

SPOROLOGICAL STUDY OF SEAM VIII IN RANIGANJ COALFIELD, BIHAR (INDIA). PART II — DISTRIBUTION OF *SPORAE DISPERSAE* AND CORRELATION

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ABSTRACT

The seam VIII (Jambad Bowlah) of the Raniganj coalfield, Bihar, sampled at Bankola, Sunerpore, Jambad Kajora and East Jambad collieries in the eastern sector has been studied sporologically in detail. The distribution of the various spore genera and species represented in the seam has been given sample-wise. A comparison of the miospore assemblages, both qualitative as well as quantitative, from these samples shows a remarkable similarity thereby proving that the seam at the above collieries is one and the same. The homogeneity of the four collieries has also been proved statistically by the use of *Chi-square* test. These results are confirmatory to the geological correlation.

INTRODUCTION

THE first part of this paper (BHARAD. & SALUJHA, 1964) deals with the taxonomic aspect of the miofloral assemblage of the Jambad Bowlah seam at Bankola, Sunerpore, Jambad Kajora and East Jambad collieries, including therein a detailed description of the various genera and species. In this second part, a qualitative as well as quantitative analysis of the miospore assemblages recovered out of the Jambad Bowlah seam at each of the above collieries is made. On the basis of their miospore compositions the different collieries have been compared and qualitatively as well as quantitatively shown to be satisfactorily correlated.

MATERIAL AND METHODS

The procedure for the collection of coal samples and their maceration is as detailed by Bharadwaj (1962) and Bharadwaj & Salujha (1964). The geological sections of the seam at different collieries, the vertical gap in between the adjacent samples and their maceration numbers have been given in Table Nos. 1, 2, 3 & 4.

A total of 46 samples have been investigated, out of which 10 belong to Ban-

kola colliery and 12 each to Sunerpore, Jambad Kajora and East Jambad collieries. Usually 4-6 slides have been made for each sample. To ascertain the spore frequency, 300 specimens have been counted in each sample, the portions for the purpose having been selected at random from various parts of the slide. The frequency charts and spore histograms have been prepared to facilitate comparison of the spore flora of the Jambad Bowlah seam from the above collieries.

MIOSPORE DISTRIBUTION AND COMPARISON

The qualitative as well as quantitative distribution of the various genera and species in Bankola, Sunerpore, Jambad Kajora and East Jambad collieries appears to be almost the same. Sometimes differences have been noticed in their representation and the relative percentages but these are too small to elicit consideration. Some of the genera and species have shown a very meagre representation in one colliery and not encountered in the others. So also minor differences have been observed in their relative frequencies. The comparative qualitative and quantitative distribution of the various genera in each of the samples of the four collieries of the seam has been represented in Text-Fig. 1. The average frequencies of each of the genera in the Bankola, Sunerpore, Jambad Kajora and East Jambad collieries have been tabulated (Table 5).

In Table 5, (—) stands either for total absence of the genus in the seam from a particular colliery or at least its absence from the area of the slide selected for counting. At times, in such cases one or two specimens have been observed after an extensive scanning of a large number of slides. A qualitative and quantitative assessment of the spore complex from

Bankola, Sunkerpore, Jambad Kajora and East Jambad collieries shows that it is almost similar in all the collieries studied. The spore genera which are dominating in one colliery, also dominate in the other collieries. So also, the accessory genera are common to all the collieries. However, there are slight differences in the relative frequencies of some of the genera which are rare or very rare in the spore assemblages.

The genera dominating the miospore assemblage of all the four collieries are:

Cyclogranisporites
Horriditriletes
Thymospora
Striatites
Faunipollenites

Cyclogranisporites has almost a uniform quantitative distribution in all the four collieries, the maximum being in Sunkerpore colliery and the minimum in East Jambad colliery. The species of this genus recorded here are *C. gondwanensis* and *C. sp.* The latter species is very rare and has not been encountered in the countings of any colliery, so that the whole percentage of the genus in all the collieries is constituted by only one species i.e. *C. gondwanensis*.

Horriditriletes also, is nearly uniformly distributed in all the collieries. In Bankola colliery 5 species, *H. curvibaculosus*, *H. brevis*, *H. cf. H. ramosus*, *H. sp. A*, and *H. sp. B*, are represented. *H. curvibaculosus* and *H. sp. A*, contribute mainly to the percentage

TABLE 1 — BANKOLA COLLIERY

DESCRIPTION OF STRATA	Section of the Seam		Mac. No.		
	THICKNESS				
	Roof — Sandstone	Sample No.			
Thickness 8'-3½"	Coal	1'-3"	} 2'-3½"	Sample No. 10	282
	Stony coal (Inferior)	0'-4"			
	Coal	0'-8½"	} 3'-0"	Sample No. 9	281
	Coal	1'-10¼"			
	Shale	0'-¼"			
	Coal	1'-1½"			
Coal	3'-0"	Sample No. 8	280		
Thickness 8'-2"	Sandstone	7'-6"	Not sampled		
	Coal	0'-4"			
	Sandstone	0'-4"			
Thickness 19'-1½"	Coal	1'-1"	} 1'-4"	Sample No. 7	279
	Carbonaceous shale	0'-3"			
	Coal	1'-5½"	} 2'-9½"	Sample No. 6	278
	Shale	0'-1½"			
	Coal	0'-4½"			
	Stony Coal	0'-2"			
	Coal	0'-8½"	} 3'-0"	Sample No. 5	277
	Coal	0'-9½"			
	Carbonaceous shale	0'-3"			
	Coal	0'-3½"			
	Shale	0'-6½"			
	Coal	1'-1½"			
	Coal	3'-0"	Sample No. 4	276	
	Coal	3'-0"	Sample No. 3	275	
Coal	3'-0"	Sample No. 2	274		
Coal	3'-0"	Sample No. 1	273		

