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THE GYMNOSPERM POLLEN GENUS *CALLIALASPORITES* DEV EMEND. MAHESHWARI 1974 IN THE MESOZOIC SUCCESSION OF INDIA

VIJAYA

BIRBAL SAHNI INSTITUTE OF PALAEOBOTANY, 53, UNIVERSITY ROAD, LUCKNOW-226007, INDIA
E-mail: bsip_vijaya@yahoo.co.in

ABSTRACT

The gymnosperm pollen genus *Callialasporites* Dev emend. Maheshwari (1974) exhibits much variation in the exinal features. In India, the first appearance of this taxon is indicated by the occurrence of *C. turbatus, C. microvelatus* or *C. dampieri* species in Rhaetian – Hettangian transition. However, this genus attains abundance in the Middle Jurassic and continues upto the Lower Cretaceous on the Indian peninsula, as well as else where in the Gondwana region. During this time span, much morphological diversity has led to the erection of many species to the genus. This apparent complexity, and the stratigraphic significance of the species are investigated in this paper. Among the twenty nine species that have been erected, only nine are considered to be sufficiently distinct to be used for dating and correlating rock successions.

Keywords: Morpho-taxonomy, *Callialasporites*, Triassic, Jurassic, Cretaceous, India

INTRODUCTION

A survey of palynological literature on the Indian peninsula (Fig. 1), and studies done by the author, show that the First Appearance Datum (FAD) of the genus *Callialasporites* Dev emend. Maheshwari (1974) is observed in the latest Triassic (Rhaetian) in the Rajmahal Basin (Tripathi, 2000) and Singrauli Coalfield, Son Valley (Tripathi *et al.*, 2005). The first occurrence of this taxon has also been discussed in detail, as to evidence the on-set of Jurassic deposits in Panagarh area, Damodar Basin (Vijaya, 2000; Vijaya and Bhattacharji, 2003), and Palar Basin (Tripathi and Vijaya, 1997) in India.

The species diversity increases from the level of its FAD and the genus becomes dominant in Lower-Middle Jurassic deposits (Tripathi, 2001; Vijaya and Sen, 2005; Vijaya and Bhattacharji, 2003). Subsequently in Lower Cretaceous palynofloras, *Callialasporites* is not only abundant but also comprises many new species with overlapping features. An attempt is made here to resolve this complex taxonomic problem and delimit distinct species, which could be used as the stratigraphy markers.

TAXONOMIC NOTES

Records of the occurrence of *Callialasporites* are widely distributed geographically during the Jurassic. It is however, not established - whether only one species (*C. turbatus* or *C. dampieri*) occurred first (FAD) or all the three species (*C. turbatus, C. dampieri* and *C. microvelatus*) made their appearance simultaneously? Does the diversity indicated by the number of species of this taxon evolved steadily or randomly in a group of characters through the Jurassic and Early Cretaceous times? Answers to these questions are attempted here.

Maheshwari (1974, p.34-36) discussed in detail the morpho-taxonomy of genus *Callialasporites*, and presented a number of valid points that led to emend the diagnosis. Therefore, the taxonomic status of genus *Callialasporites* given here, is after Maheshwari (1974).

Anteturma **Pollenites** Potonie 1931
Turma **Saccites** Erdtmann 1947
Subturma **Monosaccites** Chitaley emend. Potonie & Kremp 1954
Infraturma **Prosaccites** Maheshwari 1974
Genus ***Callialasporites*** Dev 1961 emend. Maheshwari 1974

Type species: *Callialasporites* (al. *Zonalapollenites*) *trilobatus* Balme 1957; pl. 8, fig. 91

Locality : Broome No. 3 Water Bore, Canning Basin, Western. Australia

Horizon and Age : Jarlemai Siltstone; Oxfordian, Late Jurassic

Characteristic Features (after Maheshwari 1974, p. 36) : Pollen more or less circular or sub-triangular; trilete mark vestigial, rays sometimes visible, reaching up to equator of body; exine two-layered, laevigate, finely granulate, verrucate, baculate to micro-reticulate, sometimes vesiculate; not separated from central body at both proximal and distal poles; prosaccus encircling central body, variously lobed, surface strongly frilled, laevigate or finely granulate or having minute bacula.

Remarks: The generic name *Callialasporites* Dev (1961) is treated here as valid taxon. There has been much discussions on this subject by several authors (Srivastava 1966, p. 93; Bharadwaj and Kumar 1972, p.219-221; Kumar, 1973, p. 113 ; Maheshwari, 1974, p. 34-36; Singh and Kumar, 1969; Varma and Ramanujam, 1984, p. 64; Filatoff, 1975, p. 81-82) regarding the emendation of this taxon. All of the species described herein, some are previously attributed to other genera but later transferred to the genus *Callialasporites,* have been encountered in Indian succession.

Following is the brief account of only those species (Table 1), which are on record under genus *Callialasporites* in the Mesozoic succession from India (Fig. 2).

Callialasporites monoalasporus Dev, 1961
(Pl. I, fig. 1)

Holotype: Dev 1961; pl. 4, fig. 25; size 106.00 x 90 ì m.

Locality: Sehora on Sher River, Narsinghpur District, Madhya Pradesh, India.

Horizon and Age: Jabalpur Formation, Early Cretaceous.

Characteristic Features: Oval; size 94-107 x 88-98 ìm;

Table 1 : List of all the species in the genus *Callialasporites* Dev emended Maheshwari (1974), so far identified from different horizons in the Mesozoic succession of India.

Species	Horizons from where instituted
1. *C. monoalasporus* Dev 1961	Early Cretaceous
2. *C. dampieri* (Balme) Dev 1961	Late Jurassic
3. *C. tribolatus* (Balme) Dev 1961	Late Jurassic
4. *C. segmentatus* (Balme) Srivastava 1963	Early Jurassic
5. *C. rimalis* Singh et al. 1964	Early Cretaceous
6. *C. triletus* Singh et al. 1964	Early Cretaceous
7. *C. grandis* Sah & Jain 1965	Early Cretaceous
8. *C. microvelatus* Schulz 1966	Middle Jurassic
9. *C. jaisalmerensis* Srivastava 1966	Early to Middle Jurassic
10. *C. barragaonensis* Srivastava 1966	Early to Middle Jurassic
11. *C. turbatus* (Balme) Schulz 1967	Early Jurassic
12. *C. punctatus* Venkatachala & Kar 1969	Late Jurassic-Early Cretaceous
13. *C. discoidalis* (Doring) Bharad & Kumar 1972	Late Jurassic
14. *C. indicus* (Singh & Kumar) Kumar 1973	Early Cretaceous
15. *C. primus* (Singh & Kumar) Kumar 1973	Early Cretaceous
16. *C. limbatus* (Singh & Kumar) Kumar 1973	Early Cretaceous
17. *C. sehorensis* (Singh & Kumar) Kumar 1973	Early Cretaceous
18. *C. enigmaticus* (Singh & Kumar) Kumar 1973	Early Cretaceous
19. *C. fimbriatus* (Singh & Kumar) Kumar 1973	Early Cretaceous
20. *C. plicatus* (Singh & Kumar) Kumar 1973	Early Cretaceous
21. *C. doeringii* Kumar 1973	Early Cretaceous
22. *C. circumplectus* Kumar 1973	Early Cretaceous
23. *C. lametaensis* Kumar 1973	Early Cretaceous
24. *C. kattavakkamense* Ramanujam & Srisailam 1974	Late Jurassic
25. *C. reticulatus* Ramanujam & Srisailam 1974	Late Jurassic
26. *C. baculosus* (Dev) Maheshwari 1974	Early Cretaceous
27. *C. rudisaccus* Maheshwari 1974	Early Cretaceous
28. *C. lucidus* (Pocock) Maheshwari 1974	Late Jurassic
29. *C. crassimarginatus* Rao, Ramanujam & Varma 1983	Early Cretaceous

central body oval, 72-86 x 56-72 ìm, distinctly separated by an incomplete fold at body-saccus contact; prosaccus mono-winged, not frilled, 9-19 ìm wide.

