Alien elements in the Gondwana Flora of India

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The occurrence of northern hemispheric taxa in Gondwana is considered as alien to the Glossopteris and Dicroidium floras of Southern Hemisphere. The morphology, evolutionary lineages, and stratigraphic distribution of Euramerian, Cathaysian and Angaran forms in the Gondwana flora of India are examined in view of their latest discoveries in the Permian and Triassic sequences. The study indicates that some of the elements of contemporaneous floras possess characteristic affiliation with the Gondwana flora, likewise some of the Gondwana elements exemplify the comparative characters of northern forms. Possible linkages, association, existence and ancestry of the Gondwana flora *vis a vis* Northern floras are discussed.

Key-words—Alien elements, Evolutionary linkage, Gondwana flora.

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सारांश

भारत के गोंडवाना वनस्पतिजात में अन्यदेशीय अवयव

अश्विनी कुमार श्रीवास्तव

गोंडवाना में उत्तरी गोलार्द्ध के वर्गकों की उपस्थिति दक्षिणी गोलार्द्ध के ग्लॉसॉप्टेरिस एवं डाइक्रोइडियम वनस्पतिजातों में अन्यदेशीय अवयवों के समान मानी गई है। परमी एवं त्रिसंधी अनुक्रमों में भारत के गोंडवाना वनस्पतिजात में यूरामेरिकन, कैथेसियन एवं अंगारन प्ररूपों की आकारिकी, विकासीय श्रृंखलाओं तथा स्तरिकीय वितरण का अध्ययन किया गया है। इस अध्ययन से व्यक्त होता है कि समकालीन वनस्पतिजातों के कुछ अवयव गोंडवाना वनस्पतिजात से समानता प्रदर्शित करते हैं और इसी प्रकार कुछ गोंडवाना अवयव उत्तरी प्ररूपों के लक्षण व्यक्त करते हैं। गोंडवाना वनस्पतिजात तथा उत्तरी वनस्पतिजातों के मध्य सम्भाव्य श्रृंखलाओं, साहचर्य तथा पूर्वजता की विवेचना की गई है।

THE Indian Gondwana flora makes its appearance in the Early Permian strata and develops as the Glossopteris flora and in the Triassic Period it succeeds as the Dicroidium flora. Earlier, the Ptilophyllum flora considered as Jurassic in age was recognized as the uppermost flora of the Indian Gondwana (Lele, 1964, 1976a) but recent investigations suggest that continental Jurassic deposits are absent in India and the Ptilophyllum flora in all probability belongs to Lower Cretaceous (Garg *et al.*, 1988; Krishna, 1988; Acharyya & Lahiri, 1991; Venkatachala & Maheshwari, 1991).

It is believed that there was a uniformity in the Carboniferous flora of northern and southern hemispheres before Glossopteris flora came into existence (Seward, 1903; Sahni, 1939; Halle, 1937; Jongmans, 1954; Edwards, 1955; Archangelsky, 1970, 1971; Chaloner & Meyen, 1973). The wide spread Gondwana glaciation resulted into the differentiation of world floras and by the close of Carboniferous and beginning of Permian there existed four more or less well-defined botanical provinces. The Glossopteris flora occupies the southern land-mass, i.e., Gondwana including India, Australia, South America, South Africa and Antarctica. The Euramerian flora dominated by lepidodendrids, calamites, sphenophylls and pteridosperms flourished in the North America and Europe. The Angara flora characterised by Cordaitales and pteridosperms covered the Siberian region from the Petchora Basin, north-west of Urals to the Pacific Coast of the USSR and south into the north-west China. The Cathaysian flora, commonly known as Gigantopteris flora developed in China and extended to the south of Sumatra. Chaloner and Lacey (1973) sorted out characteristic genera of each floral provinces as follows: North American floral

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province, referred by them as fifth flora, is considered here under Euramerian flora for broader comparison of floras:

