d. Geb.d. Morpho.u.Physiol . 1: Heft 1.

Haberlandt G 1914. Physiological plant anatomy. MacMillan and Company, London.

Jeffrey EC 1917. The anatomy of the woody plants. University of Chicago Press, Chicago Illinois. 478p.

Karsten H 1847. Die Vegetationsorgane der Palmen. Abh. Berl. Akad. Wiss .(Phys.): 73- 236.

Keating RC 2003. The anatomy of the monocotyledons - IX. Acoraceae and Araceae. Oxford University Press, Oxford : 1-344.

Koeniguer JC 1970. Sur quelques structures de Palmiers du Mio-Pliocene du Lybie. 94th Congres national des societes savants, Pau, 1969, Sciences, III: 175 -189.

Lakhanpal RN 1955. *Palmoxylon surangei*, a new species of petrified palms from the Deccan Intertrappean Series. Palaeobotanist 4: 15-21.

Mahabale TS 1953. Occurrence of *Sparganium* in the Deccan Intertrappeans of Madhya Pradesh, India. Proceedings of the National Institute of Sciences, India 19: 623-629.

Mahabale TS & Rao SV 1973. Fossil flora of Rajahmundry area. *In:* Mahabale TS (Editor)—Proceedings of the Symposium on Deccan Trap Country. New Delhi, INSA Bulletin No. 45: 192-214.

Mahabale TS & Udwadia NN 1960. Studies on palms-Part IV. Anatomy of palm roots. Proceedings of the National Institute of Sciences 26 B: 73-104.

Mangin L 1882. Origine et insertion des racines adventives et modifications, etc. Ann. Sci. Nat. ser. 6, xiv. : 216-363.

Menon VK 1968. On a new petrified palm wood from Mohgaonkalan area. Palaeobotanist 16: 197-205.

Metcalfe CR 1960. Anatomy of the Monocotyledons. I. Gramineae. Clarendon Press, Oxford, 731 p.

Metcalfe CR 1961. The anatomical approach to systematics. Recent advances in Botany, Toronto University Press, USA 1: 146-150.

Metcalfe CR 1963. Comparative anatomy as a modern botanical discipline. *In:* Preston RD (Editor)—Advances in Botanical Research, I : 101-147. Academic Press, London and New York.

Metcalfe CR 1971. Anatomy of the Monocotyledons - V. Cyperaceae. Clarendon Press, Oxford, 597p.

Mohl H von 1845. Vermische Schriften. Tubingen.

Mohl H von 1849. On the structure of the palm stem . English translation published by the Royal Society of London.

Naegeli C von 1858. Beitrage zur wissenschaftliche Botanik, Heft i. Leipzig.

Olivier L 1880. Recherches sur l´appareil tegumentaire des racines. Ann. Sci. Nat. ser.6, xi. : 5-133.

Patil GV & Singh RB 1978. Fossil *Eichhornia* from the Eocene Deccan Intertrappean beds, India. Palaeontographica 167 B: 1-7.

Patil KS & Datar K 2002. A fossil Pandanaceous stem *Pandanaceoxylon kulkarnii* gen. et sp. nov. from the Deccan Intertrappean beds of Wardha District, Maharashtra. Geophytology 32: 61-71.

Rao AR & Menon VK 1966. A new species of petrified palm stem from the Deccan Intertrappean Series. Palaeobotanist 14: 256-263.

Russow EAF 1875. Betrachtungen uber das Leitbundel und Grundgewebe, u.s.w.Dorpat.

Sahni B & Surange KR 1953. On the structure and affinities of *Cyclanthodendron sahnii* Sahni and Surange from the Deccan Intertrappean Series. Palaeobotanist 2: 93-100.

Schopf JM 1975. Modes of fossil preservation. Review of Palaeobotany and Palynology 20: 27-53.

Seubert E 1996a. Root anatomy of palms II. Calamoideae. Feddes Repertorium 107: 43-59.

Seubert E 1996b. Root anatomy of palms III. Ceroxyloideae, Nypoideae, Phytelepheae. Feddes Repertorium 107: 597-619.

Seubert E 1997. Root anatomy of palms I. Coryphoideae. Flora 192: 81-103.

Seubert E 1998a. Root anatomy of palms IV. Arecoideae, Part I. General remarks and description of the roots. Feddes Repertorium 109: 89-127.

Seubert E 1998b. Root anatomy of palms IV. Arecoideae, Part II. Systematic implications. Feddes Repertorium 109: 231-247.

Shete RH 1989. *Scirpusoxylon indicum* gen. et sp. nov., a cyperaceous rhizome from Deccan Intertappean beds of India. *In:* Biradar NV (Editor)—Proceedings of the Special Indian Geophytological Conference 1987 : 161-163. Poona.

Shukla VB 1946. *Palmoxylon sclerodermum* Sahni from the Eocene beds of Nawargaon, Wardha District, C.P. Journal of the Indian Botanical Society 25: 105-116.

Stenzel KG 1904. Fossilen Palmenholzer. Beitrage Palaontologie und Geologie Osterreichungars und des Orients. Leipzig XVI: 107-288.

Stockmans F & Williere Y 1943. Palmoxylons Paniseliens de la Belgique. Memoires du Musee Royal d' Histoire Naturelle de Belgique 100: 1-75.

Surange KR 1950. A contribution to the morphology and anatomy of the Cyclanthaceae. Transactions of the National Institute of Sciences, India 3: 159-209.

Thorne RF 2002. How many species of seed plants are there ? Taxon 51: 511-512.

Tidwell WD, Medlyn DA & Thayn GF 1972. Fossil palm materials from the Tertiary Dipping Vat Formation of Central Utah. Great Basin Naturalist 32: 1-15.

Tidwell WD, Simper AD & Medlyn DA 1971. A *Palmoxylon* from a Green River Formation (Eocene) of Eden Valley, Wyoming. Botanique 2: 93-102.

Tieghem PEL van 1870. Recherches sur la symetrie des structure des plantes vasculaires. Ann. Sci. Nat.ser.5, xiii. pp. 5-314.

Tomlinson PB 1961. Anatomy of the Monocotyledons - II. Palmae. Clarendon Press, Oxford, 453p.

Tomlinson PB 1969. Anatomy of the Monocotyledons - III. Commelinales – Zingiberales. Clarendon Press, Oxford, 446p.

Tomlinson PB 1970. Monocotyledons - Towards an understanding of their morphology and anatomy. *In:* Preston RD (Editor)—Advances in Botanical Research 3: 207-292. Academic Press, London and New York.

Tomlinson PB 1982. Anatomy of the Monocotyledons VII. Helobiae (Alismataceae). Clarendon Press, Oxford, 559p.

Tomlinson PB 1990. The Structural Biology of Palms. Clarendon Press, Oxford, 477p.

Tomlinson PB & Wilder G J 1984. Systematic anatomy of Cyclanthaceae (Monocotyledonae) - an overview. Botanical Gazette 145: 535-549.

Trivedi BS, Srivastava RK & Bajpai SK 1985. *Hygrorhizos deccanii* gen.et sp.nov from the Deccan Intertrappean beds of Mohgaonkalan (M.P.), India. Geophytology 15: 137-140.

Verma CL 1974. Occurrence of the fossil *Nypa* root from the Deccan Intertrappean beds of M.P., India. Current Science 43: 289-290.