

A NEW CALAMITALEAN CONE FROM THE MIDDLE PENNSYLVANIAN OF SOUTHERN ILLINOIS

by F. A. HIBBERT and D. A. EGGERT

ABSTRACT. A new species of the calamitalean cone genus *Paracalamostachys* Weiss, *P. cartervillei*, is described. The holotype consists of a group of cones found in an 'ironstone' nodule of Middle Pennsylvanian age. The cones are small, ranging from 11 to 17 mm. in length, and 4.0 to 4.5 mm. in diameter. Several cones are present at a node on the cone-bearing stem, they lack peduncles, and consist of whorls of bracts and sporangiophores arranged alternately, the fertile whorls being superposed. Approximately six sporangiophores are present in the fertile whorl and twelve bracts in the sterile whorl. Each sporangiophore bears four horizontally elongate sporangia arranged in the form of a Maltese cross around a central stalk. The sporangiophores are enclosed by the upturned ends of the subtending bracts. Spores ranging in size from 40 to 100 μ were isolated from sporangia and are referable to the form genus *Calamospora* Schopf, Wilson, and Bentall, being comparable to the dispersed spore species, *C. breviradiata* Kosanke. The cone is apparently homosporous and is compared with previously described species of the genus *Paracalamostachys* Weiss and related genera.

THE holotype of a new species of the genus *Paracalamostachys* Weiss (Weiss 1884) was recently discovered at an abandoned mine site about half a mile West of Carterville, Illinois. It consists of a compressed axis bearing cones at three nodes preserved in an 'ironstone' nodule. At this Middle Pennsylvanian plant locality in Williamson County (Sec. 4, T 9 S, R 1 E), Herrin Quadrangle, nodules containing plant material are found in place in shales above the Herrin (Illinois No. 6) coal, and in weathered shales forming the upper part of the overburden material removed from above the coal during mining. The horizon from which the holotype is derived is in the Carbondale Formation of the Kewanee Group (Kosanke *et al.* 1960).

The original appearance of the specimen is shown in Plate 93, figs. 1 and 2. The fossil was more fully exposed by etching with a 10 per cent. solution of phosphoric acid which removed the nodular matrix. This etching action of the acid was allowed to proceed for varying lengths of time, while being observed under a binocular dissecting microscope. Periodic flushings with distilled water were applied to halt the action of the acid so that critical examination of the progress of the etching could be determined. The above technique revealed that the cones were preserved in some depth in the matrix and that they were not so compressed as the original appearance of the specimen suggested. This method of study has yielded a considerable amount of information concerning the structure of the cones and may prove to be particularly useful with reproductive structures found in comparable nodules. In some cases a fine white material, apparently consisting of phosphates produced in the treatment, may form on the nodular surface. Application of a dilute solution of ammonium hydroxide followed by thorough washing with distilled water removes most of this unwanted by-product of the acid treatment.

Spore samples were taken from sporangia in various positions along the axis of the cone. These were picked off, as spore masses, as the phosphoric acid etching proceeded. Extremely short oxidation (2 to 3 minutes) with concentrated HNO_3 followed by a washing with 10 per cent. potassium hydroxide solution released the individual spores

from the spore mass and made them more readily examined, without affecting their structure.

Genus PARACALAMOSTACHYS Weiss

Paracalamostachys cartervillei sp. nov.

Plate 93, figs. 1-5; text-fig. 1

Diagnosis. Small cone composed of alternating whorls of bracts and sporangiophores with sporangiophores of successive whorls superposed. Approximately six sporangiophores and twelve bracts in each of the two types of whorls. Each sporangiophore having a central stalk bearing four horizontally elongate sporangia. Cones homosporous, having spores of the *Calamospora breviradiata* Kosanke type. Position of attachment of sporangiophore stalk to cone axis not known.

Stratigraphic occurrence. Shales above the Herrin (Illinois No. 6) coal, Carbondale Formation, Kewanee Group, Middle Pennsylvanian.

Holotype. Specimen No. 563 and slide preparations in the Paleobotanical Collections, Botany Department, Southern Illinois University.

