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J. E. Potzger
The Butler University Botanical Studies journal was published by the Botany Department of Butler University, Indianapolis, Indiana, from 1929 to 1964. The scientific journal featured original papers primarily on plant ecology, taxonomy, and microbiology. The papers contain valuable historical studies, especially floristic surveys that document Indiana’s vegetation in past decades. Authors were Butler faculty, current and former master’s degree students and undergraduates, and other Indiana botanists. The journal was started by Stanley Cain, noted conservation biologist, and edited through most of its years of production by Ray C. Friesner, Butler’s first botanist and founder of the department in 1919. The journal was distributed to learned societies and libraries through exchange.

During the years of the journal’s publication, the Butler University Botany Department had an active program of research and student training. 201 bachelor’s degrees and 75 master’s degrees in Botany were conferred during this period. Thirty-five of these graduates went on to earn doctorates at other institutions.

The Botany Department attracted many notable faculty members and students. Distinguished faculty, in addition to Cain and Friesner, included John E. Potzger, a forest ecologist and palynologist, Willard Nelson Clute, co-founder of the American Fern Society, Marion T. Hall, former director of the Morton Arboretum, C. Mervin Palmer, Rex Webster, and John Pelton. Some of the former undergraduate and master’s students who made active contributions to the fields of botany and ecology include Dwight. W. Billings, Fay Kenoyer Daily, William A. Daily, Rexford Daubenmire, Francis Hueber, Frank McCormick, Scott McCoy, Robert Petty, Potzger, Helene Starcs, and Theodore Sperry. Cain, Daubenmire, Potzger, and Billings served as Presidents of the Ecological Society of America.

Requests for use of materials, especially figures and tables for use in ecology text books, from the Butler University Botanical Studies continue to be granted. For more information, visit www.butler.edu/herbarium.
AN INTERESTING MEGASPORE SPECIES FOUND IN INDIANA BLOCK COAL

By G. K. GUENNEL

Specimens of Block coal collected during the past 5 years for miospore analysis have aroused the curiosity of both geologists and the author. Many reddish-brown specks have been observed on bedding planes with the naked eye. Because of their abundance in the Block coals, megaspores were believed to provide an additional statistical aid in correlating coals. Finally, during the summer of 1954, a study of these large spores was undertaken. Unfortunately, the preliminary work, especially preparing coal samples for study and assembling widely scattered literature on megaspore analysis, proved more time-consuming than was anticipated. The author, however, expects to continue these studies and hopes that the later report will provide an additional means of correlating coals.

This report is concerned primarily with the great variation of spore morphology encountered in attempting to identify certain spores. The wide-field stereoscopic microscope used to scan the macerated coal for spores has insufficient magnification to enable differentiation of morphological characteristics. On the other hand, the dense, opaque spores proved to be difficult objects to examine under the biological scope. Arnold (1950, pp. 97-98) shows figures of spores photographed with transmitted light and red filters to bring out details of the more or less opaque spore body. This method was tried, and a red Wratten filter, F 29, proved to be satisfactory, especially for photographing specimens. (See figs. A and B, pl. 1.) The thinner, more translucent parts are best viewed and photographed with unfiltered light. For certain spores a combination of filters, F 29 and D45, the latter a purple filter, gave the best results. The two-filter method proved unsatisfactory, however, when applied to photomicrography.

1 Published with permission of the State Geologist, Indiana Geological Survey.
2 Paleobotanist, Indiana Geological Survey.
Plate 1

Photomicrographs of *Triletes triangulatus* Zerndt. x 50
A. Specimen photographed without filter to show flange.
B. The same specimen photographed with Wratten filter F 29 to show details of body structure.
C. Spore without perisporal membranes, showing suture and mesospore.
D. Spore showing details of reticulum.
Filter F 29 was used to photograph specimens shown in C and D.

