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BIOMETRIC STUDY OF *PLICATIPOLLENITES* LELE AND *POTONIEISPORITES* BHARDWAJ IN THE LOWER GONDWANA FORMATIONS OF THE HUTAR COALFIELD, BIHAR, INDIA

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ABSTRACT

The data on the morphological trends of the *Plicatipollenites/Potonieisporites* populations worked out from Talchir to Barakar in the Hutar Basin are investigated. These trends are compared with the average picture obtained earlier from the synthesis of five basins. This study reveals that there is a reasonable degree of similarity between the morphological evolutionary trends of the *Plicatipollenites/Potonieisporites* populations of the Hutar basin and those obtained in the synthesis from the five Lower Gondwana basins by Lele and Shukla.

Key-words — Biometry, Morphological variations, *Potonieisporites*, *Plicatipollenites*, Lower Gondwana (India).

सारॉश

बिहार (भारत) में हुतार कोयला-क्षेत्र के अधर गोंडवन शैल-समूहों से उपलब्ध प्लिकेटिपोलिनाइटिस लेले एवं पोतोनियेस्पोराइटिस भारद्वाज का जीवसाँख्यिकीय अध्ययन – केशव मुकुन्द लेले एवं मनोज शुक्ला

हुतार द्रोणी में तालचिर से बाराकार तक अन्वेषित प्लिकेटिपोलिनाइटिस/पोतोनियेस्पोराइटिस समष्टियों की आकारिकीय प्रवृत्तियों के आँकड़े अन्वेषित किये गये हैं। इन प्रवृत्तियों की तुलना पाँच द्रोणीयों के संश्लेषण के पहले से प्राप्त औसत अनुमान से की गई है। इस अध्ययन से यह व्यक्त होता है कि लेले एवं शुक्ला द्वारा पाँच अधर गोंडवन द्रोणीयों के किये गये संश्लेषण से उपलब्ध तथा हुतार द्रोणी से प्राप्त प्लिकेटिपोलिनाइटिस-पोतोनियेस्पोराइटिस समष्टियों की आकारिकीय वैकासिक प्रवृत्तियों में आपस में बहुत कुछ समानता है।

MORPHOLOGICAL transitions between *Plicatipollenites* Lele and *Potonieisporites* Bhardwaj have been noted by several earlier workers (Potonié & Lele, 1961; Lele, 1964, 1974; Maheshwari, 1967). Recently a detailed biometric study on morphological variation of the two genera through the Talchir to the Lower Barakar times has been published by Lele and Shukla (1978). In this synthesis, five Lower Gondwana basins, viz., South Rewa, Jayanti, Giridih, North Karanpura and Hutar were investigated. Of these basins, the data worked out from the Hutar Basin has a particular significance because here a more or less complete stratal sequence from the Talchir to the Barakar is available for carrying out a successional study of morphological variations through time. It was, therefore, considered useful to work out in greater detail the morphological/evolutionary trends of the *Plicatipollenites-Potonieisporites* populations in the Hutar Basin and demonstrate their compatibility with the general picture synthesized earlier by Lele and Shukla (1978) from the five Lower Gondwana basins. The present paper deals with this objective in view.

The genera *Plicatipollenites* and *Potonieisporites* can be differentiated on the basis of a new criterion called " Distal saccus spread " (Lele & Shukla, 1978). According to this *Plicatipollenites* belongs to the " monosaccate group " characterized by " Uniform saccus spread " and *Potonieis-*

sporites to the monosaccoid group characterized by "Differential saccus spread". The study of Lele and Shukla (1978) further reveals that *Plicatipollenites* population shows a strong association of bilateral spores with monolete to monoletoid mark and bilateral infold system.

MATERIAL AND METHOD

In the present paper the methodology of Lele and Shukla (1978) has been adopted in order to bring out the individual trends of *Plicatipollenites* and *Potonieisporites* in the Hutar Coalfield and to check how far they agree with the overall trends found out earlier by Lele and Shukla (1978).

The samples from which the actual counts were done are as detailed below (Map 1):

Section	Formation	Sample No.	Lithology
Deori Nala	Lower Karharbari	DK_5 DK_6	Shale & Carbonaceous Shale
	Talchir	DT_2	Needle shale
Koel River	Barakar	KB_7 KB_8	Carbonaceous sandy shale
	Lower Karharbari	KB_3	Coaly-shale
	Talchir	KT_1	Needle shale

Upper Karharbari beds of the Deori Nala Section do not possess well-preserved specimens of the genera *Plicatipollenites* and *Potonieisporites* and hence they have been excluded from the biometric study.

Norms — All the six basic morphological types or norms instituted earlier by Lele and Shukla (1978) have been used in the biometric study of the palynoflora in the Hutar Coalfield. For the sake of clarity these are re-stated below.

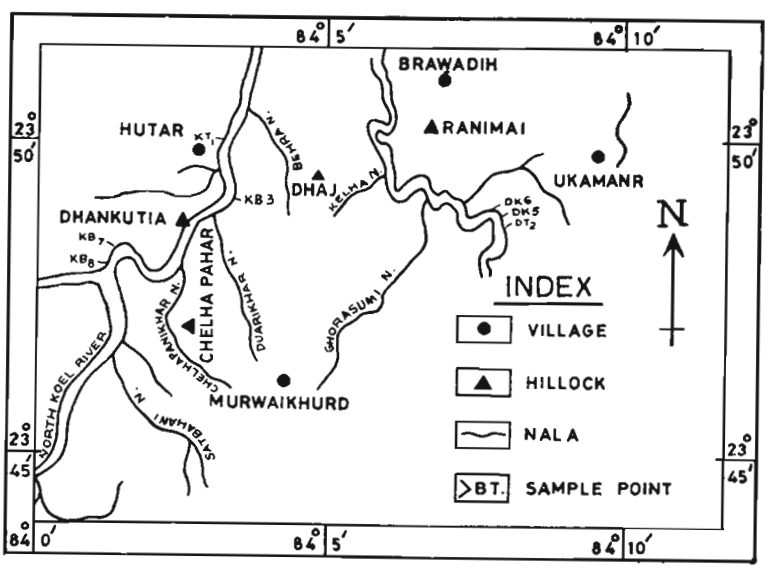
Plicatipollenites population:

Norm A_1 — Characterized by radial symmetry of miospore and uniform saccus spread (Pl. 1, figs 1-4).
Spore circularity ratio $= 1 \pm 0{\cdot}1$
Body infold circularity ratio $= 1 \pm 0.1$
Saccus spread value $= \pm 0.1$