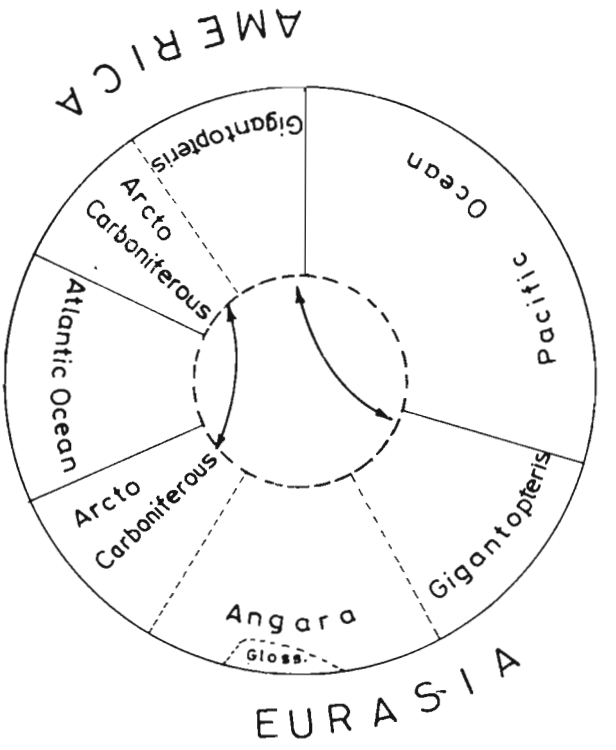
	Euramerian	Angara	North America	Cathaysia	Glossopteris
Alethopteris	+				
Calamites	+				
Sigillaria	+				
Cordaites	+	+	+	+	
Pecopteris	+	+			
Callipteris	+	+	+		
Neuropteris/Odontopteris	+	+			
Sphenophyllum	+	+	+	+	
Annularia	+	+			
Walchia	+	+	+		
Taeniopteris	+		+	+	
Intia					
Tschernovia		+			
Annulina		+			
Viatscheslavia		+			
Angaridium		+			
Paragondwanidium		+			
Rufloria		+			
Vojnovskya		+			
Supaia			+		
Glenopteris			+		
Russellites			+		
Giganotopteris			+	+	
Protoblechnum			+	+	
Tingia			+		
Lobatannularia			+		
Gondwanidium					+
Noeggerathiopsis					+
Gangamopteris					+
Glossopteris					+
Trizygia					+
Lycopodiopsis/Cyclodendron					+
Schizoneura					+

Sahni (1935) explained the distribution of each flora by viewing the globe from the Arctic Pole (Text-figure 1).

While discussing the Permo-Carboniferous floral provinces with special reference to India, he indicated that the floras of Northern Hemisphere, i.e., Euramerian, Cathaysian and Angara are more in common than any one of them has with the Gondwana flora. The compilation of the floras by Chaloner and Lacey (1973) also reflects such association with certain reservation.

PERMIAN GONDWANA FLORA VIS A VIS NORTHERN HEMISPHERIC FLORAS

Morphology, affinities and distribution of the flora in different formations, i.e., Talchir, Karharbari, Barakar, Barren Measures and Raniganj have earlier



Text-figure 1

been discussed by many workers (Surange, 1975; Lele, 1976b; Maheshwari, 1976; Srivastava, 1986) and they strongly favoured the idea of endemism in the Gondwana flora. However, during the last ten years, the knowledge of the Indian Gondwana palaeobotany has increased rapidly and the discoveries of newer elements having comparative similarities with the northern hemispheric forms provide evidence to consider the Gondwana flora in a broader perspective rather than conservative flora of its own domain.

There are several limitations to know the exact affinities of Gondwana plants because most of them are known only by their sterile foliage characters, however, the organization and venation pattern of leaves demonstrate their positive affiliation with different groups of plants. Discovery of male and female fructifications of glossopterid has enabled us to identify it as a distinct plant group of the Gondwana flora. Its unequivocal affinity with pteridosperms and other groups of gymnosperms signifies a unique position in the taxonomy of plants.