Description of cone. The overall length of the entire specimen (Pl. 93, figs. 1, 2) is 3.8 cm., the diameter of the axis bearing the cones ranging from 2.5 mm. just above a node, to about 3.0 mm. immediately below a node. The length of the cones, which are present at three nodes along the axis, varies from 11 to 17 mm. while their maximum diameters range from 4.0 to 4.5 mm. Three cones are present at each of the two upper nodes and two cones are present at the lowest node. The type of foliage borne by the fertile stem cannot be determined; however, a few elongate structures suggestive of *Asterophyllites* type foliage are present in the nodule (Pl. 93, fig. 1, B) and have an orientation consistent with their having been leaves of the stem.

Prior to treatment with phosphoric acid, each cone showed several horizontal rows of brown, somewhat spherical structures which subsequent study showed to be sporangia and spore masses. Numerous bracts, present in whorls, alternate with the whorls of fertile parts and have broad basal portions and acute tips. The exact number of bracts in each whorl is estimated at being twelve on the proportion of the diameter of the cone which one bract occupies. Except where the bracts are obviously displaced due to crushing, they turn abruptly upward immediately to the outside of the sporangia and cover the fertile parts, giving the cone a compact appearance.

Selective etching of the matrix has made it possible to determine some features of the sporangiophores. The part and counterpart of the cone indicated by the letters A in Plate 93, figs. 1 and 2 respectively were chosen for this purpose since they appeared to be the most complete. Fig. 3 shows this cone (Pl. 93, fig. 1, at A) at the same magnification after

EXPLANATION OF PLATE 93

Figs. 1-5. *Paracalamostachys cartervillei* sp. nov. 1, 2, Part and counterpart of holotype showing appearance before treatment to expose material. Cone which was more fully exposed by acid treatment indicated by A; possible foliar structures indicated by B. $\times 3$. 3, Cone indicated by A in fig. 1 after acid treatment. $\times 3$. 4, Enlarged view of exposed cone showing details of sporangiophores. Indications explained in text. $\times 9$. 5, Isolated spore of *Calamospora breviradiata* type from holotype specimen. $\times 500$.

removal of the matrix. Portions of six whorls of sporangiophores have been uncovered. The upper and lower whorls are very incomplete, but the four central whorls are exposed in a fair degree of completeness (Pl. 93, fig. 4). Each sporangiophore bears four sporangia which are circular in outline, except for flattened areas where they are in mutual contact, when viewed in the tangential aspect (Pl. 93, fig. 4, at c). The horizontally elongate form of the sporangia can be seen in views that are more radial (Pl. 93, fig. 4, at d). The sporangiophore stalks are generally poorly preserved and their positions are marked by hole-like depressions in most cases. No distal expansion or head was found on the stalks of the sporangiophores, but the preservation does not preclude their having been present originally. In the centrally located sporangiophore of the third whorl from the top of the cone (Pl. 93, fig. 4, at c) the tissue of the sporangiophore stalk is preserved and consists of a slightly raised area having a circular outline. The sporangia of each sporangiophore occur in two superposed pairs. Superposition is also evident between the sporangiophores of the second and third whorls from the top of the cone, while those of the fourth whorl are less clearly superposed with the members of the higher whorls (Pl. 93, fig. 4). This is due to vertical separation of the sporangia in the centre of the whorl, which occurred during the acid treatment. Although it is difficult to delimit some of the members of the whorls of sporangiophores, it is most likely that they were superposed throughout the cone. In cases where the sporangiophore stalk (or the depression marking its position) is viewed in radial aspect this structure has an essentially horizontal orientation (Pl. 93, fig. 4, at d). The form and orientation of the parts of the sporangiophores suggest that the sporangiophore stalks were attached to the cone axis approximately midway between bract whorls. Unfortunately, no clear instance of the attachment of a sporangiophore stalk to the cone axis was found.

Parts of the cone which were uncovered most completely suggest that the number of sporangiophores was probably six per whorl. These sporangiophores are closely enveloped by the bracts which appear as fine lines of dark material in the nodular matrix in side view (Pl. 93, fig. 4, above the arrow at d).

Poor preservation of cuticular remains present in the specimen does not allow a determination of the structure of the epidermis.

