Abundance of spore tetrads in the Early Triassic sediments of India and their significance

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A number of spore tetrads with variable ornamentation have been observed during the palynological study of Lower Panchet sediments (Early Triassic) of the Raniganj Coalfield. They are either cingulate (ornamented or smooth) or simple verrucose spores, and can be attributed to *Lundbladispora, Densoisporites* and *Verrucosisporites*. The abundance of tetrads in the assemblage may be assigned to the diminishing effect of callase due to change in climate. This perhaps resulted into the non-dissolution of the callose-wall which holds the spores together in a tetrad.

Key-words—Palynology, Spore tetrads, *Lundbladispora, Densoisporites, Verrucosisporites*, Raniganj Coalfield, Early Triassic (India).

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सारॉंश

भारत के प्रारम्भिक त्रिसंधी कालीन अवसादों में बीजाणु-चतुष्कों की बाहुल्यता तथा इनका महत्व

रामशंकर तिवारी एव किन्दु लाल मीना

रानीगंज कोयला-क्षेत्र के अधरि पंचेत अवसादों (प्रारम्भिक त्रिसंधी) का परागाणविक अध्ययन करते समय अस्थायी अलंकरण वाले अनेक बीजाणु-चतुष्क प्रेक्षित किये गये हैं। ये चतुष्क या तो सिंगुलेटी हैं अथवा सामान्य वेरुकोसी बीजाणु हैं तथा **लुन्ब्लाडिस्पोरा, डेन्सोस्पोराइटिस** एवं **वेरुकोसिस्पोराईटिस** से इन्हें नामांकित किया जा सकता है। समुच्चय में चतुष्कों की बाहुल्यता केलेज़ की न्यूनता के कारण हो सकती है जो कि जलवायु परिवर्तन से संभव है। सम्भवतः केलेज़ भित्ति न टूटने के कारण ही ऐसा हो सकता है वास्तव में यही भित्ति चतुष्क रूप में बीजाणुओं को एक साथ विन्यस्त रखती है।

THE sporogenous tissue from which the spore mother cell originates normally gives rise to four spores after meiotic division. Subsequently, these four haploid bodies generally get free from each

PLATE 1 →

All figures. × 500.

1. *Densoisporites* : A tetrad in which one of the member spore is missing showing distorted smooth exine, contact areas and inner body; Slide no. BSIP 9313.
2. *Lundbladispora* : Tetrad showing small coni and thick exine of spore; Slide no. BSIP 9314.
3. *Lundbladispora* : Tetrad having coni with elongated tips; Slide no. BSIP 9314.
4. *Lundbladispora* : A tetrad bearing long coni; Slide no. BSIP 9313.
5. *Verrucosisporites* : A tetrad basically smooth and finely intrapunctate but bearing at places few globular smooth bodies irregularly attached on exine; Slide no. BSIP 9315.
6. *Lundbladispora* : Tetrad showing spars spines; Slide no. BSIP 9313.
7. *Lundbladispora* : Tetrad with elongated, narrow, closely placed spines; Slide no. BSIP 9606.
8. *Lundbladispora* : Spines on tetrads big, broad-based, massive; Slide no. BSIP 9606.
9. *Lundbladispora* : One of the members of tetrad missing; Slide no. BSIP 9608.
10. *Lundbladispora* : Exine partially distorted, spines present.
11. *Lundbladispora* : Similar to fig. 1; Slide no. BSIP 9312.
12. *Lundbladispora* : Similar to fig. 8; Slide no. BSIP 9313.

