Gondwana Eight, Findlay, Unrug, Banks & Veevers (eds) © 1993 Balkema, Rotterdam. ISBN 90 5410 304 3

Taxonomic diversity of Triassic seeds from India

Shyam C. Srivastava & S. R. Manik
Birbal Sahni Institute of Palaeobotany, Lucknow, India

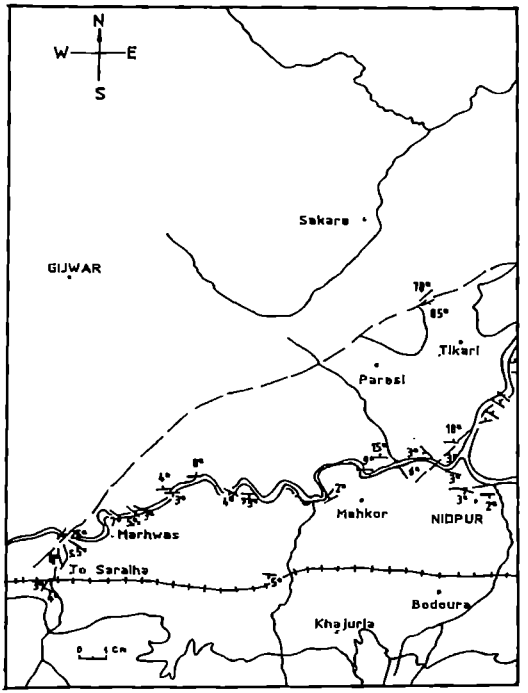
ABSTRACT: Based upon the distinctive cutinized membranes, six new genera: Sahnispermum, Delevorvaspermum, Cupolaspermum, Urceolaspermum, Tayloriaspermum and Konaspermum have been identified from the plant bearing sediments of Nidpur. The Triassic bed occurs in a small fault-bounded outcrop containing exquisitely preserved plant organs in carbonaceous sandy shale of dark to light-grey colours. The study has been carried out on isolated seed compressions found in detached conditions. Generally, the fossil seeds yield three to five membranes which are outer-inner cuticle of the integument, nucellus and megaspore membrane. The seed taxa have been differentiated using the following parameters: cutinization of integument and nucellus, cell shape and size, surface striations, occurrence of papillae, thickness of anticlinal wall, presence or absence of inner cuticle of integument, presence or absence of megaspore membrane, structural organization of pollen chamber, extent of fusion of integument with nucellus and nature of micropylar hole. The relationship of genera have been determined on the circumstanstial evidence provided by morpho-taxonomical details of seed cuticle.

INTRODUCTION

The Triassic sequence in the Son Valley of South Rewa Gondwana Basin consists of three distinct formations. In ascending order, these are the Panchet (including Upper Pali), Tiki and Parsora formations (Roy Chowdhary et al, 1975). The Nidpur beds are considered to be the youngest unit and are exposed in the Gopad river (=Tiki Formation). The outcrop has revealed an extremely diverse plant assemblage including foliage , unattached fertile organs, scale leaves, and seeds. Palynomorphs have also been re-trieved from the fragile carbonaceous shale (Srivastava, 1988, Bharadwaj & Srivastava, 1969, and Tiwari & Ram Awatar 1990). All the major taxonomic groups are represented in the flora. Among these, Pteridospermophyta is the most diverse and dominant group, and is represented by the taxa Lepidopteris, Dicroidium and the microsporangiate organ Pteruchus. Of these taxa Dicroidium is overwhelmingly dominant. The preponderance of nonsriate bisaccate grains has also been recorded. Palaeofloristically a Middle Triassic age for the Nidpur beds is ascertained. Like other plant organs, seeds are also preserved in a variety of ways depending upon their structure and the conditions prevailing at the time of deposition. Seeds are represented as cast, impression, compression and petrifactions.

Morphologically, the seed consists of an envelope (integument) with a micropyle and mgasporangium (the nucellus) inside which there is megagametophyte consisting of nutritive tissue and archegonia.

From the Mesozoic of India, the fossil seed impression Samaropsis was recorded by Feistmantel (1880) from the Panchet Formation of Raniganj Coalfield. Later, Lele



LOCATION-MAP (After Raja Rao,1983)

(1955,1962) furnished an illustrated account of seed impressions revealing representative of several species of Samaropsis and Cardaicarpus from the Parsora Formation of South Rewa Basin. Banerji et al (1976,1978)reported impressions of seed-like bodies from the Triassic of the Gopad River section near Nidpur, and also recorded Spermatitis spp. i.e. impressions from Upper Triassic exposures of the Janar Nala section near Harai. In addition some isolated compressed seeds identical to Amphorispermum were described by Bose and Banerji (1984) from Middle Upper Jurassic strata of Kachchh.