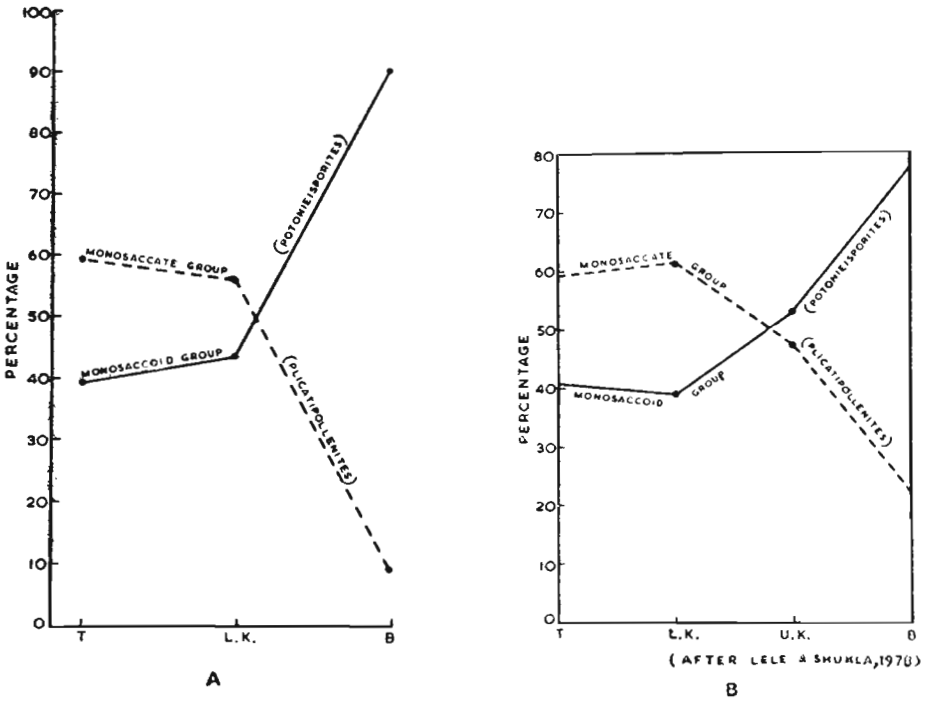
Norm A_2 — Characterized by bilateral symmetry of miospore and uniform saccus spread (Pl. 1, figs 5-7).
Spore circularity ratio $= > 1.1$
Body infold circularity ratio $= > 1.1$
Saccus spread value zero or less (negative value)

Potonieisporites population:

Norm B_1 — Characterized by bilateral symmetry of miospore and diffe-



MAP 1



TEXT-FIG. 1 — Distribution trend of monosaccate and monosaccoid groups through time — **A**, in the Hutar Coalfield, and **B**, in the Lower Gondwana (after Lele & Shukla). T=Talchir, L.K.=Lower Karharbari, U.K.= Upper Karharbari, B=Barakar.

rential saccus spread. Body infold bilateral and horizontally oriented, i.e. its longer axis (x) is parallel to longer axis of spore (X) (Pl. 1, fig. 8).
Spore circularity ratio = >1.1
Body infold circularity ratio = >1.1 but less than spore circularity ratio, hence the saccus spread value is always positive.

Norm B_2 — Characterized by bilateral symmetry of miospore radial symmetry of body infold and differential saccus spread (Pl. 1, figs 10, 11).
Spore circularity ratio = >1.1
Body circularity ratio = 1 ± 0.1
Saccus spread value = >0.1

Norm B_3 — Characterized by bilateral symmetry of miospore and differential saccus spread. Body infold bilateral and vertically oriented, i.e. its longer axis (x) is at right angle to longer axis (X) of miospore (Pl. 1, figs 12-14).
Spore circularity ratio >1.1
Body infold circularity ratio = <0·9
Saccus spread value = >0.1

Norm B_4 — Characterized by radial symmetry of miospore and differential saccus spread. Body infold bilateral and vertically oriented as in Norm B_3 (Pl. 1, figs 15, 16).
Spore circularity ratio = 1 ±0.1
Body infold circularity ratio = 0.9
Saccus spread value = 0.1

EVALUATION OF VARIABILITY TRENDS

1. *Miospore Symmetry* — An assessment of spore circularity parametral trend shows that mean spore circularity (Table 2) in the Talchir Formation is 1.16 (Deori Nala 1.14 & Koel River 1.19). It increases up to

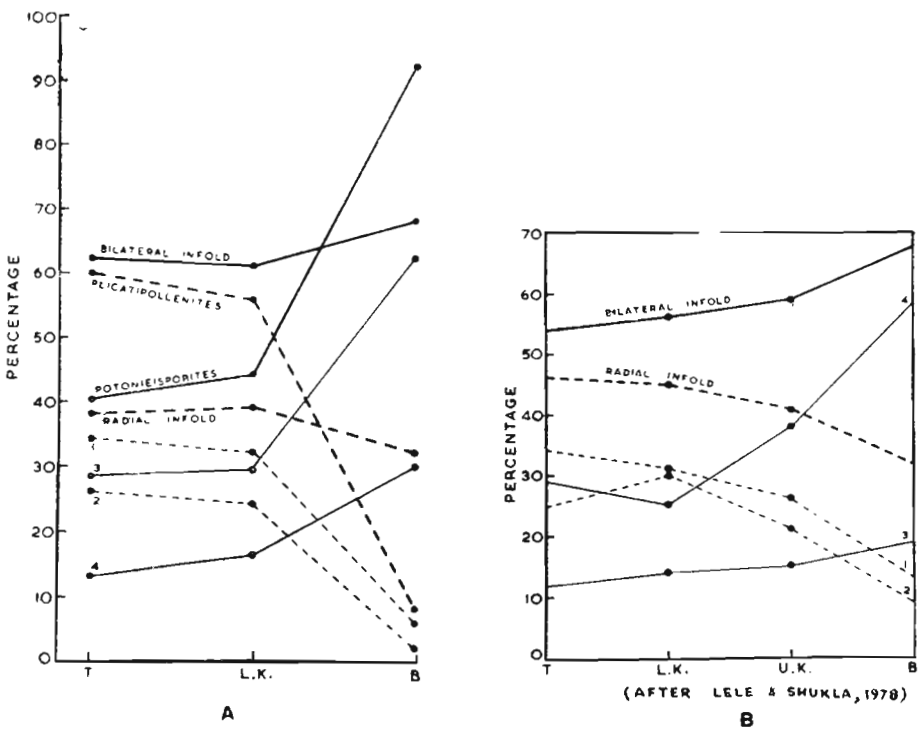
TABLE 1 — MEAN PERCENTAGE DISTRIBUTION OF RADIAL AND BILATERAL MIOSPORES OF *PLICATIPOLLENITES* AND *POTONIEISPORITES* IN THE KOEL RIVER AND DEORI NALA SECTIONS AND MEAN OF BOTH SECTIONS

Locality	Miospores symmetry	Talchir	Lower Karharbari	Barakar
Deori Nala	Radial	35	32	×
	Bilateral	65	68	×
Koel River	Radial	30	25	6
	Bilateral	70	75	94
Mean	Radial	32	28	6
	Bilateral	68	72	94

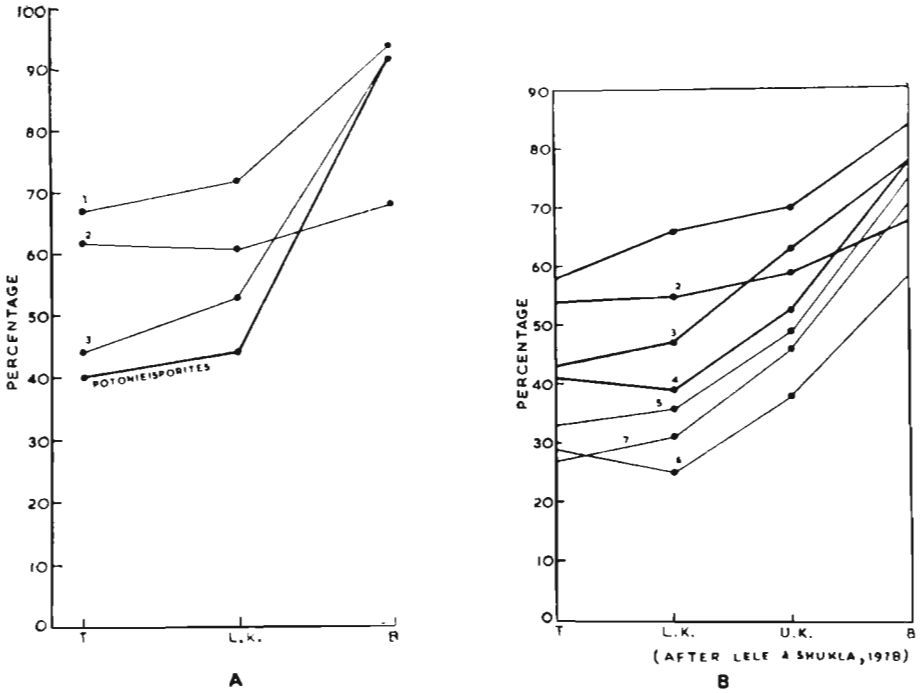
TABLE 2 — MEAN SPORE CIRCULARITY RATIO OF THE SPORES OF *PLICATIPOLLENITES* AND *POTONIEISPORITES* FROM DEORI NALA AND KOEL RIVER SECTIONS AND MEAN OF BOTH SECTIONS