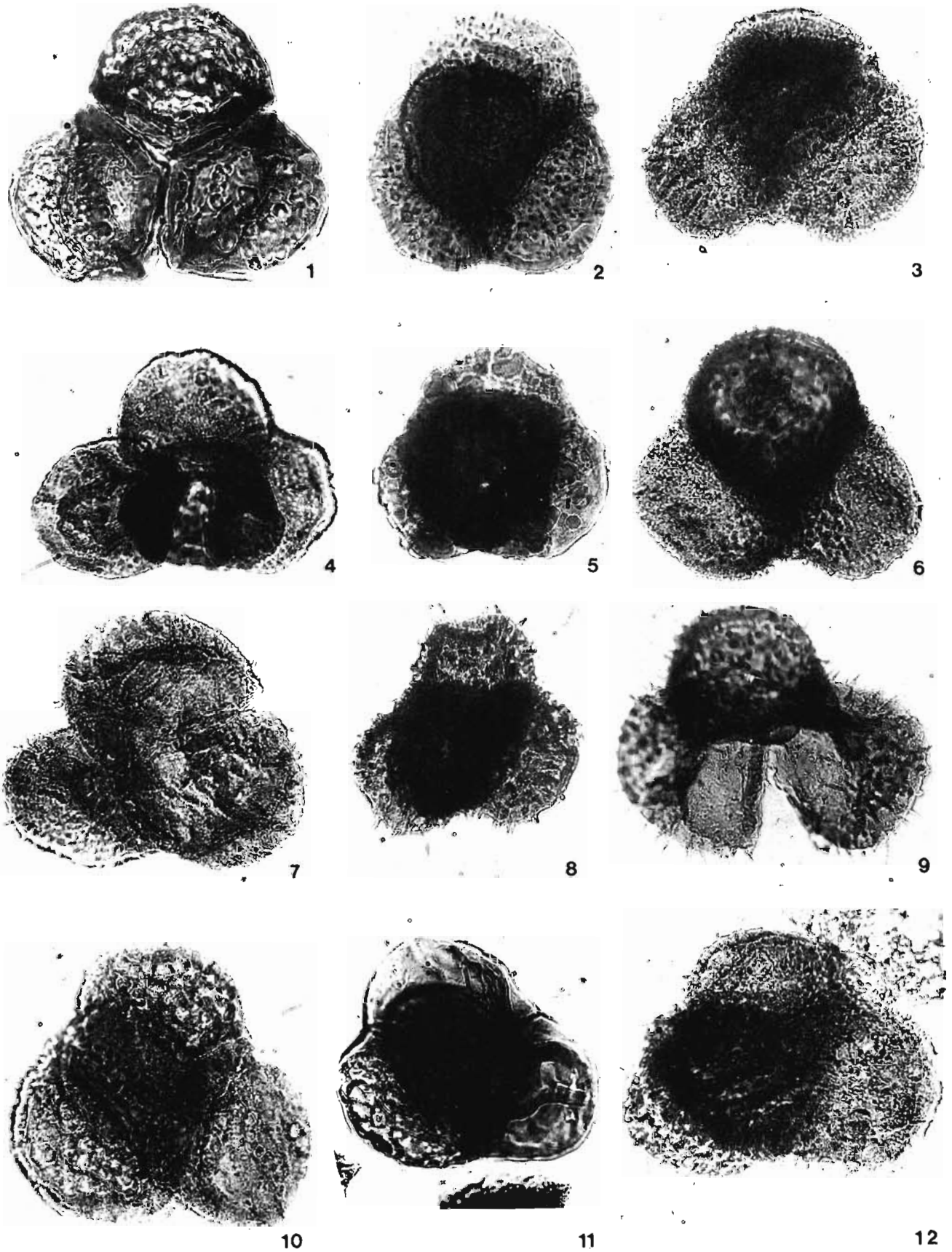

PLATE 1

other, but in certain cases they remain adhered together in the form of a tetrad (rarely dyads, polyads; Erdtman, 1945).

In the case of tetrahedral tetrads, the four spore members are arranged in two planes. Besides, the cross tetrad or linear tetrads are also found within the plant groups. It is well known that in the tetrahedral tetrads, the four member-spores are arranged as if each were on one apex of a pyramidal tetrahedron. Each of the cell touches the three other ones at three points and these three contact points form an isosceles triangle on the proximal polar region. In pteridophytes, the germinal apparatus is normally found at these contact lines (trilete mark).

In fossil condition, the occurrence of tetrads has been reported by several workers (Hennelly, 1958; Potonié & Lele, 1961; Visscher, 1968) and at times, given the status of a separate genus.

During the course of analysis of dispersed spores and pollen in the sediments of Panchet Formation, sampled from bore-hole no. RAD-7 and RAD-8 in the eastern part of East Raniganj Coalfield, West Bengal, a large number of tetrahedral tetrads were found. The individual spore-member of such tetrads, mostly cingulate, rarely non-cingulate, cavate organization, shows a wide variation in range of ornamentation. The abundance of such tetrads in dispersed condition is peculiar and needed discussion.

Following is the description of the major groups of tetrads found in the present study.

OBSERVATIONS

The tetrads which were found in the presently studied Panchet palynoflora, have been divided into two major groups:

1. Ornamented forms
2. Laevigate forms

In general, the spore members of tetrads are triangular to subtriangular in shape, bearing a distinct trilete mark having an equatorially thickened, well-defined cingulum. The exine of the body is finely structured showing infrapunctate to infragranulose structures. In case of ornamented forms, the sculpture is present only on the distal surface and to some extent on the cingulum but normally it is absent from the proximal surface. The inner body has been noticed in a number of specimens, particularly in the laterally flattened members of the tetrad, where it appears to be separate along the distal part of the cavity.

1. *Ornamented forms*—On the basis of ornamentation, described as under, five groups could be identified:

(a) *Setae-like spines*—2-5 μm long, less than 1 μm wide, 2-4 μm apart from each other, narrow setae-like appendages.

(b) *Coni*—1-2 μm wide at base, ± 2 μm high with fine projecting apex, closely packed, at places appearing as verrucae.