Callialasporites dampieri (Balme) Dev, 1961
(Pl. I, fig. 2)

Holotype: Balme 1957; pl. 8, fig. 88; size 47 ìm.

Locality: Broome No. 3 Water Bore, 1,405 – 1,427 ft., Canning Basin, Western Australia

Horizon and Age: Jarlemai Siltstone, Oxfordian, Late Jurassic.

Characteristic Features: Size 53-78 ìm; central body large, rounded triangular, 37-53 ìm, exine microgranulate; prosaccus narrow, weakly frilled, 8-15 ìm wide.

Callialasporites trilobatus (Balme) Dev, 1961
(Pl. I, fig. 3)

Holotype: Balme 1957; pl. 8, fig. 91; size 64 ìm.

Locality: Broome No. 3 Water Bore, 1,405 – 1,427 ft., Canning Basin, Western Australia

Horizon and Age: Jarlemai Siltstone, Oxfordian, Late Jurassic.

Characteristic Features: Size 65-91 ìm; rounded triangular; vestigial scar seldomly present; central body subtriangular, ± 45-50 ì m, exine 1-2 ìm thick, rugose or wrinkled; prosaccus distinctly trilobed or single saccus partially notched in three lobes, finely granulate, marked by radial folds, ±15 ìm wide.

Callialasporites segmentatus (Balme) Srivastava, 1963
(Pl. I, fig. 4)

Holotype: Balme 1957; pl. 9, fig. 93; size 47 ìm.

Locality: GSI Seismic Shot Hole A 32, 40 ft., Hill River-Jurian Bay area, Perth Basin, Western Australia.

Horizon and Age: Cockleshell Gully Sandstone, Early Jurassic

Characteristic Features: Size 44-60 ì m; trilete mark indistinct; central body big, circular, ± 35-40 ì m, exine 2-3 ì m thick, rugose; prosaccus narrow, heavily crumpled, surface frilled, 6-10 ì m wide.

Callialasporites rimalis Singh *et al.*, 1964
(Pl. I, fig. 5)

Holotype: Singh *et al.*, 1964; pl. 7, fig. 94; size 80 x 74 ì m.

Locality: Coal pit near Ghuneri, Kutch Basin, Kachchh District, Gujarat, India.

Horizon and Age: Bhuj Formation, Early Cretaceous.

Characteristic Features: Size 80-90 ìm; central body circular, ± 40 ì m, demarcated by a thick, ± 4 ìm broad peripheral rim, exine coarsely granulose, simulating a negative reticulum; prosaccus monowinged, undulated, ± 8-10 ì m wide.

Remarks: In exine sculpture *C. rimalis* is close to *C. reticulatus,* and similar to that *C. monoalasporus* in having a rim / fold around body.

Callialasporites triletus Singh *et al.,* 1964
(Pl. I, fig. 6)

Holotype: Singh *et al.*, 1964; pl. 7, fig. 96; size 80 x 84 ì m.

Locality: Coal pit near Ghuneri, Kutch Basin, Kachchh District, Gujarat, India.

Horizon and Age: Bhuj Formation, Early Cretaceous.

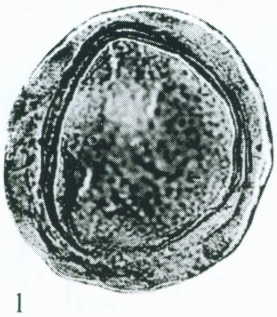
Characteristic Features: Size 72-100 ìm; trilete mark distinct triradiate ridge, rays extend upto body equator, lips elevated; central body rounded triangular, ± 45-50 ì m ,exine ± 2-5 ì m

EXPLANATION OF PLATE I

(The Holotype specimen for each species scanned from original publication is illustrated here. Magnification is not to scale.)

1. ***Callialasporites monoalasporus*** 90 x 106 ìm
2. ***C. dampieri*** 47 ì m
3. ***C. trilobatus*** 64 ìm
4. ***C. segmentatus*** 47 ìm
5. ***C. rimalis*** 80 x 74 ìm
6. ***C. triletus*** 80 x 84 ì m
7. ***C. grandis*** 130 x 150 ì m
8. ***C. microvelatus*** 63 ì m
9. ***C. jaisalmerensis*** 65 ì m
10. ***C. barragoanensis*** 70 ì m
11. ***C. turbatus*** 64 ì m
12. ***C. punctatus*** 90 ì m
13. ***C. discoidalis*** 80 ì m
14. ***C. indicus*** 63 x 76 ì m
15. ***C. primus*** 96 ì m