Earlier investigators considered the Gondwana records of *Phyllotheca, Schizoneura, Noeggerathiopsis, Cordaites, Sphenophyllum, Pecopteris, Sphenopteris, Alethopteris, Ptychocarpus* as the representatives of northern hemispheric flora (Zeiller, 1896, 1902; Feistmantel, 1879-90; Arber,

1905; Srivastava, 1955; Surange, 1964). Later, many of them proved to be gondwanic in nature. The fern like pinnules have been considered to be true pteridophytes and accordingly they are placed into several new genera—*Neomariopteris, Damudopteris, Dichotomopteris, Asansolia, Dizeugotheca, Santhalea* and *Leleopteris* (Maithy, 1974a, b, 1975; Pant & Khare, 1974; Pant & Misra, 1976, 1977; Srivastava & Chandra, 1982). The forms placed under *Phyllotheca robusta* have been transferred to a new genus *Lelstotheca* Maheshwari (= *Stellotheca* Surange & Prakash 1962) and *Sphenophyllum* like foliage have been identified as *Trizygia* (Maheshwari, 1968).

Latest discoveries of plant fossil assemblages from Rajmahal, Raniganj, South Rewa Gondwana basins and Handapa areas indicate that the flora is much more diversified and contains many forms showing morphological similarity with the northern floras (Singh, Srivastava & Maheshwari, 1986; Chandra, 1984; Chandra & Singh, 1988; Bajpai & Maheshwari, 1991; Maheshwari & Bajpai, in press).

Critical assessment of the plant fossil assemblages amply demonstrates the fair representation of northern form in the Indian Gondwana flora. The following genera of Eurameria, Cathaysia and Angara floras are known in the Permian flora of Indian Gondwana:

	Eurameria	Angara	Cathaysia	Glossopteris
Schizoneura			+	+
Phyllotheca	+	+	+	+
Barakaria		+		+
Sphenophyllum	+	+	+	+
Trizygia			+	+
Psygmophyllum	+	+	+	+
Rhipidopsis	+	+	+	+
Saportaea	+		+	+
Ginkgoites	+	+	+	+
Cordaites	+	+	+	+

Meyen (1969, 1971, 1982), a strong believer of parallel evolution, suggested that similar looking sterile remains may not necessarily bear the same botanical affinity and cites the example of *Phyllotheca*, a common genus, where we find *Tschernovia* type of fructification in Angara but similar looking foliage axis bears another type of fertile structure known as *Gondwanostachys* in Gondwana (= *Giridia* Pant, Nautiyal & Misra 1981). *Manchuriostachys*, a fertile structure of Cathaysian *Schizoneura* (Konno, 1960) is an additional example which shows its differentiation with the fructification of Gondwana schizoneur (Srivastava, 1952; Surange, 1964). The occurrence of different types of fructification favours the idea of similar leaf morphology in two botanically distinct identities. But when we are dealing with a fraction or part of plant, it is very difficult to get associated or attached fertile specimens and the problem is much more serious in the Gondwana flora of India where we lack permineralized fossils and preserved fertile structures. Even the nature and affinities of dominant genus *Glossopteris* could be established only after a lapse of about 120 years since its first discovery by Brongniart (1828-1830). Though, Feistmantel in a series of monographs (1879-1890) described many glossopterid leaf assemblages from India and Australia but did not find sufficient fertile specimens. It was only in the year 1952 that Plumstead (1952-1958) discovered a large number of fertile specimens enabling us to understand the distinct taxonomic status of *Glossopteris*. Now many types of glossopterid fructifications are known in the Indian Gondwana flora (Surange & Chandra, 1978; Maheshwari, 1990 and references cited therein). However, the Indian Gondwana flora is devoid of fructifications of plants belonging to other groups and in such state of knowledge if we restrict our interpretation to the availability of fertile structures, almost all the groups of plant excepting glossopterid and pteridophyte, remain without a fair deal.