Recently, while further investigating the fertile structures from the Triassic beds of Nidpur, Pant and Basu (1977), Manik (1988) and Srivastava and Manik (1990) have reported seed compactions, namely; Rugaspermum, Savitrispermum, Nidspermum,Rotundaspermum,Pyriformispermum,Pantiaspermum and Rostrum aspermum and enriched our knowledge of the flora.

From further collections of seed compressions, six new genera have been instituted based upon their distinctive cuticular membranes, involving their exomorphic characters, viz.,Sahnispermum, Delevoryaspermum, Cupolaspermum, Urceolaspermum, Tayloriaspermum and Konaspermum. Collectively these findings have demonstrated considerable taxonomic diversity among the Triassic seeds.

TAXONOMY

Sahnispermum gen.nov.
(pl.1 Figs.1,3 Text-figs.1A-D)
Diagnosis: Seed oval,platyspermic, overall outline undulating, slightly tapering towards micropylar end, outer integument papillate, stomatiferous, papillae overcarching stomatal pit,nuceller membrane enclosing megaspore sac, pollen chamber distinctly differentiated, composed of shorter polygonal cells, more or less dome-like,end-walls converging towards micropylar end, highly cutinized, micropylar opening protruding,appearing somewhat saucer-shaped.

Type Species: Sahnispermum indicum

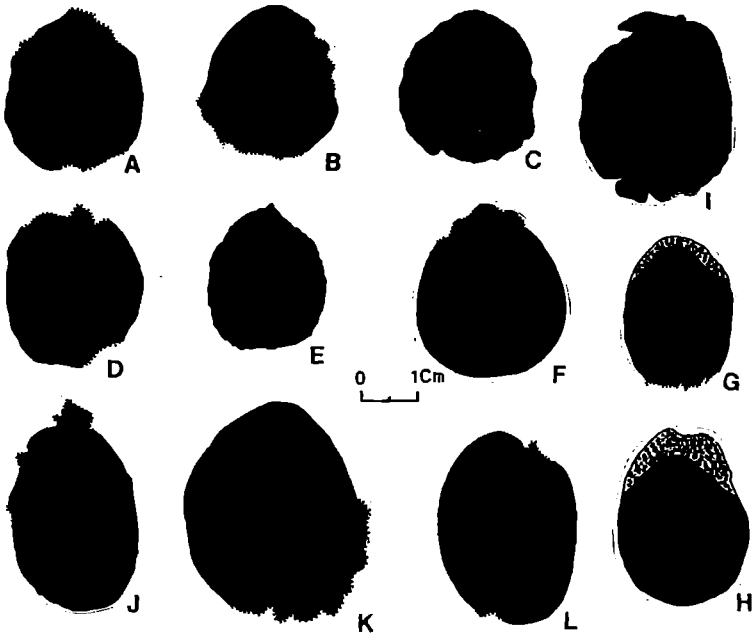
Holotype: Slide No.BSIP 10633; Middle Triassic, Nidpur, India.

Derivatio nominis: To commemorate the Birth-Centenary Year 1991 of Professor Birbal Sahni.

Discussion

In the papillate nature of the outer integument, this taxon closely approaches the seed Rugaspermum media (Pant and Basu,1977) but it is readily distinguished from the latter by the absence of wrinkles or rugose outer integument. The seed cuticle of S. indicum also resembles that of Peltaspermum thomasi, (Townrow, 1957) where the papillae overarch the stomatal pit. The epidermal character of S.indicum is similar to that of Bosea indica (Srivastava, 1975) and the general epidermal feature compares favourably with Lepidopteris indica.

Pollen grains inside the pollen chamber of S.indicum belonging to Weylandites-complex have been



Text-fig.1 Sahnispermum indicum gen.et.sp.nov.; A,C & D,Carbonised seeds. Isotype-Nos.10636,10637,10639x5; B.Holotype No.10633x5.E.Delevoryaspermum nidpurensis gen.et.sp.nov.;10641x5. F.Cupolaspermum marhwaseanum gen.et. sp.nov.; 10642x5. G. Urceolaspermum gopadensis gen.et.sp.nov.; Isotype No.10647x5; H.Holotype No.10646x5. I,J & L. Konaspermum sidhiensis gen. et.sp.nov.; Isotype No.10650,10649,10653 x5. K. Holotype No.10648.

observed. These pollen have been reported in dispersed condition from the Nidpur shale by Bharadwaj and Srivastava (1969). This indicates costate pollen grains were typically involved in pollination.

As a consequence of their constant association in the Nidpur shale, and because of the similarity of their epidermal features, the vegetative leaf Lepidopteris indica, the pollen organ Bosea indica and the seed taxon Sahnispermum indicum may have been derived from the same plant.

Affinities

The free integument from the nucellus upto the base of the seed, a characteristic feature of pteridosperms, reveals the relationship of Sahnispermum indicum with the Pteridospermales.