Locality	Talchir	Lower Karharbari	Barakar
Deori Nala Section	1.14	1.18	×
Koel River Section	1.19	1.3	1.29
Mean	1.16	1.24	1.29

1·24 (Deori Nala 1·2 & Koel River 1·28) in the Karharbari Formation and further rises to 1·29 in the Barakar Formation. These above mentioned figures agree with the results of Lele and Shukla (1978) except in the Barakar Formation where mean circularity is 1·3. It is, however, interesting to note that though in individual section the overall circularity ratio of spore increases



TEXT-FIG. 2 — A, distribution trends of the body infold symmetry through time and their correlation with *Plicatipollenites* and *Potonieisporites* trends in the Hutar Coalfield. (i) bilateral infold in *Plicatipollenites*, (ii) radial infold in *Plicatipollenites*, (iii) bilateral infold in *Potonieisporites*, and (iv) radial infold in *Potonieisporites*. **B**, distribution trends of the body infold symmetry through time and their correlation with *Plicatipollenites* and *Potonieisporites* trends (after Lele & Shukla)— (1) radial infold in *Plicatipollenites*, (2) bilateral infold in *Plicatipollenites*, (3) radial infold in *Potonieisporites*, and (4) bilateral infold in *Potonieisporites*.



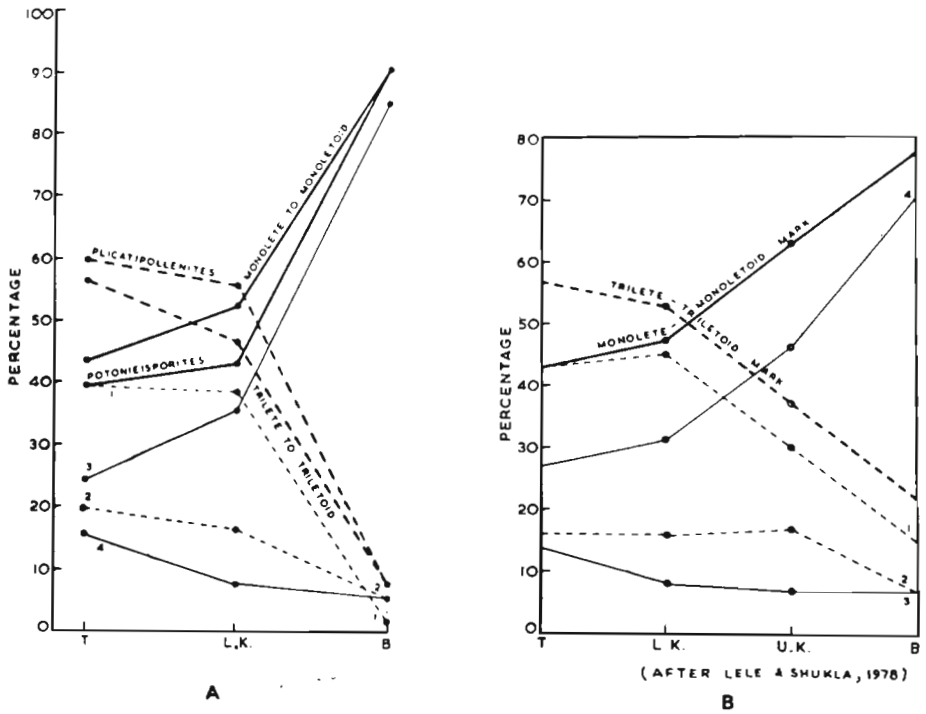
TEXT-FIG. 3 — **A**, composite correlation of variation trends in *Potonieisporites* in the Hutar Coalfield — (1) spores with bilateral form, (2) spores with bilateral body infold, and (3) spores with monolete to monoletoid mark. **B**, composite correlation of variation trends in *Potonieisporites* (after Lele & Shukla, 1978) parametral trends of bilateral spore symmetry — (1) bilateral body infold symmetry, (2) monolete-monoletoid mark, (3) *Potonieisporites* population, (4) *Potonieisporites* with bilateral spore symmetry, (5) bilateral body infold, and (6) monolete-monoletoid mark.

in time, the value of miospore circularity ratio is different from the mean value calculated. Therefore, bilateralism in spores at a particular time level may vary from field to field and from section to section but the general trend remains the same.

In the Hutar Coalfield trends of distribution of radial and bilateral spores in time show reverse tendency (Text-fig. 5) which agrees with distributional trends of *Plicatipollenites* (Text-fig. 7A) (Norm A_1 and A_2) and *Potonieisporites* (Text-fig. 3A) (Norms B_1 to B_4) respectively. Distributional trends of circular *Plicatipollenites* and *Potonieisporites* and bilateral *Plicatipollenites* and *Potonieisporites* clearly indicate that circular spore of both the genera showed a decline with the proliferation of bilateral forms (Text-fig. 5A). These trends of the Hutar Coalfield agree with the overall trends (Text-fig. 5B) given by Lele and Shukla (1978).

2. *Tetrad Mark* — The problem regarding the development of tetrad mark in spores and pollen and the type of tetrad found in these spores has already been discussed by various authors (Staplin *et al.*, 1967; Lele, 1974; Vischer, 1971) and summarized by Lele and Shukla (1978). Five types of marks: (i) trilete mark, (ii) triletoid mark, (iii) monoletoid mark, (iv) bilete mark, and (v) monolete mark — have been recognized by Lele and Shukla (1978) for biometric analysis.

Parametral variation trends of the tetrad mark reveal that the normal trilete is well-represented by 27% (Deori Nala — 29%, Koel River 25%) spores in the Talchir Formation, whereas it reduces to 24% (Deori Nala — 19%, Koel River — 29%) in the Lower Karharbari beds and finally



TEXT-FIG. 4 — **A**, distribution trends (parametral) of trilete-triletoid set and monolete-monoletoid set in time (thick lines) and their correlation with *Plicatipollenites* and *Potonieisporites* population — (1) trilete and triletoid mark in *Plicatipollenites*, (2) monolete and monoletoid mark in *Plicatipollenites*, (3) trilete to triletoid mark in *Potonieisporites*, and (4) monolete to monoletoid mark in *Potonieisporites*. **B**, distribution trends (parametral) of trilete-triletoid set and monolete and their correlation with *Plicatipollenites* and *Potonieisporites* trends (thin line) — (1) *Plicatipollenites* trilete-triletoid, (2) *Plicatipollenites* monolete-monoletoid, (3) *Potonieisporites* trilete-triletoid, and (4) *Potonieisporites* monolete-monoletoid (after Lele & Shukla, 1978).

no trilete mark is seen in the Barakar Formation (Table 3; Text-fig. 10A). In contrast to this, the incidence of monolete mark in the Talchir Formation is 5% (Deori Nala — 6%, Koel River — 4%), it further increases to 12% (Deori Nala — 13%, Koel River — 11%) in the Lower Karharbari beds and finally reaches 40% (Koel River) in the Barakar Formation (Text-fig. 10A). The asymmetrical trilete (Text-fig. 10A) in general shows a higher percentage at any time level but it shows a gradual decrease with time (Talchir — 68%, Karharbari — 54%, Barakar — 60%). These trends also agree with the trends shown by Lele and Shukla (1978) (Talchir — 69%, Karharbari — 62-56%, Barakar — 61%) (Text-fig. 10B).