Floor — Carbonaceous Shale

TABLE 2 — SUNKERPORE COLLIERY

Section of the seam

DESCRIPTION OF STRATA	THICKNESS		MAC. No.	
	<i>Roof — Shale</i>	Sample No.		
Thickness 18'-7"	Coal with thin laminations of brights	3'-0"	Not sampled	
	Coal with thin laminations of brights	4'-0"	R/JB/S/T/12-(4'-0")	294
	Coal with brights	3'-0"	R/JB/S/T/11-(3'-0")	293
	Sandstone	0'-6"	Not sampled	
	Dull Coal	0'-6"		
	Sandstone	0'-7"		
	Coal with thin laminations of brights	0'-7½"	R/JB/S/M/10-(1'-6½")	292
	Shaly coal	0'-3"		
	Coal with brights	0'-8"		
	Shale	0'-3½"	R/JB/S/M/9-(2'-1")	291
	Coal with brights	1'-9½"		
	Shale	0'-1½"	R/JB/S/M/8-(3'-4½")	290
Coal with brights	0'-5"			
Shaly coal	0'-2½"			
Coal with brights	1'-8½"			
Dull coal	0'-2"			
Coal with brights	0'-9"			
Bottom Sec- tion 18'-1"	Shale	0'-7"	R/JB/S/B/7-(1'-8")	289
	Coal with thin laminations of brights	1'-1"		
	do	0'-9½"	R/JB/S/B/6-(3'-0")	288
	Shaly coal	0'-4½"		
	Coal with brights	1'-10"		
	Shale	0'-3"	R/JB/S/B/5-(1'-5")	287
	Coal with thin laminations of brights	1'-2"		
	do	0'-7"	R/JB/S/B/4-(3'-0")	286
	Shaly coal	0'-4"		
	Coal with brights	2'-1"		
do	3'-0"	R/JB/S/B/3-(3'-0")	285	
do	3'-0"	R/JB/S/B/2-(3'-0")	284	
do	3'-0"	R/JB/S/B/1-(3'-0")	283	

Floor — Shale

TABLE 3 — JAMBAD KAJORA COLLIERY
Section of the seam

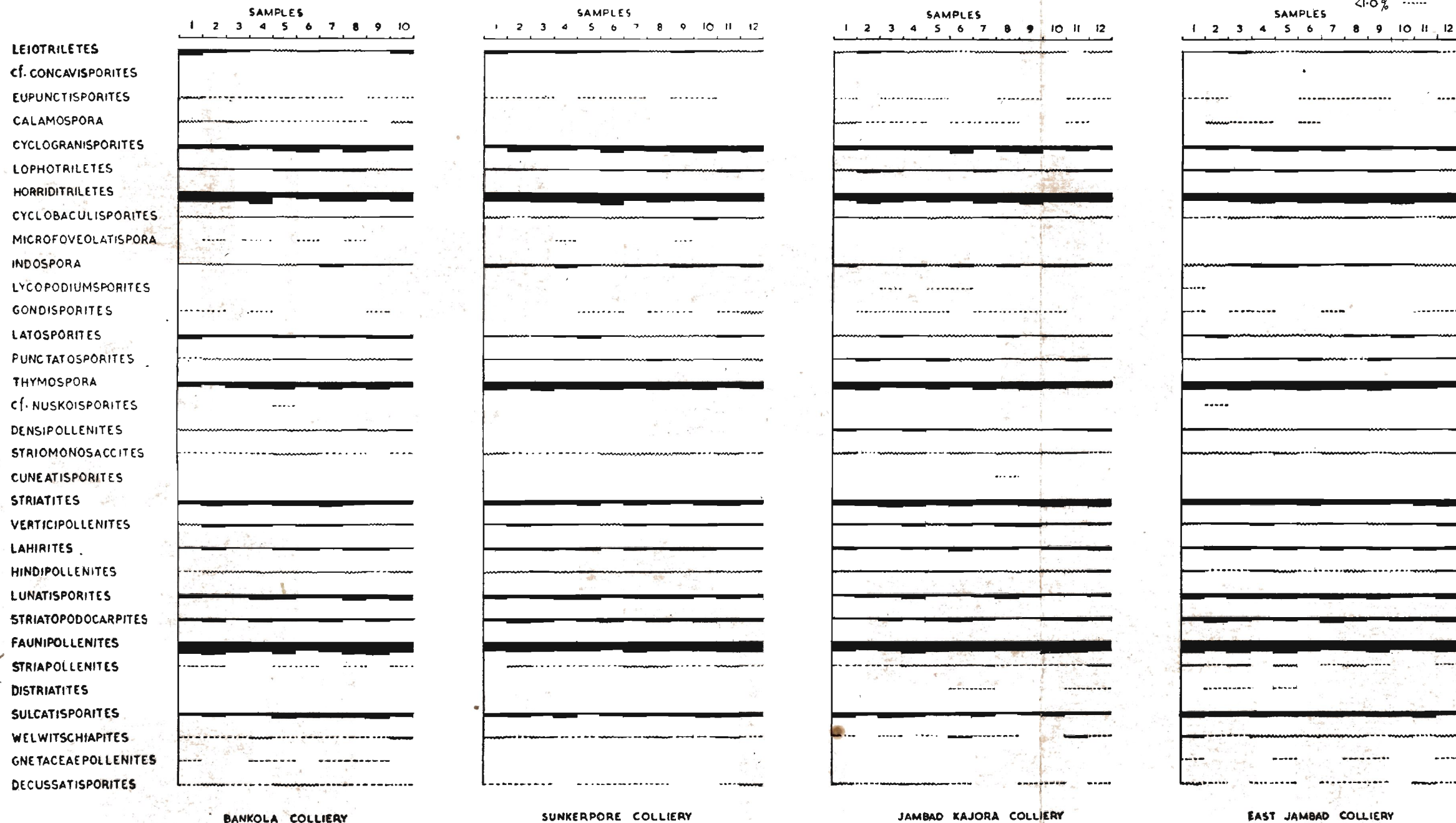
DESCRIPTION OF STRATA		THICKNESS	MAC. No.
<i>Roof — Dull coal 3'-0" (Approx.) Not sampled</i>			
Thickness 12'-0"	{ Coal	7'-0"	Top Section
	{ Shale	0'- $\frac{1}{2}$ "	
	{ Coal	0'-9"	
	{ Shale	0'- $\frac{1}{2}$ "	
	{ Coal	4'-2 $\frac{1}{2}$ "	
		<i>Sandstone 1'-0"</i>	Not sampled
Thickness 23'-7"	{ Coal	0'-5"	Bottom Section
	{ Carbonaceous shale	0'-2 $\frac{1}{2}$ "	
	{ Coal	1'-10"	
	{ Shaly coal	0'-3"	
	{ Coal	1'-7 $\frac{1}{2}$ "	
	{ Carbonaceous shale	0'-1 $\frac{1}{2}$ "	
	{ Coal	0'-5 $\frac{1}{2}$ "	
	{ Shaly coal	0'-2"	
	{ Coal	1'-10"	
	{ Shaly coal	0'-6"	
	{ Coal	0'-2 $\frac{1}{2}$ "	
	{ Carbonaceous shale	0'-5 $\frac{1}{2}$ "	
	{ Coal	3'-10"	
{ Carbonaceous shale	0'-3"		
{ Coal	11'-5"		
<i>Floor — Argillaceous sandstone (contains Carbonaceous matter too)</i>			