Delevoryaspermum gen.nov.
(Pl.1,Figs.4-5 Test figs.1-E,2,3)

Diagnosis: Seed oval having uneven outline, outer integument smooth, stomatiferous, pollen chamber broadly triangular, micropylar end bulging out somewhat like a protuberance, nucellar membrane interspersed with fine creases, megaspore centrally located.

Type species: Delevoryaspermum nidpurensis

Holotype: Slide No.BSIP 10640, Middle Triassic, Nidpur, India.

Discussion :

Delevoryaspermum, while resembling Savitrispermum and Nidispermum in its smooth surface, differs from the latter on bearing a stomatiferous integument. It differs from Sahnispermum indicum by the absence of papillae over the integument. In epidermal

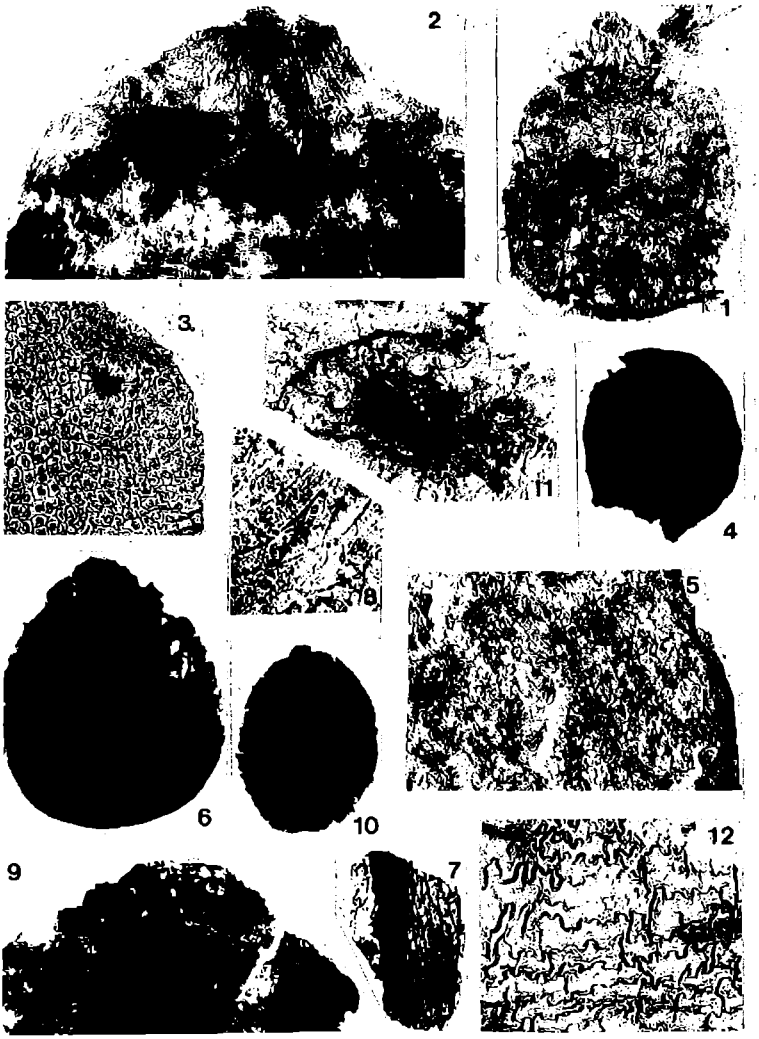
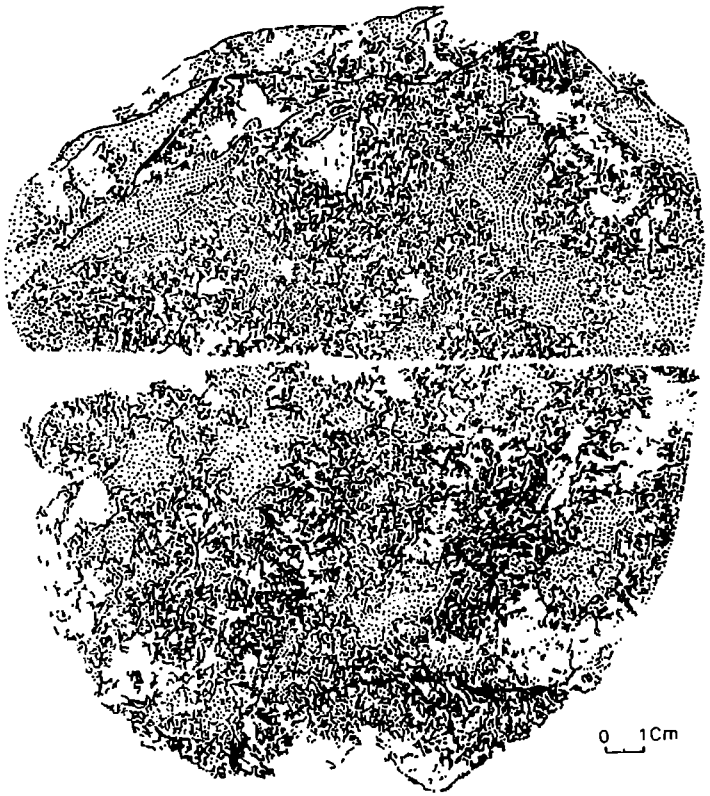