Many problems arose in attempting to identify the spores. In order to facilitate identification, a key was prepared, based mainly on the work of Schopf, Wilson, and Bentall (1944) and Dijkstra (1946). Many of the spores that were difficult to identify were finally classified as *Triletes gymnozonatus* Schopf, even though Dijkstra (1946) had made *T. gymnozonatus* synonymous with *T. triangulatus* Zerndt. Dijkstra’s figure (1946, fig. 32, pl. 4), a photograph taken with reflected light, showed the trilete mark extending to the periphery of the spore. The spores whose identity was in
doubt had shorter trilete markings; many of the sutures were split open. A large number of spores had equatorial flanges and body reticulations. These spores could be assigned to *T. triangulatus* without great difficulty. Tracing the “unknown” spores individually through the key proved unprofitable. Viewing the assemblage as a whole, however, brought to light several differentiating features. Some of the round spores had well-defined trilete rays, but they differed from *T. gymnozonatus* by having body reticulations. Others did not have reticulations and the trilete scar was obliterated by membranous lamellae. Some smooth spores had flanges or pointed, ear-like projections. In most spores three of these “ears” were visible, but in some only one or two could be seen. After much effort to classify these odd spores had been spent, an experiment was undertaken. Some typical *T. triangulatus* specimens were glued to cardboard slides. With the aid of a finely drawn-out glass tube and a single bristle attached to a glass rod, the flange was torn off the spore body. This operation, performed under the stereoscopic microscope, yielded rather startling results. In several specimens the flange and lamellae were seen to be connected, as the triradiate lamellae remained attached to the flange when the latter was pulled off. A thin reticulate membrane was attached to some flanges. Other denuded spores retained fragments of the reticulum and some spores retained even parts of the flange. It soon was evident that the flange, lamellae, and reticulum constituted a single membranous complex. This complex was found to be attached at the base of the flange and along the triradiate scar. The flange is attached to the spore body slightly above the equator, that is, toward the proximal surface of the spore. Although the author failed to demonstrate satisfactorily that the lamellae are attached as described below, several specimens seemed to have either bifurcate lamellae or two lamellar membranes lining each scar. The author believes that the latter is correct, but thinks that there are three lamellae. Each one is connected to the flange at two places and lines two rays. Figure 1 illustrates the lamellar structure as visualized by the author. The diagram shows the lamellae flattened out. As two lamellar membranes line each ray and lamellar folding tends to be prevalent, one can readily understand why the triradiate markings can be hidden.

The “ears” found protruding in many spores are simply extensions of the triradiate lamellae overlapping the pointed, widened areas
of the flange. Since there are at least two layers of membrane in these areas (possibly three if the two-lamellae theory is correct), less folding takes place in the areas opposite the ray termini. These more rigid and thicker areas therefore tend to stick out, whereas the rest of the flange may be folded over or even torn away. Compression of spores along planes other than the equator, also may result in partial obliteration of the flange.

Dijkstra (1946, p. 53) said that spores of *T. triangulatus* are marked by perispores with reticulate structures but that the reticulum is not well developed on the proximal surface where the meshes are only from 17 to 25 microns wide. The well-defined reticulations on the distal side measure from 20 to 80 μ (see fig. D, pl. 1). Although the author has not been able to determine with certainty whether the perisporal reticulations extend to the proximal surface, he believes that the contact areas are free of perisporal membranes except for the lamellae lining the rays. Coarse granulations, resembling small papillae in places, can be observed on some specimens under reflected light. This ornamentation, however, may be the result of shrinkage or other physical alteration rather than meshes of a perisporal net. Arnold (1950, p. 75) noted a “dense growth of minute bristle-like papillae” on the contact surfaces of some specimens.

A small subtriangular area is visible around the proximal pole on a large number of “naked” spores. The area is bounded by slightly curved lines running from ray to ray and is believed to be the mesospore, since some torn specimens reveal another spore coat within the outer covering. Wicher (1934, p. 176) mentioned the triangular
mesospore, and Schopf (1938, p. 37) in some specimens noted a central body which he interpreted as a "shrunken endosporal membrane."

Zerndt (1930, pp. 51-54, figs. 19-30, pl. 7) differentiated two varieties of *T. triangulatus* and designated them with Roman numerals I and II. Stach and Zerndt (1931, p. 1123) added a third subtype or variety strictly on the basis of slightly smaller size. Ibrahim (1933, pp. 29-31, figs. 23-24, pl. 3) gave the varietal trinomial designations *T. triangulatus regalis* and *T. triangulatus secundus* to Zerndt's subtypes I and II respectively. Zerndt failed, however, to refer to varieties in his later works, and Dijkstra (1946, p. 53) implied that there is little validity in subdividing the species.

That *T. gymnozonatus* is actually the spore body of *T. triangulatus* seems to be well-established fact. The triangular outline of *T. triangulatus* is the result of the triradiate lamellae continuing into the flange, which is widened and pointed opposite the ray termini. There is little doubt that the spore proper, previously named *T. gymnozonatus* by Schopf, is ornamented with a perisporal network attached to the flange and the triradiate lamellae. Figure 2 shows two views of *T. triangulatus*.