Among the 3 categories of asymmetrical trilete, the triletoid mark registers a progressive decline (Text-fig. 10A) in number (Talchir — 29%, Karharbari — 23%, Barakar — 8%). The monoletoid mark (Text-fig. 10A) shows a stabilization tendency towards Karharbari and then a slight rise (Talchir — 38%, Karharbari — 38%, Barakar — 42%). The bilete mark (Text-fig. 10A) also shows a gradual increase in the Karharbari and Barakar formations (Talchir — 1%, Karharbari — 3%, Barakar — 10%).

It is also seen that the combined trend of trilete and triletoid mark shows a decrease in time, while of monolete, bilete and monoletoid marks shows an increase through time (Text-fig. 4A). These trends are compatible with *Plicatipollenites* and *Potonieisporites* respectively (Text-fig. 4A). It is also seen that *Plicatipollenites* is dominated by the trilete and triletoid marks

TABLE 3 — PERCENTAGE DISTRIBUTION OF VARIATION CHARACTERS OF THE NORMS OF *PLICATIPOLLENITES* AND *POTONIEISPORITES* IN KOEL RIVER AND DEORI NALA SECTIONS OF THE HUTAR COALFIELD

Section	Formation	Norm A_1				Norm A_2					Norm B_1					Norm B_2					Norm B_3					Norm B_4			
		T	T_1	B	M	T	T_1	M_1	B	M	T	T_1	M_1	B	M	T	T_1	M_1	B	M	T	T_1	M_1	B	M	T	T_1	B	M
KOEL RIVER	BARAKAR	×	2	×	×	×	×	6	×	×	×	×	8	×	2	×	2	10	4	14	×	×	18	6	24	×	4	×	×
	LOWER KARHARBARI	11	12	×	×	11	3	14	1	×	2	1	11	×	4	2	4	7	2	3	×	×	4	1	5	2	×	×	×
	TALCHIR	13	11	×	×	6	8	23	×	4	2	2	10	×	×	2	2	4	×	×	2	×	4	1	×	×	6	×	×
DEORI NALA	LOWER KARHARBARI	13	12	×	1	6	8	19	×	×	×	2	4	×	2	×	×	7	×	5	×	×	8	2	5	×	5	1	×
	TALCHIR	15	13	×	×	4	9	14	×	×	4	2	7	×	2	3	×	11	1	2	×	1	2	1	2	3	4	×	×

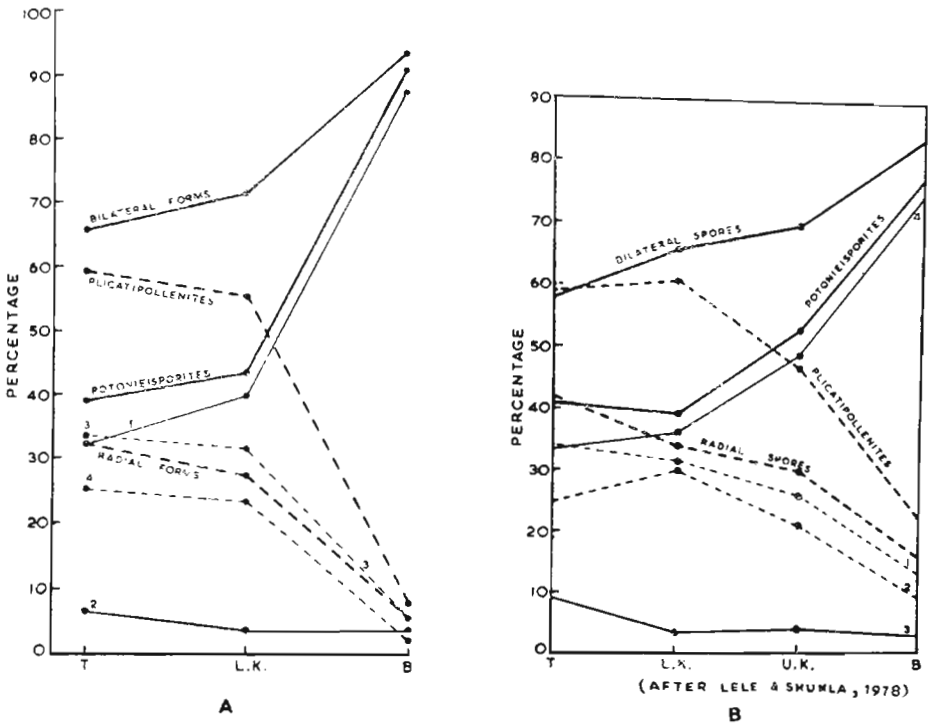
T = Trilete, T_1 = Triletoid, B = Bilete, M = Monolete, M_1 = Monoletoid.

TABLE 4 — PERCENTAGE DISTRIBUTION OF *PLICATIPOLLENITES* AND *POTONIEISPORITES* NORMS AND THEIR VARIATION CHARACTERS THROUGH TIME IN THE HUTAR COALFIELD

Norms	A_1	A_2	B_1	B_2	B_3	B_4
BARAKAR	2	6	10	30	48	4
KARHARBARI	24	32	13	15	12	4
TALCHIR	26	34	15	12	6	67

BARAKAR	×	2	×	×	×	×	6	×	×	×	×	8	×	2	×	2	10	4	14	×	×	18	6	24	×	4	×	×
LOWER KARHARBARI	12	12	×	×	9	6	17	×	×	1	1	8	×	3	1	2	7	1	4	×	×	6	1	5	1	2	1	×
TALCHIR	14	12	×	×	5	9	18	×	2	3	2	9	×	1	2	1	8	×	1	1	×	3	1	1	2	5	×	×
TETRAD MARK	T	T_1	B	M	T	T_1	M_1	B	M	T	T_1	M_1	B	M	T	T_1	M_1	B	M	T	T_1	M_1	B	M	T	T_1	B	M			

T = Trilete, T_1 = Triletoid, B = Bilete, M = Monolete, M_1 = Monoletoid.



TEXT-FIG. 5 — **A**, distribution trends of miospore symmetry through time in the Hutar Coalfield — (1) *Potonieisporites* bilateral (Norms B_1, B_2, B_3), (2) *Potonieisporites* radial (Norm B_4), (3) *Plicatipollenites* bilateral (Norm A_2), and (4) *Plicatipollenites* radial (Norm A_1). **B**, distribution trends of miospore symmetry in time (after Lele & Shukla) — (1) *Plicatipollenites* radial (Norm A_1), (2) *Plicatipollenites* (Norm A_2), (3) *Potonieisporites* radial (Norm B_4), and (4) *Potonieisporites* bilatearl (Norms B_1, B_2, B_3).

and *Potonieisporites* by monolete to monoletoid marks (Text-fig. 4A). Further, *Plicatipollenites* with trilete and triletoid marks show a declining trend but *Plicatipollenites* with monolete and monoletoid marks registers an increase in Karharbari and then a fall in Barakar (Text-fig. 4A). *Potonieisporites* with monolete to monoletoid marks registers an increase in time while those with trilete and triletoid marks show a fall in time (Text-fig. 4A).