TABLE 4 — EAST JAMBAD COLLIERY

Section of the seam

DESCRIPTION OF STRATA		THICKNESS	MAC. No.
<i>Roof — Sandstone</i>			
Thickness 36'-0"	{ Coal	4'-0"	Samples were not collected from this 4' coal.
	{ Shale	0'-5"	
	{ Coal	7'-1 $\frac{1}{4}$ "	
	{ Shale	0'- $\frac{1}{2}$ "	
	{ Coal	0'-6"	Samples for every 3' of coal have been collected separately. Samples from the top 4' coal could not be obtained as the dressing of this coal could not be done owing to very bad roof.
	{ Shale	0'- $\frac{1}{2}$ "	
	{ Coal	4'-3"	
	{ Shale	0'-5"	
	{ Coal	0'-5"	
	{ Shale	0'-2"	
	{ Coal	2'-5"	
	{ Shale	0'-3 $\frac{1}{2}$ "	
	{ Coal	1'-7"	
	{ Shale	0'-2"	
	{ Coal	0'-3"	
	{ Shale	0'-4"	
	{ Coal	1'-9"	
	{ Shale	0'-4"	
	{ Coal	0'-1 $\frac{1}{2}$ "	
	{ Shale	0'-3 $\frac{1}{4}$ "	
{ Coal	3'-0"		
{ Shaly coal	0'-1 $\frac{1}{2}$ "		
{ Coal	12'-0"		
<i>Floor — Shale</i>			

SAMPLE TO SAMPLE DISTRIBUTION OF THE VARIOUS GENERA REPRESENTED IN THE DIFFRENT COLLIERIES OF THE
JAMBAD BOWLAH SEAM



TEXT-FIG. 1—Frequency diagram showing sample to sample distribution of the various genera in the Bankola, Sunkerpore, Jambad Kajora and East Jambad collieries of the Jambad Bowlah seam.

TABLE 5—RELATIVE PERCENTAGES OF THE VARIOUS GENERA IN THE DIFFERENT COLLIERIES OF JAMBAD BOWLAH SEAM

GENERA	BANKOLA COLL.	SUNKERPORE COLL.	JAMBAD KAJORA COLL.	EAST JAMBAD COLL.
<i>Leiotriletes</i>	3.60	2.83	1.56	1.80
cf. <i>Concavisporites</i>	0.20	0.10	—	0.10
<i>Eupunctisporites</i>	0.40	0.26	0.30	0.10
<i>Calamospora</i>	0.50	0.04	0.39	0.53
<i>Cyclogranisporites</i>	8.50	8.70	7.23	6.23
<i>Lophotriletes</i>	2.70	2.40	2.80	2.50
<i>Horriditriletes</i>	15.60	12.96	5.10	13.23
<i>Cyclobaculisporites</i>	1.70	1.96	1.86	1.16
<i>Microfoveolatispora</i>	0.10	0.05	—	—
<i>Indospora</i>	2.50	3.36	2.66	2.30
<i>Lycopodiumsporites</i>	—	—	0.06	0.02
<i>Gondisporites</i>	0.13	0.30	0.30	0.28
<i>Latosporites</i>	4.26	2.50	1.83	2.03
<i>Punctatosporites</i>	1.70	2.03	2.16	2.23
<i>Thymospora</i>	11.00	10.66	12.16	9.66
cf. <i>Nuskosporites</i>	—	—	—	0.02
<i>Densipollenites</i>	1.60	1.93	2.23	2.20
<i>Striomonosaccites</i>	0.63	0.76	1.10	1.20
<i>Cuneatisporites</i>	—	—	0.02	—
<i>Striatites</i>	7.50	7.10	8.90	8.20
<i>Verticipollenites</i>	2.90	2.76	2.70	2.40
<i>Lahirites</i>	3.13	4.00	4.03	4.14
<i>Hindipollenites</i>	1.26	1.73	1.63	1.23
<i>Lunatisporites</i>	4.80	5.40	4.20	6.80
<i>Striatopodocarpites</i>	3.60	4.80	3.50	5.70
<i>Faunipollenites</i>	14.10	16.40	15.35	17.10
<i>Striapollenites</i>	0.21	0.40	0.76	0.65
<i>Distriatites</i>	—	—	0.09	0.07
<i>Sulcatisporites</i>	5.90	5.46	6.12	6.33
<i>Welwitschiapites</i>	0.60	0.70	0.40	1.10
<i>Gnetaceapollenites</i>	0.20	—	—	0.20
<i>Decussatisporites</i>	0.66	0.43	0.56	0.46

of the genus. *H. brevis* has a poor occurrence. *H. sp. B*, is represented by a single specimen. In Sunkeppore, Jambad Kajora and East Jambad collieries only 2 species, *H. curvibaculosus* and *H. sp. A*, are represented. *H. brevis* which is rare in Bankola colliery, appears to be absent in these collieries.

The average frequencies of *Thymospora* in the various collieries are nearly uniform, the variation in them being of 2.5 per cent. In all the above collieries the genus shows up itself by only one species, *T. gondwanensis*.