Plate I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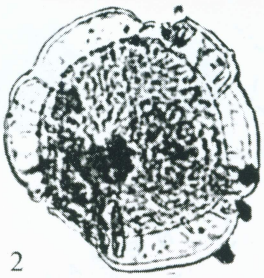
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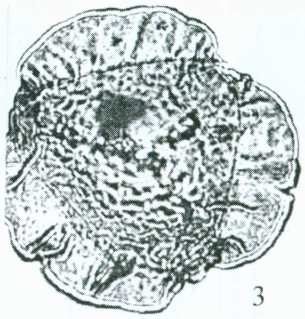
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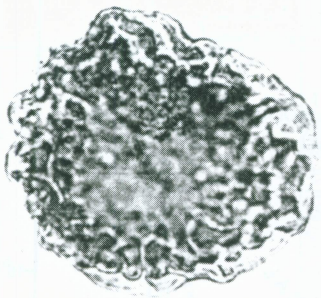
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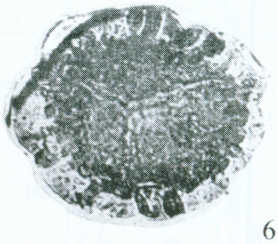
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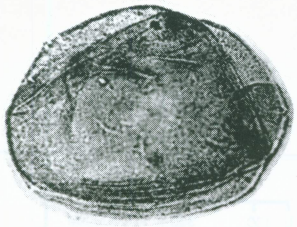
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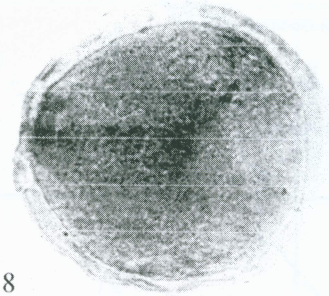
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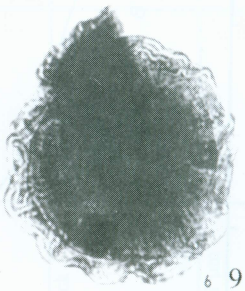
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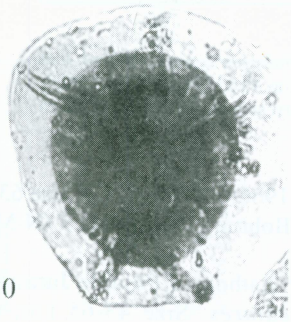
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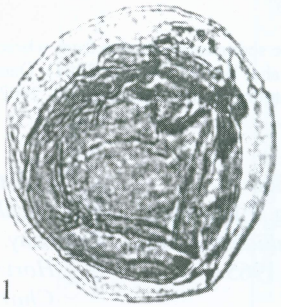
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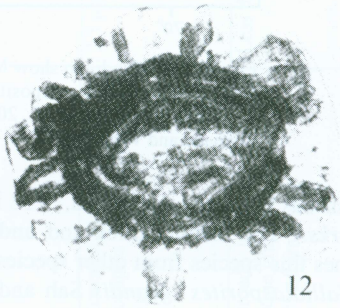
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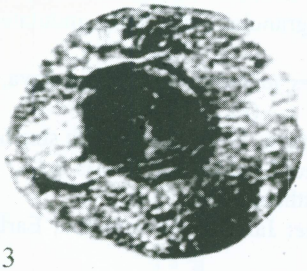
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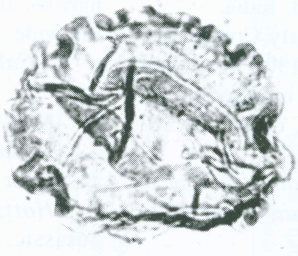
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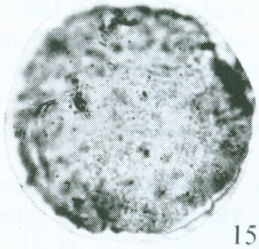
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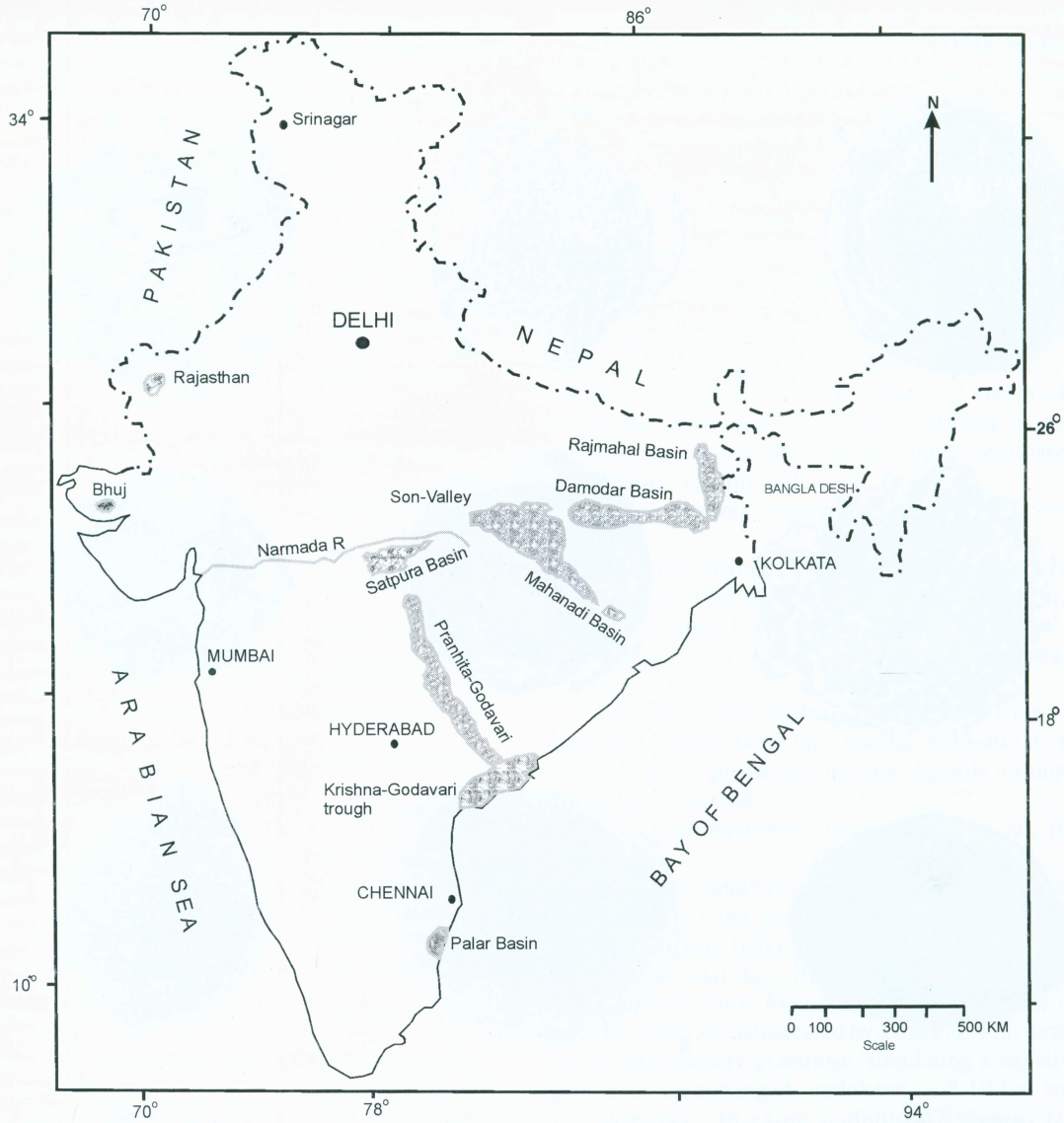


Fig. 1. Map of India to show Mesozoic sedimentary basins from where the genus *Callialasporites* is on record, that evidences the Jurassic deposits. Rajmahal Basin (Tripathi, 2004); Damodar Basin (Vijaya and Bhattacharji, 2003); Son-Valley (Tripathi *et al.*, 2005); Satpura Basin (Kumar, 2000, 2002); Rajasthan (Srivastava, 1966); Palar Basin (Tripathi and Vijaya, 1997).

thick; prosaccus dissected and frilled, ±12 ìm wide.

Remarks: The distinct thick and undulating trilete mark distinguishes this species from other species of *Callialasporites*.

Callialasporites grandis Sah and Jain, 1965
(Pl. I, fig. 7)

Holotype: Sah and Jain, 1965; pl. 4, fig. 86; size 130 x 152 ì m.

Locality: Basko, Rajmahal Hills, Jharkhand, India.

Horizon and Age: Rajmahal Formation, Early Cretaceous.

Characteristic Features: Size 80-152 x 60-130 ì m; central body big, broadly triangular, 80 x 95 ì m, exine infragranulose; prosaccus narrow, trilobed, baculate, unfolded, each lobe 10-20 ì m wide.

Remarks: Except for being larger, *C. grandis* is similar to *C. trilobatus.* The bacula on the exine surface are too small to be measured.

Callialasporites microvelatus Schulz, 1966
(Pl. I, fig. 8)

Holotype: Schulz, 1966; pl. 7, figs. 1,2; size 63 ì m.

Locality: Dogger, Bohrung Greifswald 3 (N-Mecklenburg) Germany.

Horizon and Age: Bathonian, Middle Jurassic.

Characteristic Features: Size 43-65 ì m; trilete mark distinct; central body big 45 x 50 ì m, exine of central body finely infrareticulate to finely infragranulate; prosaccus very narrow, flimsy, infragranulate, unevenly undulated, 3.5 – 4.5 ì m wide.

Callialasporites jaisalmerensis Srivastava, 1966
(Pl. I, fig. 9)

Holotype: Srivastava, 1966; pl. 4, fig. 6; size 65 ì m.

Locality: Jaisalmer Slim Hole, 492-505 ft / 1, 32.0 / 109.2, Jaisalmer area, Rajasthan, India.

Horizon and Age: Jaisalmer Formation, Early to Middle Jurassic.

Characteristic Features: Size 65 ìm; traces of trilete mark on central body, rays extend up to equator; central body

Species	Grain Size	Central Body Ratio in relation to overall size	Exine	Germinal Mark	Prosaccus Width/nature	Remarks	Holotype Specimens
C. monoalasporus Dev 1961	94-107 µm	Oval, occupies 4/5 area of grain size		Not visible	Simple, narrow, unfolded, single saccus, 9-19 µm wide	Distinct one thick circular fold around body	
C. dampieri (Balme) Dev 1961	53-78 µm	Circular or roundly triangular, occupies 3/4 area of grain size	1-2 µm thick	Vestigial scar	Narrow, few radial folds, monosaccus, 8-15 µm wide		
C. tribolatus (Balme) Dev 1961	65-91 µm	Sub-triangular, 3/4 area of grain size	1-2 µm thick, rugose or wrinkled	Vestigial triradiate scar seen as folds	Wide, trilobed or single trilobate, constricted, each lobe ±15 µm wide	Distinctly trilobed prosaccus	
C. segmentatus (Balme) Srivastava 1963	40-60 µm	Circular, big, occupies total width of grain	2-3 µm thick, rugose	Indistinctly visible	Narrow, crumpled, heavily frilled, 6-10 µm wide	Prosaccus highly crumbled	
C. rimalis Singh et al. 1964	80-90 µm	± Circular, big, occupies 4/5 area of grain size, ±4 µm thick rim around body	Coarsely granulose, negative reticulum	Faintly visible	Narrow, unfolded mono saccus, 8-10 µm wide	Comparable with *C. monoalasporus* in having thick circular rim	
C. triletus Singh et al. 1964	72-100 µm	Rounded triangular, occupies 3/4 area of grain size	2.5 µm thick	Distinct, triradiate ridges extending up to body equator, lips elevated	Narrow, dissected, frilled, ± 12 µm		
C. grandis Sah & Jain 1965	80-152 x 60-130 µm	Broadly triangular, big, exine granulose, occupies 4/5 of grain size	Less than 1 µm	Not visible	Narrow, deeply lobed, unfolded	Comparable with *C. trilobatus*	

Fig. 2. Species in genus *Callialasporites* recorded from the Mesozoic succession in India and their salient characteristics.