It is apparent that during course of evolution the trilete and triletoid marks dominate the genus *Plicatipollenites* (Norms A_1 & A_2) (Text-fig. 6A) and in *Potonieisporites* (Norms B_1, B_2, B_3) the trilete and triletoid marks have been gradually eliminated (Text-fig. 6A) and replaced by the monolete to monoletoid mark (Text-fig. 8A). Thus the present study confirms the results of Lele and Shukla (1978).

TABLE 5 — MEAN PERCENTAGE DISTRIBUTION OF CIRCULAR AND BILATERAL BODY INFOLD OF *PLICATIPOLLENITES* AND *POTONIEISPORITES* IN KOEL RIVER AND DEORI NALA SECTIONS AND THEIR MEAN

LOCALITY	MIOSPORES SYMMETRY	TALCHIR	LOWER KARHARBARI	BARAKAR
Deori Nala Section	Radial	45	38	×
	Bilateral	55	62	×
Koel River Section	Radial	32	51	32
	Bilateral	68	49	68
Mean	Radial	38	48	32
	Bilateral	62	52	68

3. *Body Infold System* (Tables 5 and 6) — Body infold system marks the point of separation of saccus (sexine) from the body

TABLE 6 — MEAN INFOLD CIRCULARITY RATIO OF *PLICATIPOLLENITES* AND *POTONIEISPORITES* FROM DEORI NALA AND KOEL RIVER SECTIONS AND THEIR MEAN

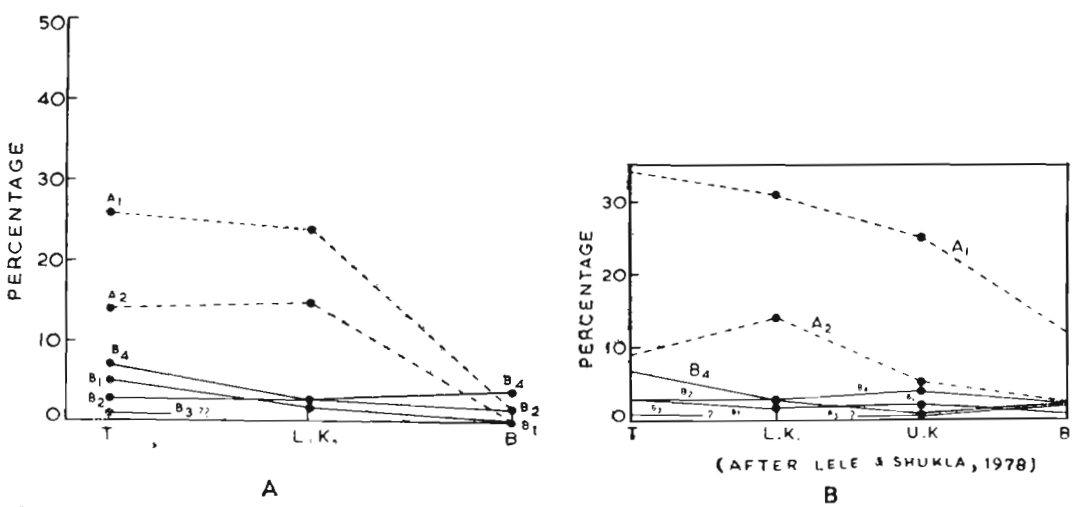
Locality/ Formations	Talchir	Lower Karharbari	Barakar
Deori Nala	1.06	1.05	×
Koel River	1.08	1.05	0.95
Mean	1.07	1.05	0.95

(nexine) in the genera *Plicatipollenites* and *Potonieisporites* (Lele, 1964). The area circumscribed by the infold is said to mark the germinal area of tenuitas (Potonié & Lele, 1961; Lele, 1964; Bharadwaj, 1964a, 1974a). The body infold is of various shapes (Text-fig. 11 of Lele & Shukla, 1978). They have been grouped into 3 major types on the basis of body infold circularity ratio.

	Body infold circularity ratio
1. Vertical bilateral body infold	$< \times 0.9$
2. Circular body infold	$\pm 1 \times 0.1$
3. Horizontal bilateral body infold	$> \times 1.1$

An objective assessment of parametral variation trends shows that radial body infold system has a downward trend of distribution through time (Talchir = 38%, Lower Karharbari = 48%, Barakar = 32%) and bilateral fold shows an upward distribution in time (Talchir = 62%, Lower Karharbari = 52%, Barakar = 68%) (Table 5; Text-fig. 2A). These distributional trends are compatible with genera *Plicatipollenites* and *Potonieisporites*. *Plicatipollenites* is mostly associated with radial fold and *Potonieisporites* with bilateral fold (Text-fig. 2A). Norm A_2 (*Plicatipollenites*) has bilateral fold yet it meets the same fate as Norm A_1 which has radial folds. But Norm B_1, which is nearer to Norm A_2, shows somewhat stabilizing tendency and after that Norms B_2 and B_3 show step by step rise in the distribution and advancement of morphology (Text-fig. 9A). This suggests a time proportionate evolutionary relationship and gradual establishment of bilateral infold from horizontal to vertical position. The above results are in general agreement with the results of Lele and Shukla (1978).

Body symmetry — Central body of the genera *Plicatipollenites* and *Potonieisporites* shows considerable variation in shape patterns, which may be due to compressional factors, original curvatures of the body, saccus attachment and its thickness and the



TEXT-FIG. 6 — Distribution trends of trilete-triletoid mark in the Norms of *Plicatipollenites* (A_1, A_2) and *Potonieisporites* (B_1, B_2, B_3, B_4)— **A**, in the Hutar Coalfield and **B**, in the Lower Gondwana beds (general) (after Lele & Shukla, 1978).

TABLE 7 — MEAN BODY CIRCULARITY RATIO OF *PLICATIPOLLENITES* AND *POTONIEISPORITES* FROM DEORI NALA AND KOEL RIVER SECTIONS AND MEAN OF BOTH SECTIONS

LOCALITY/ FORMATION	TALCHIR	LOWER KARHARBARI	BARAKAR
Deori Nala	1.13	1.125	×
Koel River	1.2	1.16	1.02
Mean	1.16	1.14	1.02

TABLE 8 — MEAN PERCENTAGE DISTRIBUTION OF CIRCULAR AND BILATERAL BODY OF *PLICATIPOLLENITES* AND *POTONIEISPORITES* IN KOEL RIVER AND DEORI NALA SECTIONS AND MEAN OF BOTH SECTIONS

LOCALITY	MIOSPORE SYMMETRY	TALCHIR	LOWER KARHARBARI	BARAKAR
Deori Nala Section	Circular	34	59	×
	Bilateral	66	41	×
Koel River Section	Circular	26	42	56
	Bilateral	74	58	44
Mean	Circular	30	50	56
	Bilateral	70	50	44

flexibility of exine. Therefore to reconstruct the original shape of the body a study of all these factors is called for. But these factors do not appreciably affect the symmetry of the body which can be determined from the Body circularity ratio.