Striatites, a disaccate genus, has the average percentages of 7.5 per cent in Bankola, 7.1 per cent in Sunkeppore, 8.9 per cent in Jambad Kajora and 8.2 per cent in East Jambad collieries. The species of this genus represented in the seam are listed below:

- Striatites notus*
- S. rhombicus*
- S. subtilis*
- S. obtusus*
- S. solitus*
- S. communis*

It is observed that the above species occur in all the collieries of the seam. The species *S. rhombicus*, *S. subtilis* and *S. obtusus* are comparatively more commonly represented. The remaining species of the genus have scanty representation.

Of all the dominant genera, *Faunipollenites* is the most represented. The average frequencies of the genus in Bankola, Sunkeppore, Jambad Kajora and East Jambad collieries are 16.43, 14.83, 15.3 and 16.13 per cent respectively. It is represented by three species:

- Faunipollenites varius*
- F. sp. A*
- F. sp. B*

Out of all the species *F. sp. A*, has the maximum distribution. *F. varius* is fairly represented in all the collieries and *F. sp. B*, being very rare, is recorded from the Bankola colliery only.

The accessory genera commonly represented in the different collieries of the seam are listed below:

- Leiotriletes*
- Lophotriletes*
- Cyclobaculisporites*
- Indospora*
- Latosporites*
- Punctatosporites*
- Densipollenites*
- Verticillipollenites*

- Lahirites*
- Hindipollenites*
- Lunatisporites*
- Striatopodocarpites*
- Sulcatissporites*

Leiotriletes is represented by a single species *L. sp.* in all the four collieries. It has its maximum frequency in Bankola colliery and the minimum in Jambad Kajora colliery.

Lophotriletes is fairly and almost uniformly represented in all the four collieries. The genus is represented by the following 4 species:

- Lophotriletes rectus*
- L. sp.*
- cf. *L. pseudogranus*
- cf. *L. rarus*

L. rectus is the most common and thus a representative species of the genus occurring consistently in all the collieries. The other species have a very meagre and irregular representation.

Cyclobaculisporites, like other genera, also has almost a uniform occurrence in all the collieries of the seam and is represented by two species i.e. *C. indicus* and *C. minutus*. The former species is comparatively abundantly represented than the later.

Indospora has the average frequencies of 2.5, 3.36, 2.66 and 2.3 per cent in Bankola, Sunkeppore, Jambad Kajora and East Jambad collieries respectively. Following species of the genus have been recorded:

- Indospora laevigata*
- I. macula*
- I. sp.*

I. sp., constitutes the bulk of the total percentage of the genus and thus, is the representative species. *I. laevigata* and *I. macula* are rather poorly represented throughout the seam.

Latosporites is represented by two species, *L. colliensis* and *L. sp.* The former species is abundantly represented and thus constitutes the bulk of the average percentage of the genus. *L. sp.*, represented by only 1-2 specimens from East Jambad colliery and thus has not been recorded in counting.

Punctatosporites occurs nearly uniformly in all the collieries. Throughout the seam the genus is represented by a single species *P. sp.*

Densipollenites has the maximum distribution in Jambad Kajora colliery and the

minimum in Bankola colliery. It is represented by the following three species:

Densipollenites indicus

D. invisus

D. sp.

Out of these species, *D. invisus* and *D. sp.*, are encountered from all the collieries of the seam, whereas *D. indicus*, comparatively poor in occurrence, is restricted to Sunerpore, Jambad Kajora and East Jambad collieries only.

Verticipollenites is almost uniformly distributed throughout the seam. The various species of the genus met with in this assemblage have been tabulated here:

Verticipollenites crassus

V. finitimus

V. subcircularis

V. gibbosus

The above species are represented in all the collieries of the seam. *V. finitimus* and *V. subcircularis* are richer in distribution than *V. crassus* and *V. gibbosus*.

Lahirites is almost uniformly distributed in the seam at different collieries. The species of this genus recorded here are as follows:

Lahirites singularis

L. incertus

L. rotundus

L. rarus

L. parvus

L. sp.

Lahirites singularis, *L. incertus* and *L. rarus* occur comparatively more frequently than the remaining species.

Hindipollenites is almost uniformly distributed throughout the seam at different collieries. The genus is represented by two species both occurring along the whole length of the seam. They are:

Hindipollenites indicus

H. oblongus

Out of these species *H. indicus* is well represented in all the collieries of the seam, *H. oblongus* being rather poorly distributed.

Lunatisporites has the average distribution percentages of 4.8, 5.4, 4.2 and 6.8 per cent in Bankola, Sunerpore, Jambad Kajora and East Jambad collieries. Throughout the seam the genus is represented by 3 species:

Lunatisporites fuscus

L. sp. A

L. sp. B

Out of these species *L. sp. A*, and *L. sp. B*, are comparatively abundantly represented than *L. fuscus*.

Striatopodocarpites has the maximum distribution (5.7%) in East Jambad colliery and the minimum (3.5%) in Jambad Kajora colliery. Bankola and Sunerpore collieries have the average percentages of 3.6 and 4.8 per cent respectively. The genus is represented by the following 3 species:

Striatopodocarpites decorus

S. magnificus

S. diffusus

The first species is comparatively richly represented than the other two species.

Sulcatisporites is represented by the following 3 species in the present assemblage:

Sulcatisporites ovatus

S. sp. A

S. sp. B

Sulcatisporites ovatus occurs in abundance along the whole length of the seam. *S. sp. A*, although occurs in all the collieries of the seam, yet its representation is very meagre. The other, *S. sp. B*, is recorded only from Sunerpore, Jambad Kajora and East Jambad collieries. It appears to be absent in Bankola colliery.

The genera listed below are rare in their occurrence having an average frequency of about 1.0 per cent or less:

cf. *Concavisporites*

Eupunctisporites

Calamospora

Microfoveolatispora

Lycopodiumsporites

Gondisporites

cf. *Nuskosporites*

Striomonosaccites

Cuneatisporites

Striapollenites

Distriatites

Welwitschiapites

cf. *Decussatisporites*

cf. *Concavisporites* is poorly represented in Bankola, Sunerpore and East Jambad collieries but absent in Jambad Kajora colliery. In the various collieries the genus is represented by a single species, cf. *C. bankolensis*.