Paucity of fertile specimens do not necessarily warrant us to correlate the leaf or other parts of plant fossils and one is obliged to derive maximum information from available fossil specimens (Paul, 1982; Pant, 1982). Ignorance of such elements in the floral scene of Indian Gondwana would prove detrimental to draw complete knowledge of flora. In fact, qualitatively and quantitatively better specimens in the floras of northern hemisphere provide us sufficient information about their morphology but their poor occurrence and lack of fertile structures restrict us to decide their exact affinity in the Gondwana flora and as a matter of convenience we call them northern elements.

Sahni (1926, 1935) termed such "Northern" records (Table 2) in the Indian Gondwana flora as remnants or descendants of the pre-existing southern flora of Carboniferous age and emphasised that "at least some of them are hardy survivors (and in part descendants) of the cosmopolitan life of pre-Gondwana time".

Ancestry

The discovery of Lepidodendropsis flora from the Lower Carboniferous beds of Extra-peninsular India favours similarity in northern and southern floras (Pal & Chaloner, 1979; Singh *et al.*, 1982). Pre-Gondwana Late Carboniferous flora is not known in

India but this flora has been recorded in other Gondwana countries, e.g., Australia, South America and South Africa.

Earlier workers like Edwards (1952) and Krausel (1961) believe that the Carboniferous lycopods of Southern Hemisphere were distinct as compared to the northern forms. However, Archangelsky (1970) has observed similarity between Northern and southern lycopods. While transferring all the records of *Rhacopteris* from Southern Hemisphere, i.e., Argentina, Peru and Kashmir, Rigby (1985) considers *Lepidodendron* and *Pseudorhacopteris* as the diagnostic genera for New South Wales flora ranging from Namurian to Westphalian in age. In South America, South Africa and Australia it has been observed that *Botrychiopsis* (= *Gondwanidium*)—a Gondwana form, came into existence in the Late Carboniferous sequence alongwith the elements of Early Carboniferous flora (Plumstead, 1976; Rigby 1973; Archangelsky, 1986). *Nothorhacopteris, Botrychiopsis* and *Ginkgophyllum* (NBG) association has been found to be characteristic in South America. The reports of Gondwana forms, e.g., *Gondwanidium, Buriadia, Glossopteris* in the Upper Carboniferous flora of Tubarao Series and Santa Catarina of the Parana Basin of Brazil and in San Juan Province of Argentina (Fossa-Mancini, 1940; Dolianiti, 1953, 1954; Archangelsky & Sota, 1966) and the discovery of northern elements in the Early Permian Sequence of Patagonia, Paganzo Basin, Lubeckense flora of Argentina (Archangelsky & Sota, 1960; Archangelsky & Arrondo, 1975; Archangelsky, 1984, 1986), Brazil (Rosler, 1975) and Kashmir (Singh *et al.*, 1982) alongwith typical Gondwana flora clearly demonstrate that both Northern and southern floras were in some sort of agreement to each other at some stage. Such association was disturbed due to onset of Gondwana glaciation and the resultant climatic imbalances must have favoured a large scale mutation towards the appearance of Glossopteris flora and disappearance of major pre-Gondwana plants (Sahni, 1937, 1939; Pant, 1988). However, the catastrophic event did not destroy all the elements, some of them could have sustained the lethal conditions and continued their occurrence in hospitable pockets. The occurrence of the so-called northern elements and incoming records of plant fossils having comparative significance with northern elements in the Gondwana flora, e.g., *Polyspermophyllum* Archangelsky & Cuneo 1990 (Dicranophyllalean leaves in Argentina) and ginkgopsid leaves in India (Maheshwari & Bajpai, 1992) and near definite records of glossopterid leaves with other forms outside Gondwana countries (as discussed on p. 14) suggest such a phenomenon. Similar type of viability is evident in the flora of Upper Cretaceous, where we find sudden dominance of angiosperms alongwith earlier elements of Bennettitales, Cycadales, Leptostrobales and Ginkgoales (Meyen, 1987, p. 323).

Affiliation

Time and again, the comparative relationship and affinities of different plant groups of the Gondwana flora are discussed with the floras of Northern Hemisphere. On the contrary, some of the northern forms were viewed in relation to characteristics of Gondwana flora (Meyen, 1969, 1982, 1987).