(c) *Mammoid globular process*—3-5 μm long × 2-3 μm wide, subcircular, obtusely elongated or nipple-shaped processes, with or without pointed tips.

(d) *Coni with elongated apex*—Processes up to 5 μm long and 3-4 μm wide at base, fusiform, generally rounded body with stretched elongated apex.

(e) *Verrucae*—1-3 μm verrucae generally indistinct in outline and compactly disposed on the surface, projecting out on the margin, non-cingulate.

2. *Laevigate forms*—Exine smooth, no ornamentation, cingulate. In some of the specimens the exine is affected by preservational factor and appears to possess coarse reticulum or foveolae. However, its secondary nature has been determined by the fact that at times only one or two spore-members of the tetrads show this type of deformity.

The cingulate ornamented forms of tetrads belong to the genus *Lundbladispora* Playford 1965; the spores in a tetrad having laevigate exine and a cingulum show their affinity with *Densoisporites* Weyland & Krieger emend. Dettmann 1963; those with verrucose exine and simple organization are of *Verrucosisporites* Ibrahim emend. Smith *et al.* 1967. The specific identification is not attempted here because it has been established now that although the major exine wall-pattern is formed during the tetrad condition, some changes in sculpture of the exine do take place even after the breaking up of tetrad. In view of this fact, the specific assignment of a tetrad to the individual spore species of the dispersed spores, could lead to erroneous identification.

DISCUSSION

Although Visscher (1966) proposed two tetrad genera, *Lapposisporites* and *Paralundbladispora* usually found in tetrahedral tetrads, these could be assigned to other taxa known in dispersed condition. The forms assigned to *Quadrisporites* (Hennelly, 1958; Potonié & Lele, 1961) are, however, entities in themselves and do not appear to be tetrads. Further study of *Quadrisporites* from the Lower Gondwana horizon suggested that the connecting material