![Fig. 2a. Drawing of *T. triangulatus* (proximal view).](image)

![Fig. 2b. Drawing of *T. triangulatus* (side view).](image)

The extensive synonymy given by Dijkstra (1946, pp. 52-53) need not be repeated here. Two species, which Dijkstra did not include, however, seem worthy of mention. In establishing the species *T. laxomarginalis*, Zerndt (1940, p. 136) stated that the spore is very similar to *T. triangulatus*, except for a larger spore body and a wider flange. The latter he never found intact. He found the species in only two samples from the Saar Basin and did not include it in his distribution charts because it was too rare. The species has not been
reported since. Unless two distinct size groups, based on definite measurements, were obvious to Zerndt,\(^8\) the retention of *T. laxo-marginalis* as a species seems untenable.

Another species retained by Dijkstra, namely *T. arcticollatus* Nowak and Zerndt, may be synonymous with *T. triangulatus*. This spore, according to Zerndt (1937, fig. 11), has open sutures and lacks a perisporal membrane but has the wall perforated with closely spaced, minute openings. Zerndt hinted that this perforated surface may be the result of maceration and that the outer surface of the spore coat is normally continuous and smooth. As far as can be determined, no one has reported the spore since. *T. arcticollatus* may merely be the overmacerated spore body of *T. triangulatus*.

The retention of the two nomenclatorial entities, *T. triangulatus* and *T. gymnozonatus*, has no basis now that the relationship between the two "types" has been well established. Even a varietal designation, which would have some practical merit, since the frequently found naked spore body is quite distinct from the reticulate, flanged spore, seems no longer justifiable.

**DESCRIPTION OF TRILETES TRIANGULATUS ZERNDT**

The spore proper is round, smooth, and granular in texture (fig. C, pl. 1). The trilete scar in many spores is split open and extends about halfway to the spore periphery. Narrow lips line the sutures. Schopf (1938, p. 37) gave a size range of 500 to 600 microns; this coincides with the size measurements of the author. Zerndt (1934, p. 19), giving measurements exclusive of the flange for 12 specimens, stated that the specimens ranged from 238 to 531 microns in diameter, an average diametric measurement of 492 \(\mu\). The spore coat was from 20 to 30 \(\mu\) thick.

A perisporal network is attached to the spore proper in many spores, but some spores lack this perispore. The perisporal membrane is reticulate on the distal surface. The meshes measure from 20 to 80 \(\mu\). This reticulate membrane may be fairly elastic and thus cause the reticulations to vary in size. If the membrane is loosely attached, the meshes seem larger, whereas a closely adhering mem-

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\(^8\) This apparently was not the case, since he gave no measurements in the description of the species.
brane has smaller reticulations. The reticulum is attached to a flange which girdles the spore. Dijkstra (1946, p. 53) gave a range of 70 to 100 μ for the width of the flange and the author's measurements ranged from 55 to 120 microns. The flange broadens opposite the ray termini to form triangular, pointed, ear-like extensions, which give the spore a more or less triangular outline. Triradiate lamellae, which line the trilete rays, are attached to the flange at these areas. The lamellae are higher in the middle than they are at either end and may attain a height of 80 μ. The lamellae, as well as the flange, tend to be indented and undulating because of their fragility. They are highly translucent.

The proximal surface apparently is free of perisporal matter, except for the lamellae which line the rays, even though coarse granulations, resembling small papillae in places, cover the contact areas in some spores.

Size measurements, including equatorial flange, have been made by several authors. The minimum diametric measurement is 310 μ listed by Stach and Zerndt (1931, p. 1123). It is not clear, however, whether the flange was included in this measurement. The maximum size is 800 μ given by Dijkstra (1946, p. 53) and by Schopf (1938, p. 32). After measuring 100 specimens, the author found that the diameters range from 370 to 740 μ and that the average diametric measurement is 543.9 microns.

Schopf (1938, pp. 32-33) suggested that the megaspores classified under the form species T. triangulatus Zerndt are derived from herbaceous lycopods of the Selaginellales group.

T. triangulatus apparently has a wide geographical, as well as vertical, distribution. The species has been reported from the Calais and Nord Basins in France, from the Saar, the South Limburg Basin in Holland, from the Ruhr and Saxony Basins in Germany, from Upper Silesia and the Carpathian Basin in Poland, from Staffordshire, England, and from the Bohemian Basin in Czechoslovakia. In the United States the species has been found in Illinois, Michigan, Ohio, West Virginia, Kentucky, Pennsylvania, and now Indiana. Figure 3 shows the approximate vertical distribution of the species and relates European "Coal Measures" to North American stratigraphic units. Since little megaspore work has been done in the United
States, gaps in the distribution picture for America are due to the lack of information from those particular strata.

Fig. 3. Chart showing European and North American correlations and indicating the vertical distribution of *Triletes triangulatus*.

**LITERATURE CITED**


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