The morphographic similarity of some of the genera of the Indian Gondwana flora belonging to different plant groups with their northern counterparts is examined. The plant groups represented in the Glossopteris flora are: ?Bryophyta, Lycopodophyta, Arthrophyta, Pterophyta, Glossopteridophyta, Cycadophyta, Ginkgophyta and Coniferophyta.

Lycopodophyta—Seward and Sahni (1920) placed lycopodaceous stem axes under *Bothrodendron lesli* Seward. Later, Krausel (1928, 1961) reallocated all southern lycopods into three genera, *Lycopodiopsis* Renault, *Lycopodophlois* Krausel and *Cyclodendron* Krausel in possessing eligulate leaf scars pattern. However, presence of eligulate lycopod stem in the Upper Carboniferous flora of Angara, e.g., *Angaraphlois* (Meyen, 1982) demonstrates the ancestry of such character in northern hemispheric flora (Archangelsky & Arrondo, 1969).

Arthrophyta—Most of the genera belonging to Equisetales and Sphenophyllales, e.g., *Phyllotheca, Schizoneura, Barakaria, Trizygia, Sphenophyllum,* are known to occur in the flora of Angara, Cathaysia and Eurameria. Unfortunately, the fructifications of these genera are not known in the Indian Gondwana flora.

Sphenophyll has long been considered as distinct in having asymmetrical trizygoid leaf pattern, e.g., *Trizygia speciosa* (Maheshwari, 1968) but recent discoveries of symmetrically arranged leaf whorls in *Sphenophyllum churulianum* (Srivastava & Rigby, 1983) and heterophyllous leaf whorls with dentate to smooth margin in *Sphenophyllum gondwanensis* (Singh, Srivastava & Maheshwari, 1986) indicate the presence of typical northern hemispheric form in the Indian Gondwana flora.

Articulated leaves united or free near the nodal axes in *Lelstotheca* and *Bengalea* are comparable with the foliage pattern of *Annularia/Asterophyllites* (Maheshwari & Srivastava, 1987; Maheshwari, Singh

& Bajpai, 1989). Leafless stem axes of *Phyllotheca* and *Schizoneura* described under Angaran genus, *Paracalamites* Zalessky by Rigby (1966) and the records of *Barakaria* in the Indian and Angara floras (Meyen, 1969) having possible affinity with autophyllites of Boureau (1964) supports the existence of such forms beyond the limits of Gondwana.

Surange and Prakash (1962) observed distinction in Gondwana phyllothecs and transferred the forms described under *P. robusta* to a new genus, *Stellotheca* (= *Lelstotheca* Maheshwari, 1972). Meyen (1971) while revising Angaran phyllothecs considered that Gondwanan and Angaran forms possess different types of fertile structure, i.e. *Tschernovia* in Angara and *Gondwanostachys* in Gondwana, hence both the forms are botanically distinct. But Meyen's (1982) noteworthy derivation of such fertile structures from the Lower Carboniferous Euramerian genera *Pothocites* (for Tschernoviaceae) and *Protocalamostachys* (for Gondwanostachyaceae) suggests possible northern ancestry for Gondwana phyllothecs—*Sakoarata polyangiata* Appert 1970. Madagascaran Gondwana phyllothec fructification showing mega- and microsporangiate organs separately demonstrate that *Phyllotheca* like plants had varied mode of fructification, a case similar with glossopterid where sometimes similar looking leaves possess different type of fructifications (Plumstead, 1958). Such explanation seems to be plausible for the occurrence of *Schizoneura* in Gondwana and Cathaysia floras (Konno, 1960; Asama, 1966).

Pterophyta—The oldest fern-like form from the Gondwana of India is *Botrychiopsis* (= *Gondwanidium*) *valida* Archangelsky & Arrondo. The genus has been found to be the earliest element of Glossopteris flora in the Late Carboniferous of Australia, Argentina and Brazil (Rigby, 1973; Archangelsky, 1986). Its exact taxonomic position is still not clear but Seward (1910) and Plumstead (1973, 1976) have compared the nature of its pinnules with northern hemispheric pteridosperms.