An assessment of body circularity ratio (Table 7) shows that the mean circularity for Talchir is 1.16 (Deori Nala — 1.13, Koel River — 1.2) and it gradually decreases to 1.14 (Deori Nala — 1.125, Koel River — 1.16) in Lower Karharbari and 1.02 (Koel River) in Barakar. Thus overall circularity of spore shows a decline trend indicating more and more circular bodies.

The parametral trends also show that circular bodies form 30% in Talchir (Deori Nala — 34%, Koel River — 26%), 50.5% in Karharbari (Deori Nala — 59%, Koel River — 42%) and 56% in Barakar (Koel River); against this the bilateral bodies show a downward trend — 70% in Talchir (Deori Nala — 66%, Koel River — 74%), 49.5% in Karharbari (Deori Nala — 41%, Koel — 50%) and 44% in Barakar (Koel River). Thus, though the two trends are opposite to each other but they do not coincide with other parametral trends and instead they show an inverse correlation (Table 8).

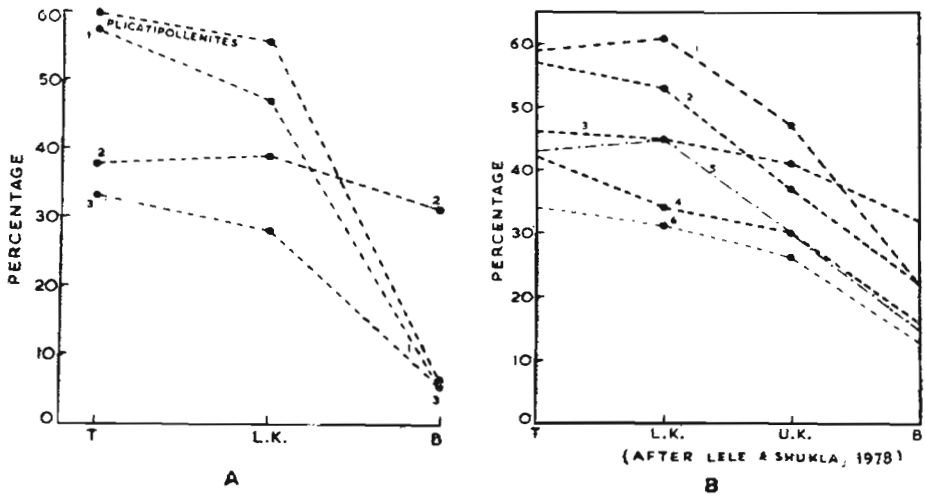
CONCLUSION

Considering the overall trend of *Plicatipollenites* and *Potonieisporites* and individual trends of parameters, *Plicatipollenites* population is marked by radial miospore symmetry, radial infold system and trilete to triletoid mark (Text-fig. 7), whereas *Potonieisporites* population is marked by bilateral spores, bilateral infold, and monolete to monoletoid mark (Text-fig. 3).

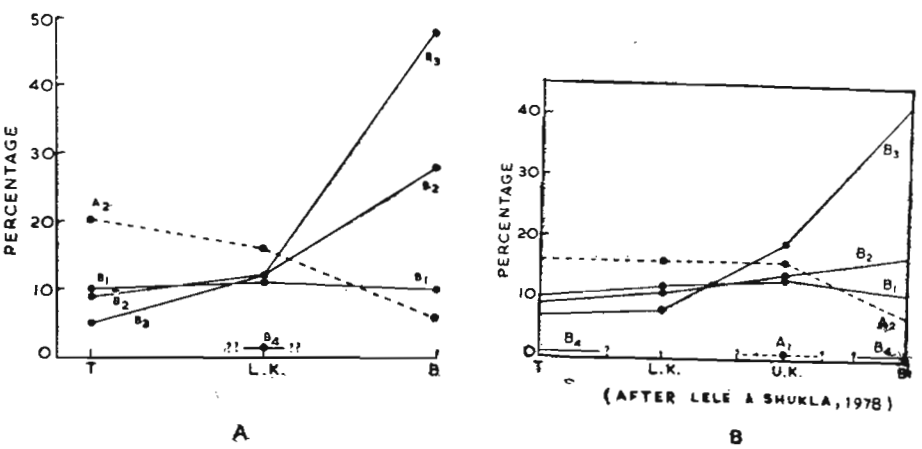
The body parameter shows an inverse correlation with both populations and rest of the parameters. It does not show enough change in symmetry to be of any use to demarcate the morphological criteria to differentiate the *Plicatipollenites* population from *Potonieisporites* population.

Plicatipollenites population is represented by Norms A_1 and A_2 which show a continuous downward trend through time (Text-fig. 9A). The *Potonieisporites* population is typically represented by Norms B_2 and B_3 which show an upward trend across time (Text-fig. 9A). Norms B_1 and B_4 of *Potonieisporites* population show superficial morphological resemblance with Norms A_2 and A_1 respectively. The Norms B_1 and B_4 also show a downward trend across time which is similar to *Plicatipollenites* population (Text-fig. 9A). Norms B_1 and B_4 could indeed be confused morphologically with *Plicatipollenites* but the biometric criteria help in separating these Norms. Biometrically B_1 and B_4 belong to *Potonieisporites* as they definitely show a step towards the advanced type of morphology defined for the *Potonieisporites* population.

The study thus demonstrates that there is a reasonable degree of similarity between the morphological evolutionary trends of the

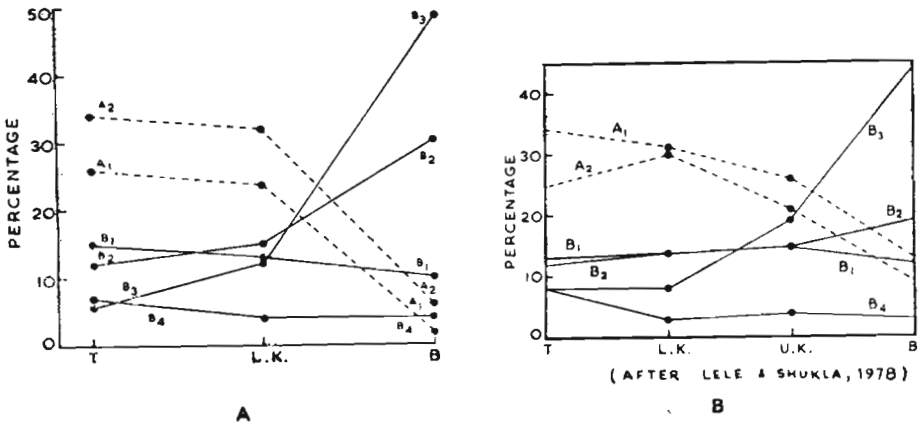


TEXT-FIG. 7 — A, composite correlation of variation trends in *Plicatipollenites* and parametral trends in the Hutar Coalfield — (1) Trilete to triletoid mark, (2) radial infold system, (3) radial miospore symmetry. B, composite correlation of variation trends (after Lele & Shukla, 1978) of *Plicatipollenites* population — (1) Parametral trends of *Plicatipollenites* population, (2) trilete-triletoid mark, (3) radial body infold symmetry, (4) radial spore symmetry, (5) *Plicatipollenites* with trilete-triletoid mark, and (6) radial spore symmetry.