C. microvelatus Schulz 1966	43-65 µm	Circular, occupies almost 4/5 area of grain size	Finely structured	Not visible	Very narrow, thin, flimsy, irregularly indented	Prosaccus flimsy, 1/8 of spore radius	
C. jaisalmerensis Srivastava 1966	65 µm	Big, occupies maximum area of grain size		Scar, extend up to body equator	Narrow, heavily crumpled	Compares with *C. segmentatus*	
C. barragaonensis Srivastava 1966	70 µm	Big body, occupies 3/4 area of grain size		Y-shaped folds, extends to saccus margin	Monosaccus, smooth, no lobbing & frilling	Compares well with *C. turbatus*	
C. turbatus (Balme) Schulz 1967	57-77 µm	Circular, thick darker polar area, 3/4 area of grain size	Less than 1 µm thick, heavily folded	No tetrad marking visible	Thin outer extension	Thickened polar area defined body and prosaccus, unfolded, thin	
C. punctatus Venkatachala & Kar 1969	64 – 90 µm	± Subcircular, occupy 3/4 area of grain size	2-3 µm thick	Not visible	Monosaccus, deeply frilled with radial folds	Saccus imperfectly intrareticulate, compares with *C. segmentatus*	
C. discoidalis (Doring) Bharad & Kumar 1972	73-82 µm	Triangular, acquires 3/4 of grain size	± Microbaculate	Faintly visible	Prosaccus appears trilobed, microbaculose structured	Transitional in between *C. trilobatus* and *C. baculosus*	
C. indicus (Singh & Kumar) Kumar 1973	52-76 µm	Big, occupies 4:1 area of grain size	Strongly folded	Not visible	Narrow, outer margin, limboid, surface radially folded	Compares with *C. dampieri / C. segmentatus*	

C. primus (Singh & Kumar) Kumar 1973	88-100 µm	Not distinctly visible, big, occupies maximum space of grain size		Not visible	Uniform, unfolded monosaccus, 14-20 µm wide	Comparable with *C. turbatus*	
C. limbatus (Singh & Kumar) Kumar 1973	50-80 µm	Big, occupies maximum space of grain size		Not visible	Unevenly constricted outer margin, 8-14 µm wide	Comparable with *C. microvelatus*	
C. sehorensis (Singh & Kumar) Kumar 1973	76-86 µm	Big, acquires maximum area of grain size		Not visible	Very narrow, 4 -6 µm wide	Comparable with *C. microvelatus*	
C. enigmaticus (Singh & Kumar) Kumar 1973	60-80 µm	Big, indistinct acquires maximum area of grain size		Not seen	Prosaccus, narrow, intensly indented, frilled	Compares with *C. segmentatus* in nature of saccus	
C. fimbriatus (Singh & Kumar) Kumar 1973	70-90 µm	Faintly perceptible, occupies 4/5 space of grain size		Not visible	12-18 µm wide, deeply frilled	Closely placed with *C. segmentatus*	
C. plicatus (Singh & Kumar) Kumar 1973	50-90 µm	Triangular, thick folds at body-saccus contact		Not visible	Trilobed, each lobe 10-17 µm wide	Comparable with *C. trilobatus*	
C. doeringii Kumar 1973	50-68 µm	Indistinctly visible		On distal pole thin area, 14-25 µm, trilete, not visible	Strongly frilled monosaccus, 10-14 µm wide	Seems conspecific with *Coptospora*	
C. circumplectus Kumar 1973	46-68.5 µm	Big, occupies full grain size	Thinner polar area, 24-25 µm in diameter	Not visible	Very narrow, not defined suppressed to body	Compares well with *C. microvelatus* except distal thin area	

C. lametaensis Kumar 1973	59-123.5 µm		Thinning on distal polar exine	Not visible	Microbaculate, single saccus, 15-36 µm wide	Seems conspecific with *Coptospora microgranulosa*	
C. kattavakkamense Ramanujam & Srisailam 1974	55-65 µm	Thickening around body seems to be 2/3 of grain size		Not visible	Incipiently notched, unfolded, monosaccus outer margin radially striate, 1-2 µm thick	Much wider thickening around central body the distinct feature	
C. reticulatus Ramanujam & Srisailam 1974	90-110 µm	Medium sized, occupies 2/3 area of grain size	Distinctly micro-reticulate	Not visible	Monosaccus, unfolded, outer margin notched irregularly	Distinct by having reticulate body exine	
C. baculosus (Dev) Maheshwari 1974	90-120 µm	Broadly triangular occupies 3/4 space of grain size	Densly micro-baculate	Not visible	Trilobed, structured with microbacula, each lobe 16-22 µm wide	Bacula much smaller, may be micrograna to conical processes, more close with *C. trilobatus*	
C. rudisaccus Maheshwari 1974	62-92 µm	Indistinct, occupies the maximum space of grain size	Invariably micro-structured	Distinct triradiate ridge	Rudimentary saccus	Gradational form with *C. triletus*	
C. lucidus (Pocock) Maheshwari 1974	60-84 µm	Occupies 3/4 space of total grain size	2-3 µm thick around body equator	Trilete scar visible	Unfolded, simple, mono saccus, ± 15 µm wide	A gradational form among *C. monoalasporus, C. turbatus, C. plicatus*	
C.crassimarginatus Rao et al. 1983	50-60 µm	Roundly triangular, occupy 3/4 area of grain size	4-8 µm wide thickening around body	Faintly visible	Single lobed, lesser radial folds, 10-12 µm wide	More similar with *C. monoalasporous*	

Species	Lithounits	Palynological Dating	Area, Basin	Reference	Remarks
C. turbatus *C. dampieri* *C. microvelatus*	Dubrajpur Formation (Triassic-Jurassic)	(Rhaetic-Hettangian) Late Triassic – Early Jurassic transition	Borehole RJNE-32 Rajmahal Basin, Jharkhand	Tripathi (2000)	*Arcuatipollenites tethysensis* Palynozone
C. turbatus *C. trilobatus*	Dubrajpur Formation (Triassic-Jurassic)	(Toarcian to Bajocian) Latest Early to early Middle Jurassic	Borehole RCH-51 Rajmahal Basin, Jharkhand	Tripathi (2001, 2004) Vijaya & Sen (2005)	*Callialasporites turbatus* Palynozone
C. turbatus *C. dampieri*	Panchet Formation (Early Triassic)	(Scythian) Early Triassic	Boreholes PGD-1, 4, 6, & 9 Panagarh area, Damodar Basin, West Bengal	Vijaya & Bhattacharji (2003)	FAD's of these species in Early Triassic Palynozones, overlain by Late Jurassic deposit with major unconformity
C. dampieri *Callialasporites* sp.	Bagra Formation Denwa Formation (Late Triassic)	(Rhaetian) Late Triassic	Outcrop Satpura Basin, Madhya Pradesh	Kumar (2002) Kumar (2000)	*Arcuatipollenites* tethysensis Palynozone
C. turbatus *C. dampieri*	Parsora Formation (Triassic)	Early to Late Triassic	Boreholes SSM-1 & 2 South Rewa Basin, Mahuli-Mahersop area, Madhya Pradesh	Tripathi et al. (2005)	*Arcuatipollenites tethysensis* Palynozone
C. baragaonensis *C. jaisalmerensis*	Lathi Formation (Early Jurassic)	Early Jurassic	Borehole Jaisalmer area, Rajasthan	Srivastava (1966)	*Callialasporites turbatus* Palynozone

Fig. 3. Details of areas / basins and formational units, from where the first occurrence of the genus *Callialasporites* (*C. microvelatus, C. turbatus, C. dampieri*) is on record in the Triassic-Jurassic transition.

circular, 50 ì m; prosaccus much segmented by radially elongated folds, 7.5 ìm wide.