Plate-1 Sahnispermum indicum gen.et sp.nov. Fig.1. Seed after alkali treatment showing distinctly differentiated pollen chamber,micropylar opening and nucellar membrane associated with inner integument. BSIP Slide No.10635x25. Fig.2. Seed showing micropylar hole and slight depession at the distal end of nucellus forming pollen chamber. Holotype-BSIP Slide No.10635x50. Fig.3.Outer investment of seed with distinct papillate periclinal wall. BSIP slide No.10637x50. Delevoryaspermum nidpurensis gen.et sp.nov. Fig.4. Unmacerated seed dipped in glycerine. BSIP Specimen No.10640x10. Fig.5. Cellular structure of outer integument showing irregular distributed stomata. BSIP Slide No. 10640X50. Cupolaspermum marhwaseanum gen.et sp.nov. Fig.6. Seed after acid treatment showing broad chalazal end and obtusely pointed micropylar end. Holotype, BSIP Slide No.10642X20. Cellular structure of outer integument alongwith a portion of nucellar membrane, BSIP Slide No.10642X50. Fig.8. A portion of outer integument showing cellular details. BSIP Slide No.10642X250. Fig.9. Dome-shaped pollen chamber coalesced with outer integument. BSIP. Slide No.10642X50. Tayloriaspermum sinuosum gen.et.sp.nov. Fig. 10. Acid treated seed. Holotype BSIP Slie No.10644X20. Fig.11. Micropylar end of seed lying in flattened position showing micropylar hole associated with cellular remains of outer integument. BSIP Slide No.10645X150. Fig.12. Outer cuticle of integument showing sinuous cells. BSIP Slide No. 10644X150.



Text-fig.2. Delevoryaspermum nidpurensis gen.et. sp.nov.; A -Upper half portion of seed showing inegument associated with nucellus. BSIP Slide No.10641 X50.;A2. Portion of outer integument in Lower half of seed-BSIP Slide No.10641 X50.

characters, Delevoryaspermum shows similarity with Dicroidium nidpurensis (Bose and Srivastava,1971). Futher, when Delevoryaspermum nidpurensis is compared with the various species of Pteruchus described from the Nidpur beds, it is noted that the former comes close to P. nidpurensis in its smooth nature of the cell surface wall and in addition to this similarity both stomatal apparatus are alike.

Thus, it can be inferred that Delevoryaspermum nidpurensis could have been the seed of the Dicroidium nidpurensis plant because of the structural similarity of the outer integument with that of the leaf cuticle of D. nidpurensis.

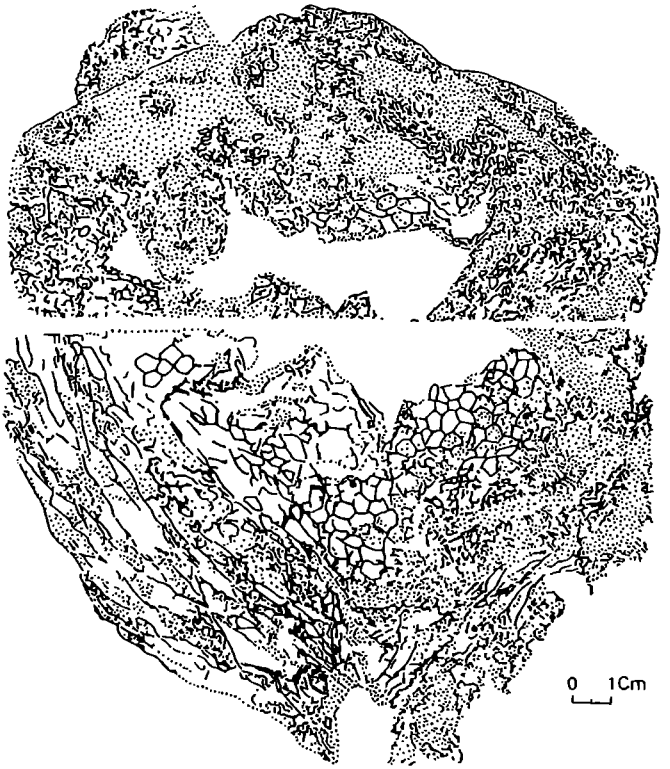
This match of epidermal features between Delevoryaspermum nidpurensis and Pteruchus nidpurensis probably indicates that they can be ascribed to the Dicroidium nidpurensis plant.