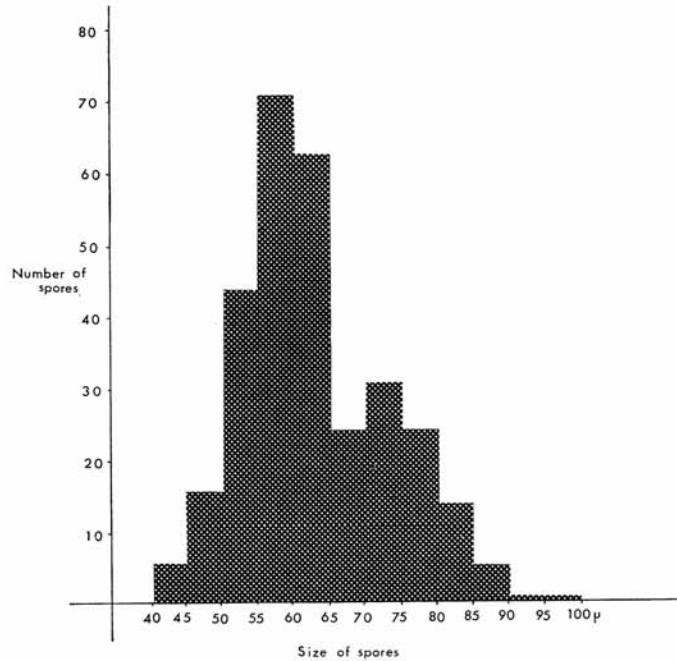
Description of spores. Spores isolated from the cones are radial, trilete, and were probably spherical prior to compression. The size range is from 40 to 100 μ with a peak at 55–60 μ . The trilete rays are short and vary in length from 11 to 16 μ . The exine is uniformly thin (less than 2 μ) and the area contagionis is present in most spores. The spores are referable to the form genus *Calamospora* S.W. and B. (Pl. 93, fig. 5).

The trilete mark is distinct, the lips slightly to more prominently elevated and the commissure is thin and attenuate. In most specimens the spore coat shows numerous folds, which may be due to the thinness of the spore wall. The spore coat is laevigate and translucent.

Spores within sporangia from all parts of the cones exhibit a similar size range. Of three hundred spores, the size ranged from 40 to 100 μ as shown in the histogram (text-fig. 1). The largest spores generally show little or no folding even though their wall thickness is the same as that of the smaller spores. It is likely that *P. cartervillei* was homosporeous since the cones exhibit a similar range in spore size throughout their lengths.

Kosanke (1950) has previously described spores of *Calamospora* from Illinois. Two

species, *C. breviradiata* Kosanke and *C. hartungiana* S.W. and B. occur at the horizon from which our cones were taken. In many specimens isolated from the cones the structure of the trilete was similar in every respect to that of *C. breviradiata* (e.g. the specimen in Kosanke 1950, pl. 9, fig. 4). In other spores isolated from the cones the lips of the trilete were lower, but definite, and extended from 1 to 2 μ on either side of the suture



TEXT-FIG. 1. Histogram of spore size distribution in the holotype of *Paracalamostachys cartervillei*.

(Pl. 93, fig. 5). In wall structure and mean size the spores are similar to *C. breviradiata* as described by Kosanke but exhibit a greater size range than that reported by him for this species. The difference in structure of the trilete, present in spores from the same sporangium, may be due to varying degrees of compression, or of spore maturity. For the present we are assigning the spores of *P. cartervillei* to the dispersed spore species *Calamospora breviradiata* Kosanke.

Discussion. Information obtained from the cones and their included spores clearly indicates a botanical affinity with the order Calamitales. The cones from Carterville are similar to several species of the genera *Paracalamostachys* and *Calamostachys* described by Weiss (1876, pl. 16, figs. 1, 2; 1884, pl. 21, fig. 6 and pl. 22, figs. 1, 2, 5, 10-14). The former genus is maintained as distinct from *Calamostachys* on the grounds that the exact position of sporangiophore attachment is not known. In *Calamostachys* the sporangio-