Remarks: This species is closely similar to *C. segmentatus*.

Callialasporites barragaonensis Srivastava, 1966 (Pl. I, fig. 10)

Holotype: Srivastava, 1966; pl. 5, fig. 1; size 65 x 70 ìm.

Locality: Deep Hole Barragaon, 390-400 ft / 2, 33.8 / 99.8, Jaisalmer area, Rajasthan, India.

Horizon and Age: Jaisalmer Formation, Early to Middle Jurassic.

Characteristic Features: Size 65 x 70 ìm; trilete-shaped folds extending to the outer margin of body; central body broadly rounded, ± 45 ì m; prosaccus a single lobe, unfolded, 10-15 ì m wide.

Remarks: This species is similar to *C. turbatus*.

Callialasporites turbatus (Balme) Schulz, 1967 (Pl. I, fig. 11)

Holotype: Balme, 1957; pl. 7, fig. 85; size 64 ìm.

Locality: G.S.I. Seismic shot Hole A 32, 40 ft, Hill-River Jurien Bay area, Perth Basin, Western Australia.

Horizon and Age: Cockleshell Gully Sandstone, Early Jurassic.

Characteristic Features: Size 57-77 ìm; no tetrad marking visible; thickened darker polar area identified, heavily folded, 36-50 ì m; prosaccus an outer thinner extension, unfolded encircling the body, 7-14.5 ì m wide.

Remarks: Nature of central body and velum distinguishes this species from other species in genus *Callialasporites*.

Callialasporites punctatus Vekatachala and Kar, 1969 (Pl. I, fig. 12)

Holotype: Venkatachala & Kar, 1969; pl. 2, fig. 35; size 90 ì m.

Locality: Khari River near Rudar Mata Temple, Kutch Basin, Gujarat, India.

Horizon and Age: Jhuran Formation, Late Jurassic-Early Cretaceous.

Characteristic Features: Size 64-90 ì m; central body 50-55 ì m, exine 2-3 ì m thick, infrapunctuate; prosaccus monowinged, imperfectly intrareticulate, surface heavily radially folded, 10-14 ì m broad.

Remarks: Compares well with *C. segmentatus* in the nature of the prosaccus. Intrareticulation in prosaccus has not been a distinct feature.

Callialasporites discoidalis (Döring) Bharadwaj and Kumar, 1972 (Pl. I, fig. 13)

Holotype: Döring, 1962; pl. 17, fig. 1-3; size 80 ì m.

Locality: Bohrung Werle 3, Mecklenburg, Germany.

Horizon and Age: Portland Formation, Late Jurassic.

Characteristic Features: Size 73-82 ìm; central body big, 62-73 ì m, broadly triangular, prosaccus appears trilobed, surface undulated, finely microbaculate, 5-12 ì m wide.

Remarks: Appears to be a transitional form within the *C.*

trilobatus and *C. baculosus* complex.

Callialasporites indicus (Singh and Kumar) Kumar, 1973 (Pl. I, fig. 14)

Holotype: Singh and Kumar, 1969; pl. 1, fig. 4; size 63 x 76 ì m.

Locality: Sehora, Narsinghpur District, Madhya Pradesh, India.

Horizon and Age: Jabalpur Formation, Early Cretaceous.

Characteristic Features: Oval to subglobose; size 52-76 ìm; central body 58-66 ì m, exine irregularly and heavily folded; prosaccus with limboid margin, 3.5-5 ìm thick, microverrucose, radially folded, 4-7 ìm wide.

Remarks: Similar to *C. dampieri / C. segmentatus*. Moreover, marginal thickening described as limboid (Kumar, 1973) might be a leathery nature of prosaccus.

Callialasporites primus (Singh and Kumar) Kumar, 1973 (Pl. I, fig. 15)

Holotype: Singh and Kumar, 1969; pl. 1, fig. 6; size 96 ì m.

Locality: Sehora, Narsinghpur District., Madhya Pradesh, India.

Horizon and Age: Jabalpur Formation, Early Cretaceous.

Characteristic Features: Size 88-100 ìm; central body circular, 50-70 ì m; prosaccus 10-15 ì m wide, surface non-frilled with 2-2.5 ì m thick limboid margin.

Remarks: Similar to *C. turbatus*.

Callialasporites limbatus (Singh and Kumar) Kumar, 1973 (Pl. II, fig. 1)

Holotype: Singh and Kumar, 1969; pl. 1, fig. 9; size ± 60 ì m.

Locality: Sehora, Narsinghpur District, Madhya Pradesh, India.

Horizon and Age: Jabalpur Formation, Early Cretaceous.

Characteristic Features: Size 52-80 ìm; central body broadly rounded, 40-60 ìm; prosaccus irregularly constricted in lobes, sometimes pseudo-trilobate appearance, 8-14 ì m wide, at places up to 4 ìm; marginal limbus 2-3 ì m thick.

Remarks: Shows an irregular-shaped thin area on distal pole. Otherwise closely comparable with *C. microvelatus*.

Callialasporites sehorensis (Singh and Kumar) Kumar, 1973 (Pl. II, fig. 2)

Holotype: Singh and Kumar, 1969; pl. 1, fig. 9; size ± 82 ì m.

Locality: Hathnapur, Narsinghpur District, Madhya Pradesh, India.

Horizon and Age: Jabalpur Formation, Early Cretaceous.

Characteristic Features: Size 76-86 ì m; central body circular, 70-82 ì m; prosaccus very narrow, single lobed, 4-6 ì m wide.

Remarks: Closely compares with *C. microvelatus*.

Callialasporites enigmaticus (Singh and Kumar) Kumar, 1973 (Pl. II, fig. 3)

Holotype: Singh and Kumar, 1969; pl. 2, fig. 20; size 62 ì m.

Locality: Sehora, Narsinghpur District, Madhya Pradesh, India.

Horizon and Age: Jabalpur Formation, Early Cretaceous.

Characteristic Features: Size 60-80 ìm; trilete mark not visible; central body incipient, 50-60 ì m; exine distally vesiculate, vesiculae irregular, densely packed; prosaccus deeply indented, 8-10 ìm wide.

Remarks: Closely compares with *C. segmentatus*. But presence of vesiculae differentiates *C. enigmaticus* from other species in the genus.

Callialasporites fimbriatus (Singh and Kumar) Kumar, 1973 (Pl. II, fig. 4)

Holotype: Singh and Kumar, 1969; pl. 2, fig. 21; size 70-90 ì m.

Locality: Sehora, Narsinghpur District., Madhya Pradesh, India.

Horizon and Age: Jabalpur Formation, Early Cretaceous.

Characteristic Features: Size 70-90 ìm; trilete mark not visible; central body faintly perceptible, 20 x 50 ìm; prosaccus monowinged, margin deeply crumpled, 12-18 ìm wide.

Remarks: This species seems to be closer with *C. segmentatus* than any other species.