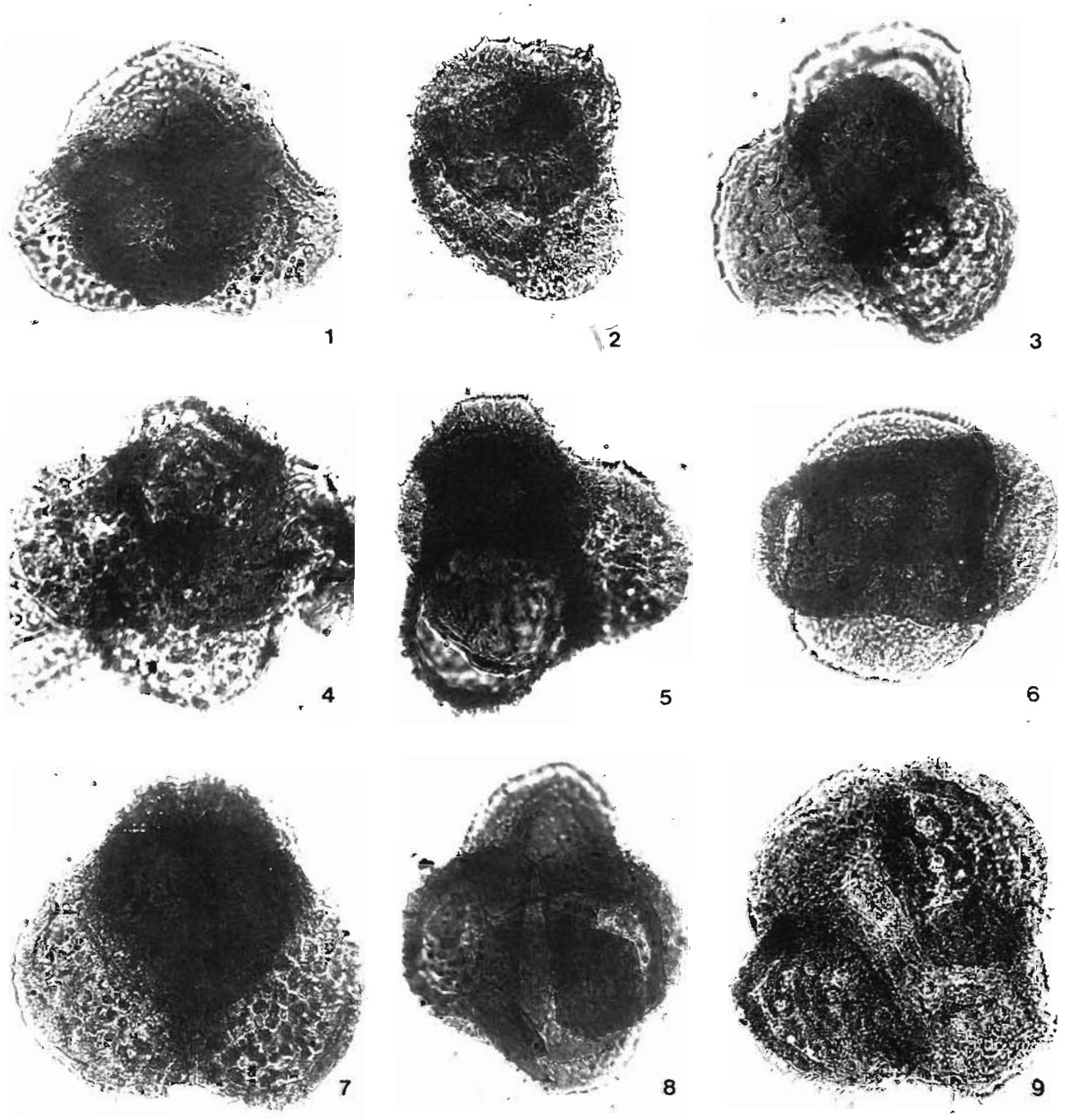

PLATE 2

All figures. × 500.

1 *Lundbladispora* Tetrad showing presence of broad-based round-ended or pointed coni and mammoid processes; Slide no. BSIP 9314.

2-4. *Lundbladispora* : Tetrad bearing small coni; Slide no. BSIP 9607

5,6,9. *Lundbladispora* : Tetrad bearing setae-like spines; Slide no. BSIP 9312.

7 *Lundbladispora* : Ornamentation broad-based, closely set massive coni; Slide no. BSIP 9606.

8. *Lundbladispora* : Tetrad bearing small coni; Slide no. BSIP 9607

which joins four members of the so-called 'tetrad', is exinal in nature. Moreover, no single member of this kind has been ever found separately in the population of dispersed spores. The nature of *Quadrisporites* to be similar to an acritarch can also be suggested on this basis.

From sediments of Panchet Group, Banerjee and Maheshwari (1975) have reported tetrads comparable to the ones described here. They assigned their specimens to *Decisporis* sp. cf. *D. variabilis* Kar 1970. They have found both tetrahedral as well as crossed tetrads. Our studies on the Triassic material and a survey of literature suggest that in the Early Triassic, spore pollen assemblages show a general tendency to have more tetrads than that in the Permian. The morphographic analysis leads to conclude that the tetrads should be treated as single spore for taxonomic purpose, and they should not be regarded as separate genera only because they are found in tetrad condition; this means that the identification of such tetrads should be sought in taxa of *sporae dispersae* on the lines of organization and morphography of the individual units of the tetrad.

The tetrad-period is critical for the formation of wall pattern in the initial stage. In the formation of a tetrad, generally two successive cleavages take place. The wall produced after meiosis bisects the meiocytes to give rise the dyad configuration and the subsequent two walls form, following meiosis II, to complete the sub-division to give rise the tetrad. These walls of tetrad are made up of callose (Heslop-Harison, 1973). The spores are released from the tetrads by the rapid dissolution of callose wall through an enzyme called callase. The enzyme appears in the locular fluid and its action is a short-lived process and, hence, it can be visualised that if this reaction fails due to some reasons or the other, it will result in a condition where a number of tetrads will remain intact and consequently no individual spore gets released. Such a situation appears to have arisen during the Early Triassic times where the occurrence of tetrad is a common feature. On the contrary, in the Raniganj palynoflora (Upper Permian), predominantly a coal-bearing horizon, almost negligible number of tetrads are found. This phenomenon thus raises the question of separation of individual spores from a tetrad which has some relationship with the changes in climate—from Permian to Triassic times. It is well known that there had been changes in the temperatures, towards warmer side, in the beginning of Triassic and it could be probable that the warmer conditions with high temperature and less rainfalls were apparently the cause of diminishing the action of callase during the advent of Triassic period and, thus the production of high frequency of tetrads in the *sporae dispersae* has resulted. This could as well be an adaptation for the protection of spores during changing situations. It, however, is not to opine here that the climate in Early Triassic was severely desertic or arid (because rich, diversified palynofloras occur during this period). Such a phenomenon appears to be an adaptation to adjust in the changing phase of climate for certain group of taxa. This contention is supported by the fact that although the same genera (e.g., *Lundbladispora, Densoisporites*, etc.) occur at the later time-level in Triassic as individual specimens, their tetrads are abundant at earlier level when the climatic change must have taken place.

CONCLUSION

The beginning of Triassic records prominence of tetrads in the *sporae dispersae*; they are generally of the cavate cingulate spores or of simple trilete spores. On the basis of morphography these tetrads should be assigned to the taxa of dispersed individuals rather than to new taxa. The probable reason for profused occurrence of tetrads at the advent of Triassic appears to be the sudden change in climate having relatively warmer phase when callase fails to dissolve the callose wall of the tetrad. This is suggestive of a short term adaptation for new set of conditions.

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