Eupunctisporites is represented by two species, *E. gravus* and *E. sp.* Out of these, *E. gravus* alone constitutes the whole percentage of the genus given above in the four collieries. *E. sp.*, is very very rare and has not been encountered in the countings.

Calamospora is represented by two species, *C. aplata* and *C. exila*. The former species is abundantly and almost uniformly represented throughout the seam whereas the

latter species has a very meagre representation, met with only as stray specimens.

Lycopodiumsporites is represented by 2-3 specimens only along the whole length of the seam. These specimens have been referred to *L. sp.*

Gondisporites is almost equally represented in all the collieries and is met with as a single species *G. sp.*

Nuskoidsporites with 2 species, cf. *N. triangularis* and cf. *N. reticulatus*, is met with only as stray specimens.

Striomonosaccites is almost uniformly distributed throughout the seam. The only species of the genus represented here is *S. circularis*. It has the maximum distribution (1.2%) in East Jambad colliery and the minimum (0.63%) in Bankola colliery.

Striapollenites is recorded along the whole length of the seam, its average frequencies being 0.21, 0.4, 0.76 and 0.65 per cent in Bankola, Sunkerpore, Jambad Kajora and East Jambad collieries respectively. The species of the genus represented here are as follows:

- Striapollenites saccatus*
- S. obliquus*
- S. sp.*

The distribution of almost all the species is very meagre and only very few specimens of each have been recovered from the whole assemblage.

Distriatites is recorded only from Jambad Kajora and East Jambad collieries of the seam; the species represented are *D. insolitus* and *D. sp.*

Welwitschiapites is represented by two species, *W. tenuis* and *W. extansus*. *W. tenuis* is abundantly distributed along the whole length of the seam. *E. extansus* is represented by only 3 specimens recovered out of Bankola and Sunkerpore collieries but they have not been encountered in the countings. So the total average percentages of the genus in the different collieries of the seam are constituted by *W. tenuis* alone.

Decussatisporites is poorly represented and is met with as a single species, cf. *D. lucifer* in all the collieries of the seam.

The remaining genera are very poorly represented so much so that most of them have often not been encountered in the counting. Such genera are listed below:

- Retusotriletes*
- Ricaspora*
- Dictyotriletes*
- Microfoveolatispora*

Cuneatisporites

Platysaccus

Vesicaspora

cf. *Gnetaceapollenites*

A comparative study of the spore assemblages from the four collieries, which has been dealt with in the foregoing pages, shows great uniformity in them. The dominant and the accessory spore genera have nearly the same percentages in all the collieries, but for minor variations. The distribution of rare and very rare genera is uniformly so in all the collieries although most of the very rare ones do not figure in the countings. In rare and very rare genera it is always possible that in some countings they are recorded and in others they are absent in the areas selected for counting. The similarity in the mioflora of the different collieries is represented by the composite histogram (TEXT-FIG. 2) wherein the average percentages of all the genera recorded from the different collieries have been plotted.

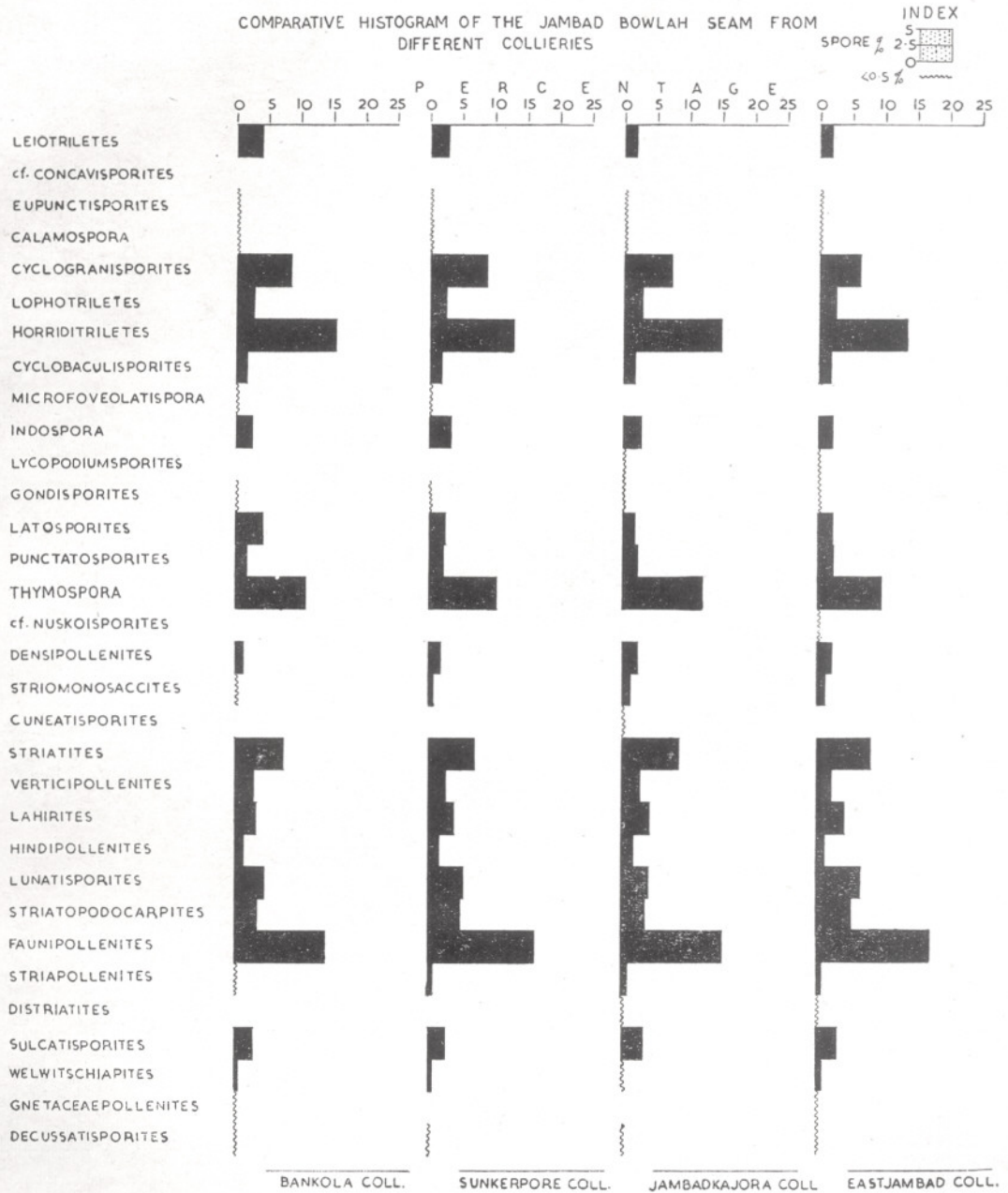
The sporological similarity between the different collieries is not only at generic level but also at the specific level. Most of the species of dominant and sub-dominant genera are common among these collieries. Only very few species show an irregular distribution, but they are either rare or very rare ones whose rarity might itself be the cause of irregularity in distribution.