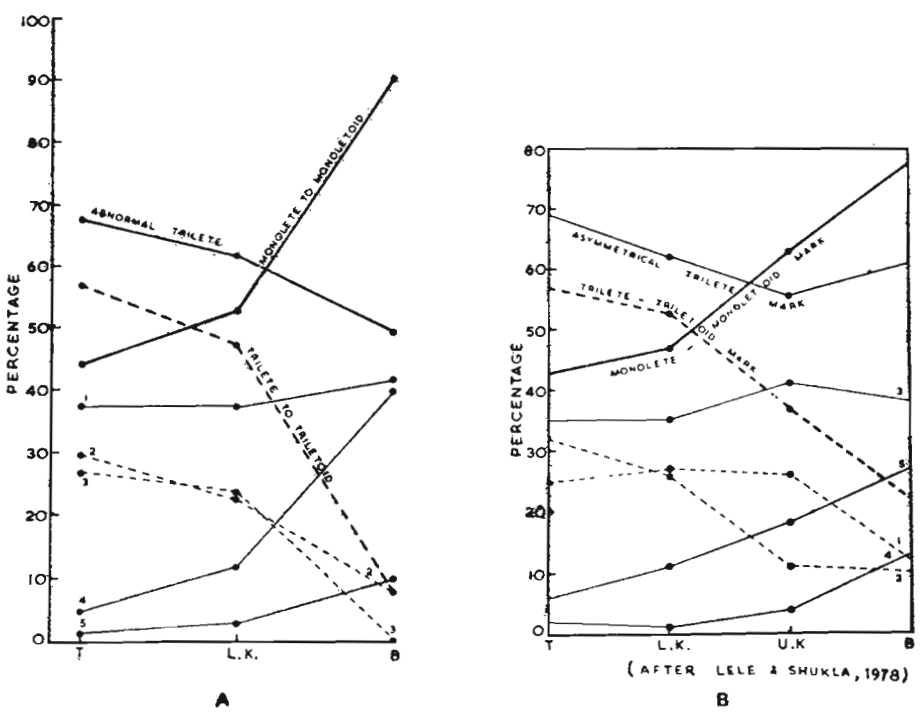


TEXT-FIG. 8 — Distribution trends of monolete-monoletoid mark in the Norms of *Plicatipollenites* (A_1, A_2) and *Potonieisporites* (B_1, B_2, B_3, B_4)— A, in the Hutar Coalfield and B, in the Lower Gondwana beds (after Lele & Shukla, 1978).

Plicatipollenites/*Potonieisporites* populations of the Hutar Basin and those obtained in the synthesis from the five Lower Gondwana basins by Lele and Shukla (1978) (Text-figs 3, 7). However, the differences of individualistic nature are reflected in the analysis of Hutar Coalfield. For example, in general trend (Lele & Shukla, 1978) Norms A_1 and A_2 of *Plicatipollenites* characterize the Talchir and Lower Karharbari respectively. In Hutar Coalfield, however, the values of Norm A_2 are not so distinctive

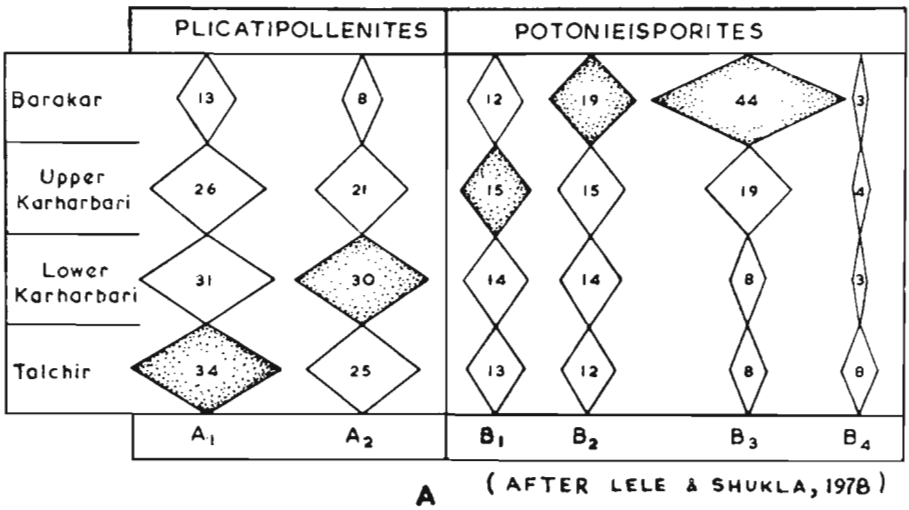


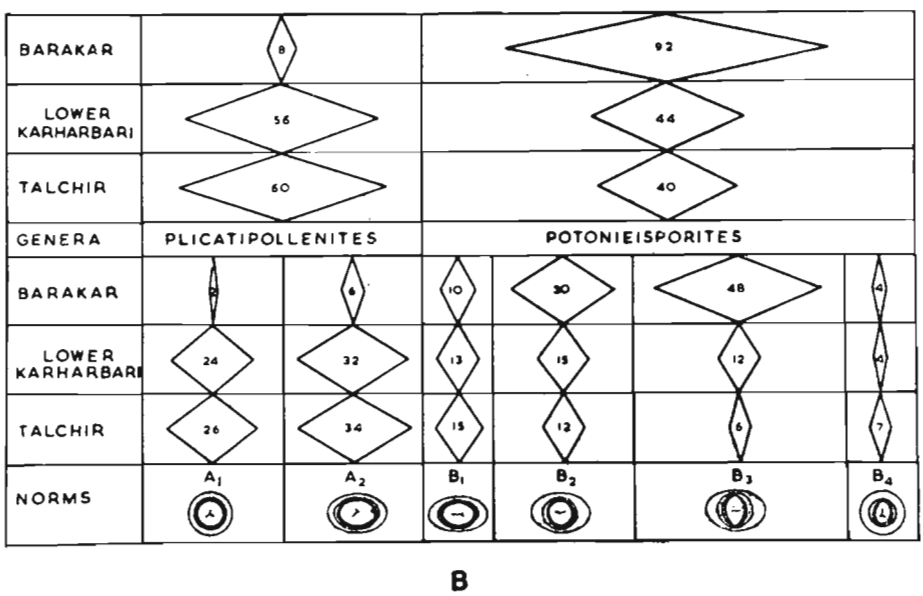
TEXT-FIG. 9 — Distribution trends of various norms of *Plicatipollenites* (A_1, A_2) and *Potonieisporites* (B_1, B_2, B_3, B_4) — **A**, in the Hutar Coalfield and **B**, in the Lower Gondwana beds (after Lele & Shukla, 1978).



TEXT-FIG. 10 — **A**, distribution trends of tetrad mark categories through time in the Hutar Coalfield — (1) monoletoid, (2) triletoid, (3) trilete, (4) monolete, and (5) bilete. **B**, distribution trends of tetrad mark categories in time — (1) trilete, (2) triletoid, (3) monoletoid, (4) bilete, and (5) monolete (after Lele & Shukla, 1978).

for the Lower Karharbari (Text-fig. 11). Similarly the distributional values of Norm B_1 (*Potonieisporites*) are not at all well-marked in stratigraphical time even in the general synthesis. Perhaps the best of the *Potonieisporites* Norms is B_3, followed by





TEXT-FIG. 11 — **A**, percentage frequency distribution of the norms of *Plicatipollenites* and *Potonieisporites* (after Lele & Shukla). **B**, percentage frequency distribution of *Plicatipollenites* and *Potonieisporites* and their respective norms through time in the Hutar Coalfield.

B_2, both of which show continuous rise in frequencies across time. In this respect the Hutar data fully agree with the general synthesis of Lele and Shukla (1978). Therefore, we are of the opinion that Norms B_2 and B_3 are more trustworthy forms for the biostratigraphical determinations than B_1 or B_4.