Callialasporites plicatus (Singh and Kumar) Kumar, 1973 (Pl. II, fig. 5)

Holotype: Singh and Kumar, 1969; pl. 2, fig. 28; size 72 x 79 ì m.

Locality: Lameta Ghat, Jabalpur District, Madhya Pradesh, India.

Horizon and Age: Jabalpur Formation, Early Cretaceous.

Characteristic Features: Size 60-94 ìm; central body triangular, distinct, 55-59 ì m, having 4-6 ìm thick folds, 3 in number, each at body-saccus attachment; prosaccus, indistinctly three-lobed, 12-17 ìm wide.

Remarks: Comparable to *C. trilobatus*

Callialasporites doeringii Kumar, 1973 (Pl. II, fig. 6)

Holotype: Singh and Kumar, 1969; pl. 1, fig. 15; size 60 ì m.

Locality: Sehora, Narsinghpur District, Madhya Pradesh, India.

Horizon and Age: Jabalpur Formation, Early Cretaceous.

Characteristic Features: Size 55-68 ìm; central body faintly visible, 48-54 ì m; broadly oval depressed area on polar region, 20-34 ì m in diameter; prosaccus monowinged, deeply frilled, 10-14 ì m wide.

Remarks: The depressed polar area on distal face separates this species from other species of the genus *Callialasporites*, might be similar to that of genus *Coptospora*.

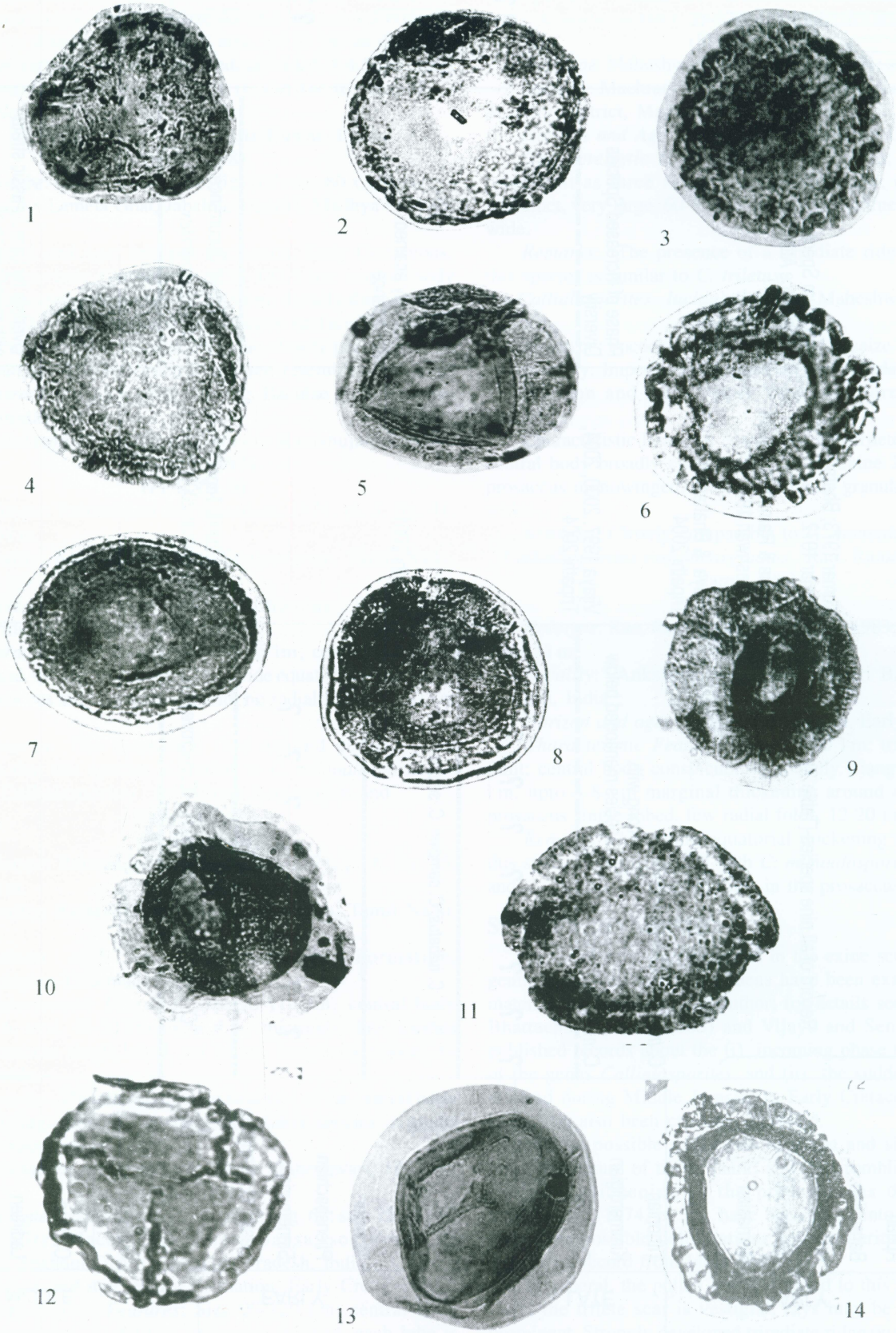
Callialasporites circumplectus Kumar, 1973 (Pl. II, fig. 7)

EXPLANATION OF PLATE II

(The Holotype specimen for each species scanned from original publication is illustrated here. Magnification is not to scale.)

1. ***C. limbatus*** 60 ì m
2. ***C. sehorensis*** 82 ì m
3. ***C. enigmaticus*** 62 ì m
4. ***C. fimbriatus*** 70 x 90 ì m
5. ***C. plicatus*** 72 x 79 ì m
6. ***C. doeringii*** 60 ì m
7. ***C. circumplectus*** 53 x 63 ì m
8. ***C. lametaensis*** 80 x 96 ì m
9. ***C. kattavakkamense*** 58.5 ì m
10. ***C. reticulatus*** 98 ì m
11. ***C. baculosus*** 75 ì m
12. ***C. rudisaccus*** 72 ìm
13. ***C. lucidus*** 75 ìm
14. ***C. crassimarginatus*** 45 ì m

Plate II



Period		Age	Significant Species	Reference	Events	Relative presentation at varied levels (species number)
CRETACEOUS	EARLY	Aptian Barremian Hauterivian Valanginian Berriasian	Record of all nine species (Table 2)	Kumar 1973; Bharadwaj & Kumar 1972 Varma & Ramanujam 1984; Maheshwari 1974 Vijaya & Bhattacharji 2002; Tripathi 2004	Maximum Species Diversity & Dominance Attained	
JURASSIC	LATE	Tithonian Kimmerdigian Oxfordian Callovian	*C. triletus* *C. reticulatus* : : Along with : species mentioned below *C. monoalasporus* :	Vijaya 1997, 2000, 2004; Tripathi 2004	Phase of increased Species Diversity	
	MIDDLE	Bathonian Bajocian Aalenian	? ? ? ? ? ? ? ? *C. turbatus, C. dampieri, C. segmentatus*	Tripathi 2001	Suddenly attained Abundance	? ? ? ?
	EARLY	Toarcian Pliensbachian Sinnemurian Liassic / Hettangian	? ? ? ? ? ? ? ?	Tripathi 2000; Tripathi et al. 2005; Kumar 2000, 2002	Established Occurrence of *Callialasporites*	? ? ? ?
TRIASSIC	LATE	Rhaetian Norian	*C. turbatus* *C. dampieri* *C. microvelatus*			
	MIDDLE	Carnian Ladinian			Overlain by Late Jurassic strata with major phase of non-deposition	
	EARLY	Anisian Scythian basalmost Triassic	*C. turbatus, C. dampieri* P /Tr Transition	Vijaya & Bhattacharji 2003 Vijaya & Sen 2005	First occurrence of *C. turbatus / dampieri* (one / two specimens)	

Holotype: Kumar, 1973; pl. 5, fig. 105; size 53 x 63 ì m.