Recent investigations of sterile and fertile fronds recovered from the Barakar and Raniganj formations suggest that they are distinct from northern hemispheric forms of *Alethopteris, Cladophlebis, Cyclopteris, Merianopteris, Pecopteris, Sphenopteris,* etc. The Indian forms are now known as *Asansolia, Dichotomopteris, Damudosorus, Damudopteris, Dizeugotheca, Leleopteris, Neomariopteris, Santhalea* and *Tritbecopteris.*

Pant and Khare (1974) and Pant (1976) grouped the ferns into two families, viz., Damudopteridaceae characterized by free eusporangia with a transverse annulus, and Asterothecaceae which includes the synangiate ferns apparently closer to northern ferns.

Glossopteridophyta—This is the dominant group of the Gondwana flora and is represented by simple leaf genera having reticulate or non-reticulate venation pattern with or without midrib, e.g., *Belemnopteris, Euryphyllum, Gangamopteris, Glossopteris, Palaeovittaria, Rhabdotaenia* and *Rubidgea.* Srivastava (1991) has observed an evolutionary tendency in the venation pattern of glossopteridalean leaves. Different types of male and female fructifications have been found attached or in association with such leaves (Surange & Chandra 1978; Maheshwari, 1990, and references cited therein).

Glossopterids are essentially the Gondwana forms and their records in other floral provinces have often been doubted in the absence of associated fertile structure (Edwards, 1955; Alvin & Chaloner, 1970; Chaloner & Crebe, 1983; Li Xingxue, 1986; Maheshwari & Bajpai, 1988). However, finding of *Vertebraria* alongwith *Glossopteris* leaves in New Guinea flora (Visser & Hermes, 1962) and my observation of type specimens of *Glossopteris anatolica* Archangelsky & Wagner 1983 at the British Museum suggest the probable occurrence of glossopterid leaves in association with northern floras. Meyen (1969) discussed the authenticity of glossopterid leaves in Angara flora and after careful scrutiny states, "It does not mean, however, that *Glossopteris* is completely absent from Angara flora. V. G. Zimina (1967) described typical *Glossopteris* leaves from the Upper Permian of the Far East".

The Late Carboniferous flora of Southern Hemisphere lacks any positive evidence to demonstrate the ancestry of glossopterids. However, noteworthy distribution and similarity of Northern and Southern forms in South America (= Lubeckense flora, Archangelsky & Arrondo, 1965, 1975) during Early Permian invite our attention to look into certain non-gondwanic forms to find the character affiliation of glossopterids.

The external morphological features of Angara genus *Zamiopteris* are similar to the glossopterid genus *Euryphyllum* and that too, to some extent with *Rubidgea* in having non-anastomosing, dichotomising veins, whereas Late Carboniferous Euramerian genus *Lesleya* is comparable with the leaves of *Palaeovittaria* and *Maheshwariphyllum* in having midrib only up to 1/2 or 3/4 of leaf lamina with dichotomizing veins. Cuticular features of *Zamiopteris* and *Lesleya* are also similar with *Palaeovittaria* (Pant & Verma, 1964; Remy & Remy, 1975, 1978; Meyen, 1982). On the basis of such similarities Leary (1991) considers *Lesleya* as the

possible ancestor of Permian glossopterids.

Meyen (1982) and Maheshwari (1990) have correlated the female fructification, *Krylovia* of Angara flora with the glossopterid fructification *Arberia*. Possible relationship of *Arberia/Dolianitia*-plan with cordaitean fructification—*Cordaitanthus*, as suggested by Schopf (1976) also demonstrates the probable ancestry of glossopterids in Euramerian flora. The chances of getting glossopterid fructifications are rare even in the Gondwana flora, however, different types and varied modes of male and female fertile organs (Surange & Chandra, 1978; Maheshwari, 1990) do not rule out the possibility of getting their comparative forms in non-gondwanic countries. Likewise seed-bearing fructifications—*Veekaysinghia* and *Birbalsahnia*, recovered from the Permian strata of India enhances the existence of northern hemispheric pteridosperms in Gondwana flora (Bajpai & Maheshwari, 1991).