phore stalk is attached to the cone axis approximately midway between successive bract whorls. As the new material did not allow the position of sporangiophore attachment to be determined, appropriate comparison can best be made with species of *Paracalamostachys*. Among the various species of this genus, the new form is somewhat similar to *P. minor* Weiss (1884) but differs from that species in that the spores of the new cone are distinguishable from those of *P. minor* as described by Hartung (1933). *P. striata* Weiss is distinguished from the Illinois cones in part by being heterosporous (Hartung 1933), while *P. polystachya* (Sternberg) Weiss has elongate peduncles and exposed sporangia. *P. rigida* Weiss is a smaller cone, but little is known concerning this form and it cannot, therefore, be adequately compared with the cones from Illinois. The species *P. heterospora* recently described by R. and W. Remy (1958) is a very large cone, about 15 cm. long, and is heterosporous. It seems most likely that the new species, *P. cartervillei*, may have been of the *Calamostachys* type since compression specimens of *Palaeostachya* often show some indication of the axillary attachment of the sporangiophores in the form and orientation of the sporangia even when the sporangiophore stalk is not visible (e.g. figures in Weiss 1884, pl. 21, figs. 3, 4). The new cone is also distinct in numerous ways from the recently described genus *Calamocarpon* (Baxter 1963).

The more than twenty-five species of *Calamostachys* currently recognized encompass a very wide range in form, size, and mode of preservation. The only feature common to all of these forms is the mid-internodal attachment of the sporangiophore stalks to the cone axis between successive bract whorls. The structural details of some species, primarily petrified forms, such as *C. binneyana*, *C. ludwigi*, *C. casheana*, and *C. americana* are known. In the case of most of the compression forms much less is known and comparison among the various supposed species is limited to obvious features such as cone length, diameter, and the spacing of fertile and sterile whorls. In a few instances the number of bracts and sporangiophores present in the whorls can be estimated and has been used in distinguishing some of the compression species.

Paracalamostachys cartervillei resembles *Calamostachys binneyana* in the approximate number of bracts and sporangiophores present in the cone whorls, but it is smaller in length and diameter. The spores of *C. binneyana* persisted in tetrads which often contained aborted spores and were enclosed in a perispore membrane. There is no evidence that these features were present in *P. cartervillei*. On the basis of measurements presented by Hartung (1933) for the spores of *C. binneyana*, it appears that *P. cartervillei* produced spores of greater diameter and with a greater size range than did *C. binneyana*. Of the remaining forms of *Calamostachys* which may be compared with the Carterville cones, *C. ludwigi* should be noted for its similarity. *C. ludwigi* differs from the Carterville cones in the same features which set them apart from *C. binneyana*. All the remaining species of *Calamostachys* are clearly distinct from *P. cartervillei* on the basis of numerous features.

Inability to determine the exact position of sporangiophore stalk attachment to the cone axis makes it necessary to refer the Carterville cone for the present to the genus *Paracalamostachys* in which this structural feature is not known.

Acknowledgements. The authors thank Dr. W. S. Lacey for helpful suggestions and a critical reading of this paper prior to publication while serving as Visiting Professor in the Botany Department, Southern Illinois University. This research was supported in part by National Science Foundation Grant GB 1540.