Some species represented here must be exclusively characteristic of the Jambad-Bowlah seam individually as well as collectively constituting the index species or group of species. However, this will be known only when all the other seams in the succession of Raniganj coalfield have been sporologically studied and the vertical distribution of each species has been ascertained.

STATISTICAL

Recently Gray and Guannel (1961) have tried to apply a statistical test for the stratigraphic correlation of coal beds. They advocate the use of *Chi-square* test to indicate the differential or homogeneous nature of coal samples.

With a view to corroborate our sporological conclusions on the homotaxial nature of Bankola, Sunkerpore, Jambad Kajora and East Jambad collieries the *Chi-square* test has been also applied here. For this purpose the large number of spore genera represented in the seam have been reduced



TEXT-FIG. 2—Histogram showing the average percentages of the various genera in Jambad Bowlah seam, from Bankola, Sunkerpore, Jambad Kajora and East Jambad collieries.

into groups by combining some of the morphologically similar spore genera or those very meagrely represented. Thus, 18 spore groups have been considered for *Chi-square* test as given in Tables A, B, C, D for the different collieries.

The observed frequencies (f) of each of the 18 spore groups in the four collieries A (Bankola coll.), B (Sunkerpore coll.), C (Jambad Kajora coll.) and D (East Jambad coll.), along with the corresponding expected frequencies (F) calculated by summing up

TABLE A — COMBINATION OF MIOSPORE GENERA FOR STATISTICAL PURPOSES

Bankola Colliery

GENUS	AVERAGE FREQUENCY (percent)	SPORE GROUP	GENUS	AVERAGE FREQUENCY (percent)
<i>Leiotriletes</i>	3.60	1.	<i>Leiotriletes</i>	3.60
<i>Eupunctisporites</i> <i>Cyclobaculisporites</i>	0.40 1.70	2.	<i>Cyclobaculisporites</i>	2.10
<i>Cyclogranisporites</i>	8.50	3.	<i>Cyclogranisporites</i>	8.50
<i>Lophotriletes</i>	2.70	4.	<i>Lophotriletes</i>	2.70
<i>Horriditriletes</i>	15.60	5.	<i>Horriditriletes</i>	15.60
<i>Indospora</i>	2.50	6.	<i>Indospora</i>	2.50
<i>Latosporites</i>	4.26	7.	<i>Latosporites</i>	4.26
<i>Punctatosporites</i>	1.70	8.	<i>Punctatosporites</i>	1.70
<i>Thymospora</i>	11.00	9.	<i>Thymospora</i>	11.00
<i>Densipollenites</i>	1.60	10.	<i>Densipollenites</i>	1.60
<i>Striomonosaccites</i>	0.63	11.	<i>Striomonosaccites</i>	0.63
<i>Striatites</i> <i>Verticypollenites</i>	7.50 2.90	12.	<i>Striatites</i>	10.40
<i>Lahirites</i> <i>Hindipollenites</i>	3.13 1.26	13.	<i>Lahirites</i>	4.39
<i>Lunatisporites</i> <i>Striatopodocarpites</i>	3.60 4.80	14.	<i>Lunatisporites</i>	8.40
<i>Faunipollenites</i>	14.10	15.	<i>Faunipollenites</i>	14.10
<i>Sulcatisporites</i>	5.90	16.	<i>Sulcatisporites</i>	5.90
<i>Welwitschiapites</i> <i>Gnetaceapollenites</i> <i>Decussatisporites</i>	0.60 0.20 0.66	17.	<i>Welwitschiapites</i>	1.46
cf. <i>Concavisporites</i> <i>Calamospora</i> <i>Microfoveolatispora</i> <i>Lycopodiumsporites</i> <i>Gondisporites</i> cf. <i>Nuskosporites</i> <i>Cuneatisporites</i> <i>Striapollenites</i> <i>Distriatites</i>	0.20 0.50 0.10 — 0.13 — — 0.21 —	18.	All others	1.14

TABLE B — COMBINATION OF MIOSPORE GENERA FOR STATISTICAL PURPOSES

Sunkerpore Colliery

GENUS	AVERAGE FREQUENCY (percent)	SPORE GROUP	GENUS	AVERAGE FREQUENCY (percent)
<i>Leiotriletes</i>	2.83	1.	<i>Leiotriletes</i>	2.83
<i>Eupunctisporites</i> <i>Cyclobaculisporites</i>	0.26 } 1.96 }	2.	<i>Cyclobaculisporites</i>	2.22
<i>Cyclogranisporites</i>	8.70	3.	<i>Cyclogranisporites</i>	8.70
<i>Lophotriletes</i>	2.40	4.	<i>Lophotriletes</i>	2.40
<i>Horriditriletes</i>	12.96	5.	<i>Horriditriletes</i>	12.96
<i>Indospora</i>	3.36	6.	<i>Indospora</i>	3.36
<i>Latosporites</i>	2.50	7.	<i>Latosporites</i>	2.50
<i>Punctatosporites</i>	2.03	8.	<i>Punctatosporites</i>	2.03
<i>Thymospora</i>	10.66	9.	<i>Thymospora</i>	10.66
<i>Densipollenites</i>	1.93	10.	<i>Densipollenites</i>	1.93
<i>Striomonosaccites</i>	0.76	11.	<i>Striomonosaccites</i>	0.76
<i>Striatites</i> <i>Verticipoilenites</i>	7.10 } 2.76 }	12.	<i>Striatites</i>	9.86
<i>Lahirites</i> <i>Hindipollenites</i>	4.00 } 1.73 }	13.	<i>Lahirites</i>	5.73
<i>Lunatisporites</i> <i>Striatopodocarpites</i>	5.40 } 4.80 }	14.	<i>Lunatisporites</i>	10.20
<i>Faunipollenites</i>	16.40	15.	<i>Faunipollenites</i>	16.40
<i>Sulcatisporites</i>	5.46	16.	<i>Sulcatisporites</i>	5.46
<i>Welwitschiapites</i> <i>Gnetaceapollenites</i> cf. <i>Decussatisporites</i>	0.70 } — } 0.43 }	17.	<i>Welwitschiapites</i>	1.13
cf. <i>Concavisporites</i> <i>Calamospora</i> <i>Microfoveolatispora</i> <i>Lycopodiumsporites</i> <i>Gondisporites</i> cf. <i>Nuskoisporites</i> <i>Cuneatisporites</i> <i>Striapollenites</i> <i>Distriatites</i>	0.10 } 0.04 } 0.05 } — } 0.30 } — } — } 0.40 } — }	18.	All others	0.89