Cycadophyta—Pant (1958) while studying the cuticular features of *Taeniopteris* leaves from the Permian Gondwana found that they are similar with glossopterid leaves and transferred them to a new genus, *Rhabdotaenia*. Similarly the leaves of *Pteronilssonia* Pant & Mehra 1963 is now considered to belong to glossopterid (Pant, 1982). Forms such as *Pseudoctenis* and *Pterophyllum* are apparently similar with the northern floras.

Ginkgophyta—Ginkgoalean fructifications are not known but leaves apparently similar with *Ginkgo* leaves are well recorded in the Gondwana flora. Such leaves are very much similar with the northern forms and recent discovery of *Saportaea*-like leaves alongwith previously known records of *Psygmophyllum, Rhipidopsis* and *Ginkgoites* in Lower Permian flora of Rajmahal Hills (Maheshwari & Bajpai, 1992) reflects a close association of ginkgopsid leaves in northern and southern floras.

Coniferophyta—Coniferales are poorly known from the Lower Permian strata by one species each of *Buriadia, Paranocladus* and *Walkomiella*. Pant and Bhatnagar (1975) have described conifer-like foliage shoot under *Searsolia* from the Upper Permian sequence but its affinity is still not clear. The genus *Buriadia* is known by its sterile and fertile structure and is distinct in having single ovule on ordinary shoots among the leaves. However, the form is comparable with the Northern genus—*Walchia* in cuticular features and hairs on shoots. Archangelsky and Cuneo (1987) consider Buriadiales as the primitive conifers and suggest parallel line of evolution in Southern Hemisphere which led to Voltziales. While studying the female shoot of *Walkomiella indica* Surange & Singh 1953 have observed its similarity with Northern forms and remarked "*Walkomiella* therefore has a female "flower" on a seed scale complex of essentially the same type as in *Lebachia* (Florin, 1951)"

Cordaitales—The genus *Noeggerathiopsis* having strap-shaped parallel veined leaves are common in the Talchir and Karharbari formations. Their closest similarity with northern hemispheric cordaite leaves has led many workers to transfer leaves of *Noeggerathiopsis* under *Cordaites* (Rigby, Maheshwari & Schopf, 1980, and references cited therein). But recent investigation of Lower Permian flora from Raniganj Coalfield demonstrates that two forms are distinguishable from each other in the absence and presence of interstitial veins/fibres in between major veins. Accordingly *Cordaites* and *Noeggerathiopsis* leaves are described in the Gondwana flora (Srivastava, 1988, 1992).

RELATIONSHIP OF TRIASSIC GONDWANA AND NORTHERN FLORAS

The Triassic sequence of India is mostly arenaceous, ferruginous and devoid of coal. Plant fossil assemblages are poorly known and have been recorded from Panchet of Raniganj and Auranga Coalfields, Bihar; Parsora Formation and Nidpur beds of South Rewa Gondwana Basin and Maleri beds of Andhra Pradesh (Lele, 1964; Bose, 1974).

The incoming of *Dicroidium* in this sequence makes it distinct from the Glossopteris flora; however, Permian plant remains, viz., *Glossopteris, Rhabdotaenia, Schizoneura, Trizygia* and *Neomariopteris* continue in the Lower Triassic flora.