Affinities :

Delevoryaspermum nidpurensis clearly demonstrates its relationship to the pteridospermales by its distinctive free outer integument upto the seed base, and by the elaborate pollen chamber.

Cupolaspermum gen.nov.
(Pl.1 Fig.6-9 Text-figs.1-F)

Diagnosis: Seed ovate; forming apically distinctive cupola bearing ornate or sculptured edge; outer integument smooth marginal flange-cells around micropylar hole, perforated generally elliptical in shape.



Text-fig.3. Delevoryaspermum nidpurensis gen. et. sp.nov.; A -Upper half of seed showing nucellus and micropylar region. BSIP Slide No.10641 X150; A2-Lower half of seed showing chalazal end. BSIP Slide No.10641 X150.

Type species : Cupolaspermum marhwaseaanum

Holotype: Slide No.BSIP 10642 Middle Triassic, Nidpur, India.

Discussion:

The typical cupola enables Cupolaspermum gen.nov. to be distinguished from the seed genera Rugaspermum, Savitrispermum, Nidispermum, Rotundaspermum, Pyriformispermum, Pantiaspermum and Rostrumaspermum but in this particular character this genus closely compares with Menaisperma greenlyii (Pettitt & Lacey 1972).

Affinities

Its well developed dome shaped massive pollen chamber indicates its botanical affiliation with the pteridosperms.

Urceolaspermum gen.nov.
(Pl.2 Figs.1-3 Text-figs.1,G-H)

Diagnosis: Seed pitcher shaped, micropylar hole sub-spherical bearing jagged edge; integument surface smooth; intimately adherent to nucellus, apically nucellus free from integument leaving crescent shaped pollen chamber, nucellus apex dome-shaped, nucellar membrane enclosing dark brown massive megaspore.

Type species : Urceolaspermum gopdensis.

Holotype: Slide NO. BSIP 10646 Middle Triassic, Nidpur, India.

Discussion :

Because of its pitcher-shaped character Urceolaspermum gopadensis can be readily differentiated

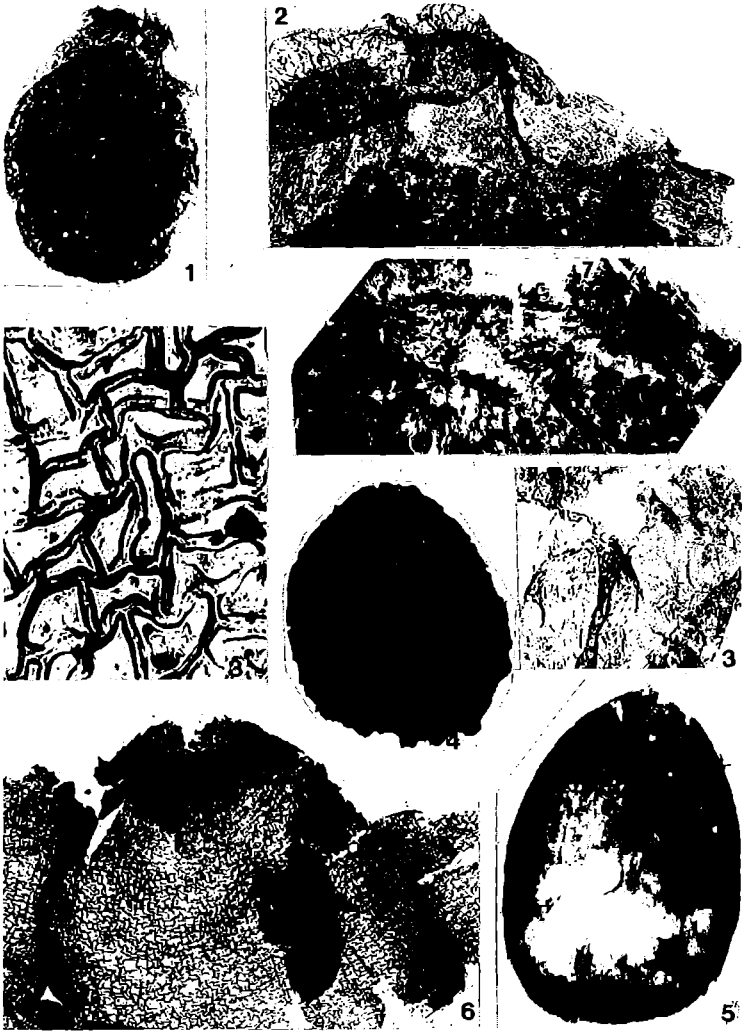
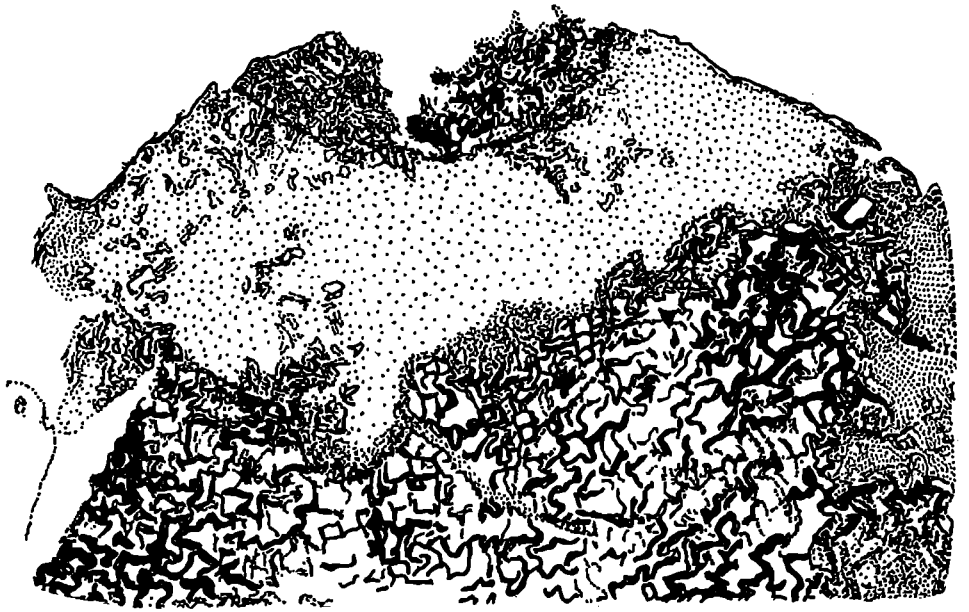