TABLE C — COMBINATION OF MIOSPORE GENERA FOR STATISTICAL PURPOSES

Jambad Kajora Colliery

GENUS	AVERAGE FREQUENCY (percent)	SPORE GROUP	GENUS	AVERAGE FREQUENCY (percent)
<i>Leiotriletes</i>	1.56	1.	<i>Leiotriletes</i>	1.56
<i>Eupunctisporites</i> <i>Cyclobaculisporites</i>	0.30 } 1.86 }	2.	<i>Cyclobaculisporites</i>	2.16
<i>Cyclogranisporites</i>	7.23	3.	<i>Cyclogranisporites</i>	7.23
<i>Lophotriletes</i>	2.80	4.	<i>Lophotriletes</i>	2.80
<i>Horriditriletes</i>	15.10	5.	<i>Horriditriletes</i>	15.10
<i>Indospora</i>	2.66	6.	<i>Indospora</i>	2.66
<i>Latosporites</i>	1.83	7.	<i>Latosporites</i>	1.83
<i>Punctatosporites</i>	2.16	8.	<i>Punctatosporites</i>	2.16
<i>Thymospora</i>	12.16	9.	<i>Thymospora</i>	12.16
<i>Densipollenites</i>	2.23	10.	<i>Densipollenites</i>	2.23
<i>Striomonosaccites</i>	1.10	11.	<i>Striomonosaccites</i>	1.10
<i>Striatites</i> <i>Verticipollenites</i>	8.90 } 2.70 }	12.	<i>Striatites</i>	11.60
<i>Lahirites</i> <i>Hindipollenites</i>	4.03 } 1.63 }	13.	<i>Lahirites</i>	5.66
<i>Lunatisporites</i> <i>Striatopodocarpites</i>	4.20 } 3.50 }	14.	<i>Lunatisporites</i>	7.70
<i>Faunipollenites</i>	15.30	15.	<i>Faunipollenites</i>	15.30
<i>Sulcatisporites</i>	6.12	16.	<i>Sulcatisporites</i>	6.12
<i>Welwitschiapites</i> <i>Gnetaceapollenites</i> cf. <i>Decussatisporites</i>	0.40 } — } 0.56 }	17.	<i>Welwitschiapites</i>	0.96
cf. <i>Concavisporites</i> <i>Calamospora</i> <i>Microfoveolatispora</i> <i>Lycopodiumsporites</i> <i>Gondisporites</i> cf. <i>Nuskisporites</i> <i>Cuneatisporites</i> <i>Striapollenites</i> <i>Distriatites</i>	— } 0.39 } — } 0.06 } 0.30 } — } 0.02 } 0.76 } 0.09 }	18.	All others	1.62

TABLE D — COMBINATION OF MIOSPORE GENERA FOR STATISTICAL PURPOSES

East Jambad Colliery

GENUS	AVERAGE FREQUENCY (percent)	SPORE GROUP	GENUS	AVERAGE FREQUENCY (percent)
<i>Leiotriletes</i>	1.80	1.	<i>Leiotriletes</i>	1.80
<i>Eupunctisporites</i> <i>Cyclobaculisporites</i>	0.10 } 1.16 }	2.	<i>Cyclobaculisporites</i>	1.26
<i>Cyclogranisporites</i>	6.23	3.	<i>Cyclogranisporites</i>	6.23
<i>Lophotriletes</i>	2.50	4.	<i>Lophotriletes</i>	2.50
<i>Horriditriletes</i>	13.23	5.	<i>Horriditriletes</i>	13.23
<i>Indospora</i>	2.30	6.	<i>Indospora</i>	2.30
<i>Latosporites</i>	2.03	7.	<i>Latosporites</i>	2.03
<i>Punctatosporites</i>	2.23	8.	<i>Punctatosporites</i>	2.23
<i>Thymospora</i>	9.66	9.	<i>Thymospora</i>	9.66
<i>Densipollenites</i>	2.20	10.	<i>Densipollenites</i>	2.20
<i>Striomonosaccites</i>	1.20	11.	<i>Striomonosaccites</i>	1.20
<i>Striatites</i> <i>Verticypollenites</i>	8.20 } 2.40 }	12.	<i>Striatites</i>	10.60
<i>Lahirites</i> <i>Hindipollenites</i>	4.14 } 1.23 }	13.	<i>Lahirites</i>	5.37
<i>Lunatisporites</i> <i>Striatopodocarpites</i>	6.80 } 5.70 }	14.	<i>Lunatisporites</i>	12.50
<i>Faunipollenites</i>	17.10	15.	<i>Faunipollenites</i>	17.10
<i>Sulcatisporites</i>	6.33	16.	<i>Sulcatisporites</i>	6.33
<i>Welwitschiapites</i> <i>Gnetaceapollenites</i> cf. <i>Decussatisporites</i>	1.10 } 0.20 } 0.46 }	17.	<i>Welwitschiapites</i>	1.76
cf. <i>Concavisporites</i> <i>Calamospora</i> <i>Microfoveolatispora</i> <i>Lycopodiumsporites</i> <i>Gondisporites</i> cf. <i>Nuskosporites</i> <i>Cuneatisporites</i> <i>Striapollenites</i> <i>Distriatites</i>	0.10 } 0.53 } — } 0.02 } 0.28 } 0.02 } — } 0.65 } 0.07 }	18.	All others	1.67