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EXPLANATION OF PLATE

(All figures are × 250 unless otherwise mentioned)

PLATE 1

1. *Plicatipollenites*, Norm A_1 (Deori Nala Section, Talchir Formation). Spore circularity ratio — (1·04). Body infold circularity ratio (1·04). Saccus spread value — Zero. Slide no. 6377.
2. *Plicatipollenites*, Norm A_1 (Deori Nala Section, Talchir Formation). Spore circularity ratio (1·1). Body infold circularity ratio (1·1). Saccus spread value (Zero). Slide no. 6394.
3. *Plicatipollenites* Norm A_1 (Deori Nala Section, Talchir Formation). Spore circularity ratio (1·1). Body infold circularity ratio (1·1). Saccus spread value (Zero). Slide no. 6394.
4. *Plicatipollenites* Norm A_1 (Deori Nala Section, Talchir Formation). Spore circularity ratio (1·05). Body infold circularity ratio (0·95). Saccus spread value (0·1). Slide no. 6390.
5. *Plicatipollenites* Norm A_2 (Deori Nala Section, Talchir Formation). Spore circularity ratio (1·45). Body infold circularity ratio (1·45). Saccus spread value (Zero). Slide no. 6394.
6. *Plicatipollenites* Norm A_2 (Deori Nala Section, Talchir Formation). Spore circularity ratio (1·34). Body infold circularity ratio (1·54). Saccus spread value (−0·2). Slide no. 6388.
7. *Plicatipollenites*, Norm A_2 (Deori Nala Section, Talchir Formation). Spore circularity ratio (1·14). Body infold circularity ratio (1·29). Saccus spread value (−0·15). Slide no. 6377.
8. *Potonieisporites* Norm B_1 (Deori Nala Section, Talchir Formation). Spore circularity ratio (1·21). Body infold circularity ratio (1·15). Saccus spread value (0·06). Slide no. 6377.
9. *Potonieisporites* Norm B_2 (Barakar Formation, Koel River Section). Spore circularity ratio (1·57); Infold circularity ratio (0·95); saccus spread value (0·62). Slide no. 6284.
10. *Potonieisporites* Norm B_2 (Barakar Formation, Koel River Section). Spore circularity ratio (1·46); Infold circularity ratio (1·04); Saccus spread value (0·42). × 500. Slide no. 6284.
11. *Potonieisporites* Norm B_3 (Barakar Formation; Koel River Section). Spore circularity ratio (1·2); infold circularity ratio (0·8); saccus spread value (0·4). Slide no. 6284.
12. *Potonieisporites* Norm B_3 (Barakar Formation, Koel River Section). Spore circularity ratio (1·44); infold circularity ratio (0·47); saccus spread value (0·97). × 500. Slide no. 6284.
13. *Potonieisporites* Norm B_3 (Karharbari Formation, Deori Nala Section). Spore circularity ratio (1·14); body infold circularity ratio (0.8); saccus spread value (0.34). Slide no. 6285.
14. *Potonieisporites* Norm B_3 (Karharbari Formation, Deori Nala Section). Spore circularity ratio (1·28); body infold circularity ratio (0·65); saccus spread value (0.63). × 500. Slide no. 6284.
15. *Potonieisporites* Norm B_4 (Barakar Formation, Koel River Section). Spore circularity ratio (1·05); body infold circularity ratio (0·6); saccus spread value (0·45). × 500. Slide no. 6286.
16. *Potonieisporites* Norm B_4 (Barakar Formation, Koel River Section). Spore circularity ratio (1·05); body infold circularity ratio (0·44); saccus spread value (0·61). × 500. Slide no. 6284.

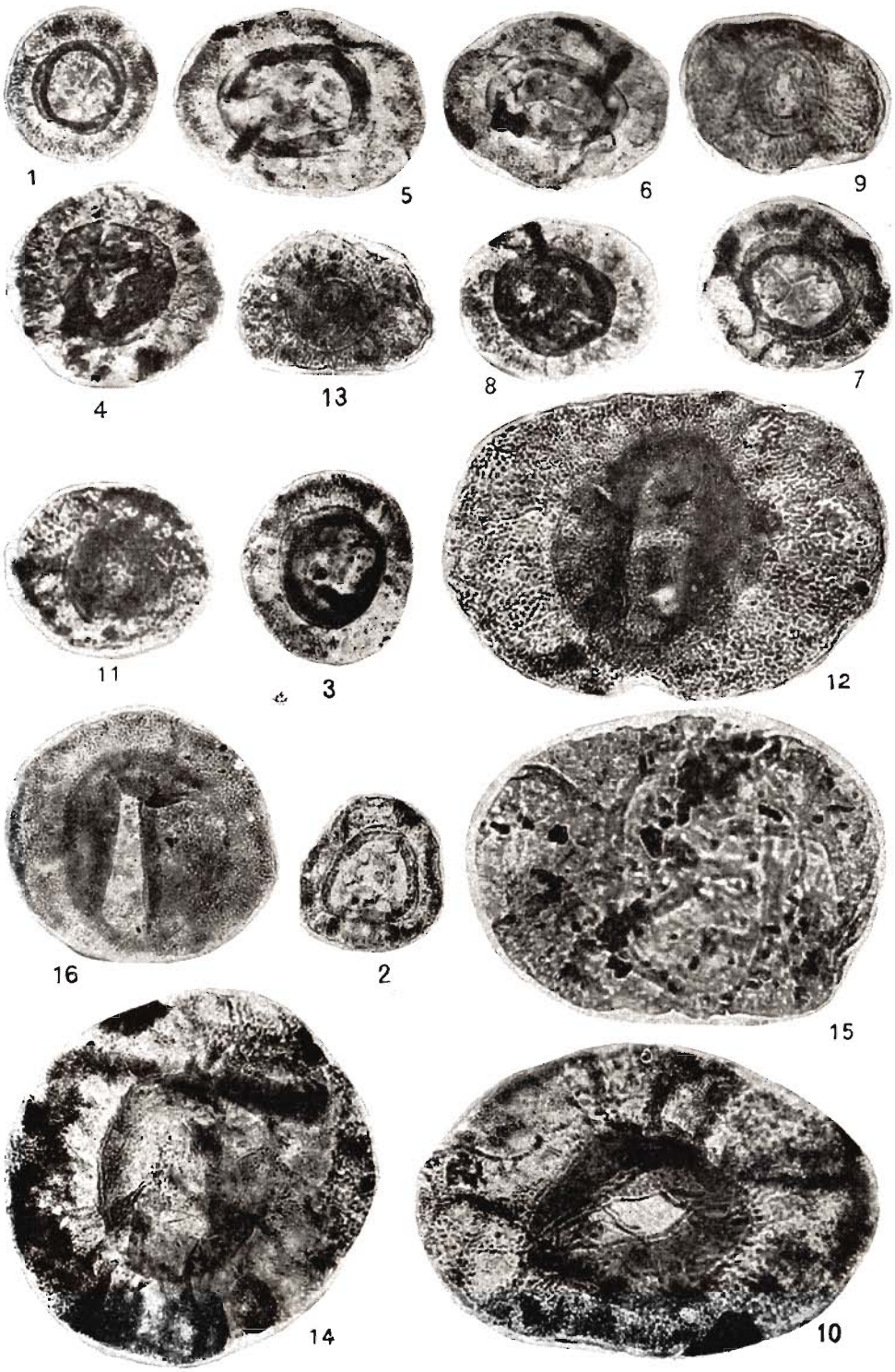

PLATE I