Locality: Harad river near Hathnapur, Narsinghpur District, Madhya Pradesh, India

Horizon and Age: Jabalpur Formation, Early Cretaceous

Characteristic Features: Size 46-68.5 ìm; central body 46 x 57.5 ì m; distally thinner polar area, 24-25 ìm in diameter; prosaccus very narrow, monowinged, unfolded, 3-4.5 ì m wide.

Remarks: *C. circumplectus* is similar to that of *C. microvelatus*.

Callialasporites lametaensis Kumar, 1973
(Pl. II, fig. 8)

Holotype: Kumar, 1973; pl. 5, fig. 107; size 80 x 96 ì m.

Locality: Lameta Ghat, Jabalpur District, Madhya Pradesh, India.

Horizon and Age: Jabalpur Formation, Early Cretaceous.

Characteristic Features: Size 59-123.5 ìm; central body distinct, convexly triangular, 48 x 88 ì m; distally thinner polar area, 25-50 ì m in diameter; prosaccus surface undulated, microbaculate, 15-36 ìm wide, baculae closely packed.

Remarks: The specimen illustrated resembles the genus *Coptospora* in having a polar thinning. Baculae seem less than 0.5 ìm in size.

Callialasporites kattavakkamense Ramanujam and Srisailam, 1974
(Pl. II, fig. 9)

Holotype: Ramanujam and Srisailam, 1974; pl. 5, fig. 41; size 58.5 ì m.

Locality: Kattavakkam near Conjeevaram, Tamil Nadu, India.

Horizon and Age: Sriperumbudur Formation, Kimmeridgian-Tithonian, Late Jurassic.

Characteristic Features: Size 55-65 ìm; central body oval to elliptical, 40-50 ì m, having 10 ì m wide equatorially thickened rim, prosaccus slightly notched, with no radial folds, 10-30 ì m wide.

Remarks: The thickened fold around central body suggests that this species is similar to *C. monoalasporus*.

Callialasporites reticulatus Ramanujam and Srisailam, 1974
(Pl. II, fig. 10)

Holotype: Ramanujam and Srisailam, 1974; pl. 6, fig. 45; size 98 ì m.

Locality: Kattavakkam near Conjeevaram, Tamil Nadu, India.

Horizon and Age: Sriperumbudur Formation, Kimmeridgian-Tithonian, Late Jurassic.

Characteristic Features: Size 90-110 ìm; central body circular to oval, 40-50 ì m, exine thin, microreticulate, meshes fine; prosaccus single lobed, not frilled, irregularly folded, 6-15 ì m wide.

Remarks: The microreticulate structure of the central body exine distinguishes this species from other species in genus *Callialasporites*.

Callialasporites baculosus (Dev) Maheshwari, 1974
(Pl. II, fig. 11)

Holotype: Maheshwari, 1974; pl. 18, fig. 62; size 75.00 ì m.

Locality: Machrar river near Bansa, south-west of Chandia, Shahdol District, Madhya Pradesh, India.

Horizon and Age: Bansa Formation, Early Cretaceous.

Characteristic Features: Size 90-120 ì m; central body broadly rounded, 71-80 ì m, prosaccus trilobed, each lobe is 16-22 ì m wide; exine microbaculate all over, bacula densely packed.

Remarks: The bacula are too small to be measured in this species, they may be gradational between the coni and grana. The species is closely comparable to *C. trilobatus*.

Callialasporites rudisaccus Maheshwari, 1974
(Pl. II, fig. 12)

Holotype: Maheshwari, 1974; pl. 19, fig. 71; size 72.00 ì m.

Locality: Machrar river near Bansa, south-west of Chandia, Shahdol District, Madhya Pradesh, India.

Horizon and Age: Bansa Formation, Early Cretaceous.

Characteristic Features: Size 62-92 ì m; trilete mark prominent as three ridges, raised, crumpled; central body indistinct, very large, 60-85 ì m; prosaccus rudimentary, 2-3 ì m wide.

Remarks: The presence of a triradiate ridge means that this species is similar to *C. triletus*.

Callialasporites lucidus (Pocock) Maheshwari, 1974
(Pl. II, fig. 13)

Holotype: Pocock, 1962; pl. 12, fig. 185; size 75 ì m.

Locality: Imperial Tidewater Carlyle, Canada.

Horizon and Age: Upper Vanguard Formation, Late Jurassic.

Characteristic Features: Size 60-84 ì m; trilete scar visible; central body broadly circular, 50-60 ì m, exine 2-3 ì m thick; prosaccus monowinged, scabrate to finely granulose, ± 15 ì m wide.

Remarks: Closely comparable to *C. monoalasporus*.

Callialasporites crassimarginatus Rao, Ramanujam and Varma, 1983
(Pl. II, fig. 14)

Holotype: Rao, Ramanujam and Varma, 1983; pl. 4, fig. 75; size 45 ì m.

Locality: Anksapur, Pranhita-Godavari Basin, Andhra Pradesh, India.

Horizon and age: Gangapur Formation, Early Cretaceous.

Characteristic Features: Size 50-60 ì m; triradiate mark faint; central body conspicuously roundly triangular, ± 30-40 ì m, upto 4-8 ì m marginal thickening around central body; prosaccus single lobed, few radial folds, 12-20 ì m wide.

Remarks: In having equatorial thickening around body, this species compares well with *C. monoalasporus*, *C. rimalis* and *C. lucidus* except for folds in the prosaccus.

SPECIES DIVERSITY

To understand the variations in the exine sculpture in the genus *Callialasporites*, specimens have been examined in the material available with the author; for details see Vijaya and Bhattacharji (2002, 2003) and Vijaya and Sen (2005). The published records about the (i) incoming phase (advent level) of the genus *Callialasporites*, and (ii) the sudden abundance attained during Middle Jurassic to Early Cretaceous times in India, has also been critically assessed.

All the possible gradations in shape and size of central body, the nature of trilete mark, and the crumbling, notching, marginal thickening in the prosaccus as discussed by Maheshwari (1974, p. 35), have been taken into account with respect to possible delimitations and similarities among the species on record from India (Table 1).

In general, the pollen grains referred to this genus are not alete, the trilete scar is vestigial, rays may be seen faint to prominent. Strongly developed triradiate ridge on proximal face is also observed in few specimens. The central body has a ±

Table 2: Among the many species of the genus *Callialasporites* (Table 1, Fig. 2), only nine species are distinct in their exinal characters, and are identifiable easily from each other. Other species (right column) are more or less conspecific with the nine species in the left column:

SPECIES	CHARACTERISTICS	CONSPECIFIC SPECIES
C. monoalasporus Dev 1961	Incomplete single fold around much bigger central body separating unfolded, rarely minutely indented monosaccus	*C. rimalis* *C. kattavakkamense* *C. lucidus* *C. crassimarginalis*
C. dampieri (Balme) Dev 1961	Monosaccus with few radial folds and indented margin around medium sized central body	*C. primus* *C. indicus*
C. trilobatus (Balme) Dev 1961	Prosaccus deeply trilobed / three lobes around medium sized central body with wrinkled to rugose surface	*C. grandis* *C. limbatus* *C. plicatus* *C. baculosus*
C. segmentatus (Balme) Srivastava 1963	Prosaccus heavily crumpled encircling quite big central body	*C. jaisalmerensis* *C. punctatus* *C. enigmaticus* *C. fimbriatus*
C. triletus Singh *et al.* 1964	Distinct triradiate ridges with elevated and crumpled lips, prosaccus much frilled encircling medium sized body	*C. rudisaccus*
C. microvelatus Schulz 1966	Very narrow, filmsy prosaccus around much bigger central body	*C. limbatus* *C. sehorensis* *C. circumplectus*
C. turbatus (Balme) Schulz 1967	Thin, unfolded monosaccus around darker, heavily folded polar area	*C. barragaonensis* *C. primus*
C. discoidalis (Doring) Bharadwaj & Kumar 1972	Prosaccus deeply notched with microbaculate structure	*C. baculosus*
C. reticulatus Ramanujam & Srisailam 1984	Central body exine distinctly microreticulate, unfolded single saccus	

circular to rounded triangular outer margin and mostly conforms to the shape of the grain. The internal structure of the exine is usually finely granulate, scabrate to microreticulate. The bladder or prosaccus, which encircles the central body, is a monosaccus, variably trilobed with irregular and incomplete notching at the outer margin, and almost flat to a deeply frilled surface, sometimes with radial folds. The outer surface varies from being smooth-finely granulate to finely baculate.