TABLE E—COMPUTATION OF SPORE GROUPS

FREQUENCY	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	TOTAL
Observed f(A)	11	6	26	8	47	8	13	5	33	5	2	31	13	25	42	18	4	3	300
Expected F(A)	7.25	5.75	23.25	7.75	42.5	8.25	8.0	6.25	32.25	6.25	2.75	32.0	15.75	29.0	47.0	18.0	3.75	4.0	300
Observed f(B)	8	7	26	7	39	10	8	6	32	6	2	30	17	31	49	16	3	3	300
Expected F(B)	7.25	5.75	23.25	7.75	42.5	8.25	8.0	6.25	32.25	6.25	2.75	32.0	15.75	29.0	47.0	18.0	3.75	4.0	300
Observed f(C)	5	6	22	8	45	8	5	7	36	7	3	35	17	23	46	19	3	5	300
Expected F(C)	7.25	5.75	23.25	7.75	42.5	8.25	8.0	6.25	32.25	6.25	2.75	32.0	15.75	29.0	47.0	18.0	3.75	4.0	300
Observed f(D)	5	4	19	8	39	7	6	7	29	7	4	32	16	37	51	19	5	5	300
Expected F(D)	7.25	5.75	23.25	7.75	42.5	8.25	8.0	6.25	32.25	6.25	2.75	32.0	15.75	29.0	47.0	18.0	3.75	4.0	300
Specimens observed	29	23	93	31	170	33	32	25	130	25	11	128	63	116	188	72	15	16	1200

the observed frequencies multiplied by the number of counts in one colliery divided by the total number of counts from the four collieries briefly put as:

$$F = (fA + fB + fC + fD) \times \frac{300}{1200}$$

where F is the expected frequency and fA, fB, fC and fD denote the observed frequencies in the four collieries, has been given in Table E.

Having calculated the value of expected frequencies (F), the value of the *Chi*-square (χ^2) has been computed according to the following formula:

$$\chi^2 = \frac{(f-F)^2}{F}$$

$$\begin{aligned} \text{Thus } -\chi^2 &= \frac{3.75^2}{7.25} + \frac{0.25^2}{5.75} + \frac{2.75^2}{23.25} + \\ &\frac{0.25^2}{7.75} + \frac{4.5^2}{42.5} + \frac{0.25^2}{8.25} + \frac{5^2}{8} + \frac{1.25^2}{6.25} + \frac{0.5^2}{33.5} \\ &+ \frac{1.25^2}{6.25} + \frac{0.75^2}{2.75} + \frac{1^2}{32} + \frac{2.75^2}{15.75} + \frac{4^2}{29} + \frac{5^2}{47} + \\ &\frac{0^2}{18} + \frac{0.25^2}{3.75} + \frac{1^2}{4} + \frac{0.75^2}{7.25} + \frac{1.25^2}{5.75} + \frac{2.75^2}{23.25} + \\ &\frac{0.75^2}{7.75} + \frac{3.5^2}{42} + \frac{1.75^2}{8.25} + \frac{0^2}{8} + \frac{0.25^2}{6.25} + \frac{0.25^2}{32.5} \\ &+ \frac{0.25^2}{6.25} + \frac{0.75^2}{2.75} + \frac{2^2}{32} + \frac{1.25^2}{15.75} + \frac{2^2}{29} + \frac{2^2}{47} + \\ &\frac{2^2}{18} + \frac{0.75^2}{3.75} + \frac{1^2}{4} + \frac{2.25^2}{7.25} + \frac{0.25^2}{5.75} + \frac{1.25^2}{23.25} \\ &+ \frac{0.25^2}{7.75} + \frac{2.5^2}{42.5} + \frac{0.25^2}{8.25} + \frac{3^2}{8} + \frac{0.75^2}{6.25} + \\ &\frac{3.75^2}{32.25} + \frac{0.75^2}{6.25} + \frac{0.25^2}{2.75} + \frac{3^2}{32} + \frac{1.25^2}{15.75} + \frac{6^2}{29} + \\ &\frac{1^2}{47} + \frac{1^2}{18} + \frac{0.75^2}{3.75} + \frac{1^2}{4} + \frac{2.25^2}{7.25} + \frac{1.75^2}{5.75} + \\ &\frac{4.25^2}{23.25} + \frac{0.25^2}{7.75} + \frac{3.5^2}{42.5} + \frac{1.25^2}{8.25} + \frac{2^2}{8} + \frac{0.75^2}{6.25} \\ &+ \frac{3.25^2}{32.25} + \frac{0.75^2}{6.25} + \frac{1.25^2}{2.75} + \frac{0^2}{32} + \frac{0.25^2}{15.75} + \\ &\frac{8^2}{29} + \frac{4^2}{47} + \frac{1^2}{18} + \frac{1.25^2}{3.75} + \frac{1^2}{4} = 24.1964 \end{aligned}$$

$$\text{Degrees of freedom (n)} = (4-1) \times (18-1) = 51$$

For larger values of n (degrees of freedom), the expression $(\sqrt{2\chi^2} - \sqrt{2n-1})$ has been used as a normal variate with unit variance, remembering that the probability for χ^2 corresponds with that of a single tail of the normal curve. Thus the value of the normal

curve for 51 degrees of freedom and 24·1964 value of *Chi*-square is:

$$\begin{aligned} &= \sqrt{2\chi^2} - \sqrt{2n-1} \\ &= \sqrt{2 \times 24 \cdot 1964^2} - \sqrt{(2 \times 51) - 1} \\ &= -3 \cdot 0934 \end{aligned}$$

Since the contending samples can be considered homogeneous or correlated up to

the normal curve value of 1·96, and the value obtained here being -3·0934 which is much less, the coal samples from the four collieries are very closely homogeneous. This test thus confirms the conclusions based upon qualitative as well as quantitative sporological (histograms) comparisons already arrived at.

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