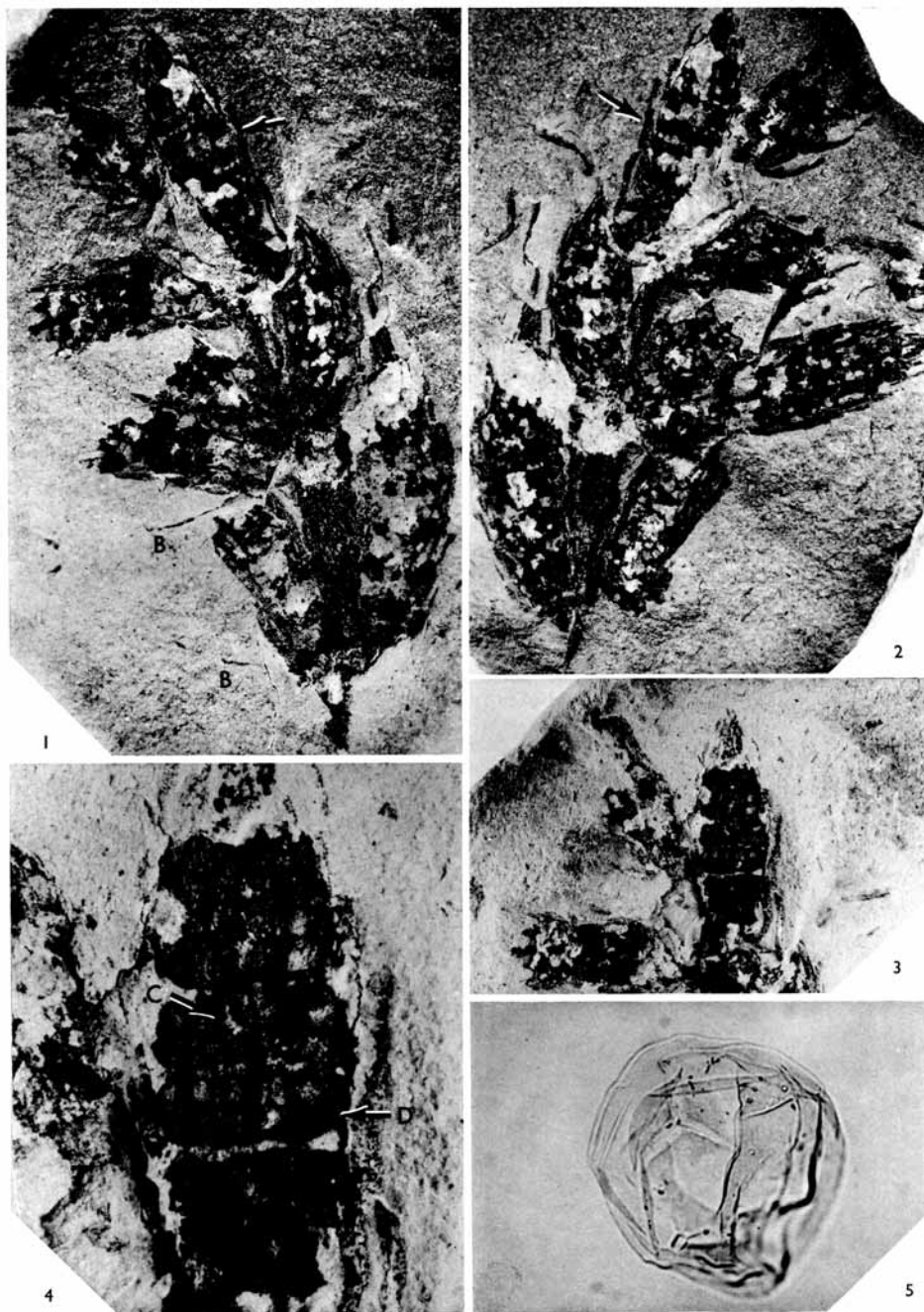
REFERENCES

- BAXTER, R. W. 1963. *Calamocarpon insignis*, a new genus of heterosporous, petrified calamitean cones from the American Carboniferous. *Amer. Journ. Bot.* **50**, 469-76.
- HARTUNG, W. 1933. Die Sporenverhältnisse der Calamariaceen. *Inst. Paläobot. u. Petrog. d. Brennst. Arb.* **3**, 95-149.
- KOSANKE, R. M. 1950. Pennsylvanian spores of Illinois and their use in correlation. *Illinois State Geol. Surv. Bull.* **74**, 128 pp.
- SIMON, J. A., WANLESS, H. R., and WILLMAN, H. B. 1960. Classification of the Pennsylvanian strata of Illinois. *Illinois State Geol. Surv. Rept. of Invest.* **214**, 84 pp.
- REMY, R. and REMY, W. 1958. Beiträge zur Kenntnis d. Rothliegendflora Thüringens. Teil III. *Sitzber. Dtsch. Akad. Wiss.* **3**, 1-16.
- WEISS, CH. E. 1876. Steinkohlen-Calamarien. *Abhand. Geol. Specialkarte. v. Preußen u. d. Thüringischen Staaten* **2**, Heft 1, Text 149 pp.; Atlas 19 pls.
- 1884. Steinkohlen-Calamarien II. *Ibid.* **5**, Heft 2, Text 204 pp.; Atlas 28 pls.

F. A. HIBBERT
Botany School,
Downing Street,
Cambridge

D. A. EGGERT
Dept. of Botany,
University of Iowa,
Iowa City

Manuscript received 16 October 1964



HIBBERT and EGGERT, Pennsylvanian Calamitalean cone