Plate-2: Urceolaspermum gopdensis gen.et.sp.nov. Fig.1. Flask-shaped seed having distinct micropylar opening after acid treatment. Holotype-BSIP Slide No. 10646 X 20. Fig.2. A portion of micropylar end showing details of micropylar region and distinct nucellar dome. BSIP Slide No. 10646 X 50. Fig.3. A portion of outer integument covering in the micropylar region showing varied cells. BSIP Slide No.10647, X 150. Konaspermum sidhiensis gen. et sp.nov. Fig.4. Unmacerated seed dipped in glycerine. Holotype BSIP Specimen No.10648 X 10. Fig.5. Seed after alkali treatment showing differentiating membranes. BSIP Slide No.10649 X20. Fig.6. Micropylar end of seed magnified to show heavy cutinization and cutinized concentric rings all around micropylar opening associated with distinctive angulate epidermis of outer integument. BSIP Slide No.10648 X50. Fig.7. Encircling cutinized rim all around distinct micropylar opening. BSIP Slide No.10649 X150. Fig.8. Epidermal structure of outer integument showing angular cells with thickly cutinized anticlinal walls. BSIP Slide No.10651 X300.



Text-fig.4. Konaspermum sidhiensis gen. et. sp.nov.: A. Micropylar region of seed showing strong cutinization and cells of outer cuticle of integument. BSIP Slide No.10648 x 50.

from all the known seed genera. However, in its smooth surface of epidermal cells, the taxon shows resemblance to Delevoryaspermum nidpurensis, Nidispermum glabrosum and Cupolaspermum marhwaseanum. In having nucellar apex free from the outer integument Allicospermum xystum (Harris,1935) from the Rhaetic of Greenland compares very closely with U. gopadensis. Both genera possess circular, fairly thick megaspores.However,A. xystum differs in shape and is much bigger in size.

Affinities :

The pollen chamber of Urceolaspermum gopadensis is much reduced compared to those of pteridospermus seeds and in this respect U. gopadensis shows greater similarity to the cycads . Further the separation of the nucellar apex from the outer integument favours affinity with the Cycadales.

Tayloriaspermum gen.nov.
(Pl.1, Figs.10-12)

Diagnosis: Seed almond shaped, micropylar rim heavily cutinized, outer integument composed of sinuous cells a distance equivalent to three quarters the length of the nucellus towards the micropyle possessing an apical nucellar membrane separated from the outer integument, nucellar apex depressed, somewhat semilunar in appearance, pollen chamber extremely reduced appearing like a flattened apical bulge.

Type Species: Tayloriaspermum sinuosum

Derivatio nominis: After Professor Tom Taylor for his outstanding contribution to fossil seed morphology.

Holotype: Slide No.BSIP 10644 Middle Triassic, Nidpur, India.