TRIASSIC	PANCHET FORMATION (LOWER TRIASSIC)	PARSORA FORMATION (UPPER TRIASSIC)
LYCOPODOPHYTA		
Lycopodites	+	
Stigmaria?	+	+
ARTHROPHYTA		
Neocalamites		+
Trizygia	+	+
Shizoneura	+	
Phyllotheca	+	
PTEROPHYTA		
Sphenopteris	+	
Pecopteris		+
Cyclopteris		+
Marattiopsis		+
Danaeopsis		+
Parsarophyllum		+
Cladophlebis		+
PTERIDOSPERMOPHYTA		
Lepidopteris	+	+

Bosea	+	
Dicroidium	+	+
Pteruchus	+	
Nidia	+	
Nidistrobus	+	
Satsangia	+	
Sagenopteris	+	
CYCADOPHYTA		
Anomozamites		+
Pseudoctenis		+
Pterophyllum		+
Taeniopteris		+
GINKGOPHYTES		
Baiera		+
Ginkgoites		+
CONIFEROPHYTA		
Noeggerathiopsis	+	+
Podozamites		+
Desmiophyllum		+
Araucarites		+
GLOSSOPTERIDOPHYTA		
Rhabdotaenia	+	
Glossopteris	+	
Glottolepis	+	
Vertebraria	+	
INCERTAE SEDIS		
Marwasophyllites	+	
Sidhiphyllites	+	
Rewaphyllum	+	

Newer elements, viz., *Lycopodites, Cladophlebis, Parsarophyllum, Marattiopsis, Danaeopsis, Pterophyllum, Pseudoctenis, Taeniopteris, Baiera, Desmiophyllum* and *Araucarites* show their appearance in the Upper Triassic flora as under:

The floral change from Permian to Triassic corresponds with a climatic shift. Poverty of floral assemblages and the xerophytic characters in some forms indicate the existence of adverse conditions which affected the survival of Glossopteris flora. The plants belonging to lycophytes, pteridophytes, glossopterids and cordaites also started receding from the floral scene of Early Triassic Period (Lele, 1964). On the contrary, new gymnosperm rich assemblage having affinity with cycadophytes, ginkgophytes, alongwith conifers, pteridosperms and ferns appeared on the scene in the later part of Triassic indicating return of favourable conditions for the development of plants loving warm humid climate (Lele, 1976a).

The common occurrence of *Ginkgoites, Psygmophyllum, Rhipidopsis, Taeniopteris, Pseudoctenis, Pterophyllum, Ctenis, Araucarites*, etc. in Northern and Southern floras demonstrates the uniformity of Triassic flora. However, *Dicroidium*—a characteristic genus of the Gondwana, is still open to question about its real affinity. Schopf (1976) postulates its Northern ancestry while Lele (1976a) states "*Dicroidium* is also rather polymorphous and some workers treat it in a more comprehensive sense including several other plants like *Xylopteris, Johnstonia, Stenopteris, Displasiophyllum, Zuberia, Protoblechnum* etc.".

CONCLUSION

The available examples and comparative significance of the Indian Gondwana flora *vis a vis* contemporaneous northern floras suggest that in all probability the elements of Glossopteris flora had its ancestry in the Late Carboniferous flora and the change in climatic set up resulted to evolve a glossopterid rich assemblage in Gondwana countries, whereas pteridosperms, cordaites, conifers and ginkgopsids continued to flourish in Northern Hemispheric floras.

Floristic analysis suggests that the plant groups other than glossopterid in Gondwana flora owe their character affiliation with Northern floras, however, at times they did change themselves in comparison to their Northern counterparts but still retained their lineage with them. The so-called "Alien" elements or "Northern" elements might not be alien but they bring out the uniform nature of Northern and Southern floras. Northern Hemispheric genera, e.g., *Lesleya, Zamiopteris* and *Krylovia* having affinity with Gondwana flora probably conceived the characters of glossopterids in Late Carboniferous flora. However, such elements did not get enough chance for their survival and development in the contemporaneous floras, whereas they succeeded into the development of Glossopterid-like forms in Southern Hemisphere.

The occurrence of uniform floral composition towards the end of Triassic in Northern and Southern floras signifies the viability of contemporaneous elements in Gondwana flora. They underscore themselves in Permian because of the super dominance of Glossopteris flora and as soon as this flora started disappearing from the scene, they succeeded in outplaying the Glossopteris flora.

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