These exinal characters have led to the identification of many species (Table 1), at different levels in the basalmost Jurassic to Lower Cretaceous successions of India. And it is apparent that too many species have been reported so far (Table 1) and this problem is to be resolved here.

Among the species, *C. monoalasporus, C. turbatus, C. microvelatus, C. triletus* and *C. reticulatus* are very distinct and therefore easy to identify (Table 2). *C. dampieri, C. segmentatus* and *C. trilobatus*, display a gradation in their form from *C. segmentatus* through *C. dampieri* to *C. trilobatus*. This gradation in salient features is more apparent just above at the level of their first appearance, but at the same time the three types became more clearly distinguishable in younger horizons; and hence, constitute different species (Reiser & Williams 1969, p. 13; present study).

C. jaisalmerensis and *C. barragaoensis* instituted from the Lathi Formation, Rajasthan (Srivastava 1966; pl. 4, fig. 6, pl. 5, fig. 1) are similar to the *C. segmentatus* and *C. turbatus* respectively in the nature of prosaccus and central body.

The species delimitation within this genus is very tentative and many species are conspecific. The species which bear most similar exinal features are kept in one group, and only nine species (Table 2) are accepted from those twenty nine on record (Table 1, Fig. 2). Now, it is easier for a species to be identified, and then implemented in biostratigraphy.

DISTRIBUTION

The genus *Callialasporites* Dev emend. Maheshwari (1974) is a fairly abundant taxon in the Jurassic palynoflora and continues up into Early Cretaceous deposits in India and other parts of world. Here, main emphasis is given to the first appearance or occurrence of genus and species, hence some of the relevant literature related to this event includes – Helby *et al.*, 1987; Upadhyay *et al.*, 2005; Rebecai, 2007, etc.). Although its botanical affinity remains uncertain, it is widely thought to have Podocarpacean or Araucariaceae relationships (Archangelsky, 1994; Gammerro, 1965; Batten and Dutta 1997; Abbink *et al.*, 2004).

Although, the palynological transition across the Triassic-Jurassic boundary in India is still unresolved as shown in Figure 3, and it needs to be worked-out in more detail. The presence of specimens assignable to *C. microvelatus* and *C. turbatus* have been reported from the basalmost part of the Dubrajpur Formation of the Rajmahal Basin, which has been assigned a Rhaetian to Hettangian age (Tripathi, 2000). The first occurrence of *C. turbatus* / *C. dampieri* at different depths in the Panchet

Formation Early Triassic, is notable (Vijaya and Bhattacharji 2003) because this strata is overlain by Late Jurassic deposit with a hiatus of Middle Triassic to the Middle Jurassic. Specimens similar to *C.* cf. *dampieri* are also reported from the Denwa and Bagra formations (Late Triassic) in Satpura Basin, India, which is dated Rhaetian in age (Kumar, 2000, 2002). *C. jaisalmerensis* and *C. barragaonensis* are on record from Lathi Formation, Lower to Middle Jurassic (Srivastava, 1966).

The established occurrences of *Callialasporites* species (*C. turbatus, C. microvelatus, C. dampieri, C. segmentatus*) in the Panchet Formation, Panagarh area, Damodar Basin (Vijaya and Bhattacharji, 2003), and in Dubrahpur Formation, Rajmahal Basin (Vijaya and Sen, 2005; Tripathi 2004) definitely inferred the existence of late Middle to Upper Jurassic deposits in these areas in India (Fig. 4). Although, the two sharply defined horizons — (i) assemblage containing Triassic spore and pollen with first record of *C. turbatus / C. dampieri* and (ii) with an abundance of *Callialasporites* in the condensed deposits of Middle to Upper Jurassic envisages a significant hiatus of that Middle Triassic to Early Jurassic (Vijaya, 1997, 2000; Tripathi, 2001).

The species *C. turbatus, C. microvelatus, C. segmentatus, C. dampieri* and *C. trilobatus* have a wide distribution in the Jurassic and Cretaceous sediments. The genus *Callialasporites* is represented mainly by *C. microvelatus,* C. *turbatus, C. dampieri* and *C. segmentatus* in the late Early to early Middle Jurassic in the Rajmahal Basin (Tripathi 2001) and Middle to Upper Jurassic sediments in other basins (Vijaya 2000a). Specimens assignable to *C. monoalasporus* and *C. trilobatus* appear at slightly younger level, which is Tithonian-Berriasian (Vijaya, 2000; Vijaya and Bhattacharya, 2002; Tripathi, 2001, 2004), and are meagerly represented in the total population of palynomorphs.

C. triletus and *C. reticulatus* are represented in very low numbers in the palynoassemblages from the Early Cretaceous succession on Indian peninsula (Singh *et al.*, 1964; Kumar, 1973; Ramanujam and Srisailam, 1974; Maheshwari, 1974; Varma and Ramanujam, 1984). Recently, these two species have also been reported from the Rajmahal Formation of the Rajmahal and Damodar basins (Tripathi, 2004; Vijaya, 2004, present study).

Many other species described by Kumar (1973), and Bharadwaj and Kumar (1972) (*C. punctatus, C. rimalis, C. discoidalis, C. baculosus, C. rudisaccus, C. kattavakkamense)* seem to be conspecific with those already mentioned, and it is difficult to be sure of their identity (Table 2). These species are fairly widespread in time and space that is known mainly from the Lower Cretaceous (Barremian to Aptian) of Jabalpur Formation, Satpura Basin; Bansa Formation, Son Valley; Sriperumbudur Formation, Palar Basin and Athgarh beds, Mahanadi Basin (Dev, 1961; Maheshwari, 1974; Ramanujam and Srisailam, 1974; Varma and Ramanujam, 1984; Maheshwari, 1975; Jana and Tiwari, 1986).

Of the stratigraphically useful species, *C. microvelatus* first occurs in *Arcuatipollenites tethysensis* palynozone in Borehole RJNE-32 at 335 m depth , Rajmahal Basin, Jharkhand, India (Tripathi, 2000); that is the basalmost Jurassic (Rhaetic – Liassic / Hettangian level). This species has also been reported from the *Murospora florida* palynozone identified in the subsurface Triassic succession (Panchet Formation) in Panagarh area, Damodar Basin (Vijaya and Bhattacharji, 2003). This species is an important element in the oldest Jurassic rocks along with *C. turbatus* and *C. dampieri*. The first appearance or occurrence of any of these three species either on their own or in group, help to identify the lowermost Jurassic (See Fig. 4). Subsequently, all the three species occur widely in Middle Jurassic sediments, along with *C. segmentatus.* These species become prominent element in Late Jurassic deposits, followed by many other species (Table 2) in Early Cretaceous palynoflora (Fig. 4).

CONCLUSIONS

(i) The first occurrence of any of the three species *C. microvelatus, C. turbatus* and *C. dampieri* is suggestive of the advent level for basalmost Jurassic (Fig. 3).

(ii) Here, the two levels sharply defined — (a) containing first occurrence, (b) sudden abundance attained by genus *Callialasporites,* are suggestive of major hiatus, i.e., from that Middle Triassic to Early Jurassic (Fig. 4).

(iii) Steady and gradual species diversity is observed from the Middle to Late Jurassic into the Lower Cretaceous (Toarcian to Barremian).

(iv) Only nine species are identified (Table 2) as having distinct exinal characters, which allow them to have a key role in stratigraphy.

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