Discussion:

Tayloriaspermum sinuosum differs from other recorded seed genera because it possesses sinuous cells. It is similar to U. gopadensis in possessing a nucellar apex separated from the outer integument . In the sinuous

Text-fig.4B. Micropylar region of seedshowing circular opening and distinct nucellus. BSIP Slide No. 10649 X 50.

nature of the seed cuticle it resembles the leaf cuticle of Taeniopteris glandulata (Srivastava, 1971) from the Triassic of Nidpur.

Ctenis stewartiana (Harris, 1932) from the Rhaetic of East Greenland, resembles Tayloriaspermum sinuosum in the sinuous character of its integument. It also shows similarity with the leaf genera Nipaniophyllum raoi (Sahni,1948) and Yabeilla hirsuta (Sukh-Dev,1980) in bearing sinuous anticlinal walls thickened atthe curves.

Affinities:

Considering the extant Cycadales the leaves of Stangeria eriopus Pant and Nautiyal (1963) most closely resemble T. sinuosum because of their structural organisation of loop and crest. The leaves of S. eriopus differ however because of the presence of fine striations and plentiful hair bases. This seed genus shows affinity with the cycads due to differentiation of the outer integument from the nucellus at the apex. The nucellus remain free from the outer integument for a short distance, a feature, frequently encountered in cycadean seeds. Secondly,the extremely reduced pollen chamber and the nature of sinuous cells, justify the assignation of T. sinuosum to Cycadales.

Konaspermum gen. nov.
(Pl.2 Figs.4-8 Text-figs.4,A-B)

Diagnosis: Seed ovate, chalazal end broadly ellipsoidal,cutinized concentric rings encircling sunken micropylar opening, integument composed of angular cells, differentiated into cutinized and uncutinized areas giving a patchy or spotted appearance, inner side of anticlinal walls pronouncedly thickened, outer edge invariably shared by adjacent cells looking somewhat like a double wall, nucellus free from outer investment.

Type species: Konaspermum sidhiensis

Derivatio nominis: Hindi word "Kona" means angular.

Holotype: Slide No.BSIP 10648 Middle Triassic, Nidpur, India.

Discussion:

In possessing a depressed or sunken micropylar hole, spotted or patchy appearance and thickening of cell interiors, Konaspermum closely compares with Amphorispermum pullum (Harris, 1932,1964) but the later is conspicuously different in the absence of angular epidermal cells. In its angulate cells K. sidhiensis compares with seed-type-2 described from the Permian of Congo (Hoeg and Bose,1960).The other seeds described from the Triassic of Nidpur differs from Konaspermum by possessing a spotty and patchy integument consisting of angulate cells.

Affinities

Konaspermum sidhiensis belongs to the order Coniferales because the nucellar membrane is free from the integument over most of the seed and because there is no definite pollen chamber.

CONCLUSION

Study of these gymnospermous seeds has revealed a great diversity indicating all major taxonomic groups;Pteridospermales, Cyucadales and Coniferales flourished in the vicinity of Nidpur. Based on the resemblance of their epidermal features, the notable alliances are: the leaf Lepidopteris indica, the pollen organ Bosea indica containing Weylandites type pollen and the seed Sahnispermum indicum have been attributed to the Lepidopteris- type plant; the leaf Dicroidium nidpurensis, pollen organ Pteruchus nidpurensis and seed Delevoryaspermum nidpurensis have been ascribed to the plant Dicroidium nidpurensis. Amongst the cycadean seeds, Taloriaspermum sinuosum shows its affinity with Taeniopteris glandulata. In additon Savitrispermum crateriformis, the seed taxon represented in the Gondwanic continent is quite prolific in the Nidpur sediments and based upon epidermal features has shown similarity with seed fructification Umkomasia. The present study of fossil seeds provide a significant key to our understanding of the structure and differentiation of the various groups of plants represented in the flora. The systematic taxonomy further strengthens the view that the Nidpur area was a sheltered fresh water lake or estuary bordered by marshy habitat supporting the growth of cryptogamic plants(Algae,Bryophyta etc.). Also, the features such as trichome, papillae, heavily cutinized cell walls, sinuous cellular outlines must have developed in response to the fluctuating climatic conditions prevalent during the Triassic period at Nidpur. Thus, this investigation of fossil seeds from the Triassic of India has contributed to an acceptable reconstruction of a palaeoenvironment in which in situ burial of vegetation took place.

REFERENCES

Banerji,J., Maheshwari,H.K. & Bose M.N.(1976). Some plant fossils from the Gopad river section near Nidpur Sidhi District, Madhya Pradesh, Palaeobotanist 23: 59-71.

Banerji, J., Kumaran, K.P.N. & Maheshwari, H.K. (1978). Upper Triassic sporae dispersae from the Tiki Formation-1, Megaspores from the Janar Nala Section, South Rewa Gondwana Basin, Palaeobotanist 25:1-26.

Bhardwaj,D.C. & Srivastava, Shyam C. (1969). A Triassic mioflora from Inia. Palaeontographica B125: 119-149.

Bose,M.N. & Banerji,J. (1984). The fossil floras of Kachchh-I Mesozoic megafossils. Palaeobotanist 33:1-89.

Bose,M.N. & Srivastava,Shyam C. (1971). The genus Dicroidium from the Triassic & Nidpur, Madhya Pradesh, India. Palaeobotanist, 19: 41-51.

Bose,M.N. & Srivastava,Shyam C. (1972). Lepidopteris indica sp. nov. from the Lower Triassic of Nidpur, Madhya Pradesh. Journal of the Palaeontological Society of India, 15: 64-68.

Feistmantel,O. (1880). The fossil flora of the Gondwana System; the flora of the Damuda and Panchet Divisions. Memoirs of the Geological Survey of India, Palaeontologia Indica, 3:1-77.

Harris,T.M. (1932). The fossil flora of Scoresby Sound East Greenland Pt.2: Description of seed plants incertae sedis together with a discussion of certain cycadophyte cuticles. Meddelelser om Gronland Kjobenhavn, 85: 1-112.

Harris,T.M. (1935). The fossil flora of Scoresby Sound, East Greenland, Pt. 4, Ginkgoales, Coniferales, Lycopodiales, and isolated fructifications. Meddeleser om ronland Kjobenhavn, 112:1-176.

Harris,T.M. (1964) The Yorkshire Jurassic flora II_Caytoniales, Cycadales and Pteridopserms. British Museum (Natural History) London: 1-191.

Hoeg,O. & Bose,M.N. (1960). The Glossopteris flora of the Belgian Congo, Annales du Musee r. du Congo, Belge Serie, 8vo, 32: 1-109.

Lele,K.M. (1955). Plant fossil from Parsora in the South Rewa Gondwana Basin, India. Palaeobotanist, 4:23-24.

Lele,K.M. (1962). Studies in the

Indian Middle Gondwana flora 3: Platyspermic seeds and megaspore impressions from the South Rewa Gondwana Basin, Palaeobotanist, 11:13-18.

Manik,S.R. (1988). Some new genera of Triassic seeds.Palaeobotanist 36: 197-200.

Pant,D.D. & Basu, N. (1977). On some seeds, synangia and scales from the Triassic of Nidpur, India. Palaeontographica, B163: 162-178.

Pant,D.D. & Nautiyal,D.D. (1963). Cuticleand epidermis of recent cycadales, leaves, sporangia, seeds.Senckenbergiana biologica, 44: 257-348.

Pettitt,J.M. & Lacey,W.S. (1972). A Lower Carboniferous seed compression from North Wales. Review of Palaeobotany and Palynology, 14: 159-169.

Roychowdhury,M.K., Sastry,M.V.A., Sah,S.C., Singh,G. & Ghosh,S.C. (1975).Triassic floral succession in the Gondwana of Peninsular India: pp.149 - 158. In: Campbell, K.S.W. (Eds.) Gondwana Geology, 3rd International Gondwana Symposium, Canberra:1-705.

Sahni,B. (1948). The Pentoxyleae a new group of Jurassic gymnosperms from the Rajmahal Hills of India. Botanical Gazette 110: 47-48.

Srivastava,Shyam C. (1971). Some Gymnospermic remains from the Triassic of Nidpur, Sidhi District, Madhya Pradesh. Palaeobotanist 18: 280-296.

Srivastava,Shyam C. (1975). A new microsporangiate fructification from the Triassic of Nidpur, India. Palaeobotanist 22:19-22.

Srivastava,Shyam C. (1988). Stratigraphic positon and age of plant bearing Nidpur beds. Palaeobotanist 36: 154-160.

Srivastava,Shyam C. & Manik,S.R. (1990) Rostrumaspermum venkatachalae gen.et.sp.nov., an archegoniate seed from Triassic of Nidpur, India. In: Jain,K.P. & Tiwari,R.S. (eds.)-Proceedings of the Symposium Vistas in Indian Palaeobotany, Palaeobotanist,38: 98-104. BSIP, Lucknow.

Sukh-Dev, (1980). Occurrence of genus Yabeiella Oishi in the Jabalpur Formation. Palaeobotanist 26: 257-260.

Tiwari,R.S. & Ram-Awatar (1990). Palyno dating of Nidpur beds, Son Graben, Madhya Pradesh, In: Jain,K.P. & Tiwari, R.S. (eds) Proceedings of the Symposium "Vistas in Indian Palaeobotany" Palaeobotanist 38: 105-121. BSIP Lucknow.

Townrow, J.A.(1957): On Dicroidium probably pteriospermous leaf, and other leaves now removed from this genus. Transactions of the geological society of South Africa 60: 21-56.