ON THE STRUCTURE AND PHYLOGENETIC RELATIONSHIPS OF THE FERN *RADSTOCKIA* KIDSTON

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ABSTRACT. *Radstockia kidstonii* sp. nov. is described from compression specimens contained in ironstone concretions discovered at the Mazon Creek (Illinois) locality. The botanical affinities are suggested as being close to marattiaceous ferns.

THE genus *Radstockia* Kidston (1923) was originally described on the basis of Upper Carboniferous fertile fern-like foliage initially designated as *Schizostachys sphenopteroides* Kidston (1888) and *Hymenotheca beyschlagi* Potonié (1890). Forms placed in the genus are characterized by elliptical fructifications that display a superficial segmented appearance. In *R. sphenopteroides* the fructifications are described and illustrated as being borne either sessile or on short stalks along non-foliar laterals. They may occur singly, in pairs, or in definite clusters at lower levels on the frond.

Two foliar specimens referable to the genus *Radstockia* contained in an ironstone concretion collected at the famous Mazon Creek locality represent the material described in this account. Several additional specimens collected from the same locality and presently deposited in the palaeontological collections at the Chicago Natural History Museum and Illinois State Museum at Springfield were also examined.

The present contribution is concerned with the description of a new species and the interpretative problems which it presents.

SYSTEMATIC DESCRIPTION

Genus RADSTOCKIA Kidston 1923

Radstockia kidstonii sp. nov.

Plate 6, figs. 1–4; Plate 7, figs. 2, 3, 5

Diagnosis. Foliar units at least bipinnate, rachis straight, longitudinally striated; foliar laterals alternate, lanceolate to oblong-lanceolate, free on lateral margins. Fructifications elliptical, 2·0 mm long and 1·0 mm wide, pendant and partially embedded in abaxial surface of foliar units; spores spherical, 40–60 μ; exine thin, levigate.

Holotype. Plate 6, fig. 1. Peabody Museum of Natural History; Yale University, Paleobotanical Collections, No. 1004.

Type Locality. Mazon Creek, Will County, Illinois (U.S.A.).

Stratigraphic occurrence. Francis Creek Shale, Carbondale Formation, Kewanee Group.

Age. Middle Pennsylvanian.

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DESCRIPTION OF SPECIMENS, AND DISCUSSION

The nodule contains portions of two foliar segments (Pl. 6, fig. 1); one specimen shows features of more distal parts, while the second displays characters at more proximal frond levels. From the limited extent of the two specimens it is impossible to determine the branching level represented by the material, although the parallel relationship exhibited between the two foliar parts (Pl. 6, fig. 1) suggests that at least secondary pinnae are represented. Because of the uncertainty, however, the branching foliar axes will be referred to arbitrarily as ultimate, penultimate, and antepenultimate throughout the description that follows.

Foliage. The larger, more distal foliar specimen consists of an antepenultimate axis approximately 9·5 cm. long bearing 15 alternately arranged penultimate axes (pinnatified pinnules) (Pl. 6, fig. 1). These pinnules are broadly lanceolate to oblong-lanceolate and are constricted where they are attached to the primary (antepenultimate) rachis (Pl. 6, fig. 3). Margins are deeply lobed and free from surrounding foliar units (Pl. 7, figs. 2–3). The rachis is straight and characterized by longitudinal striations (Pl. 6, figs. 1–3) that may represent vascular strands or accompanying sclerenchyma fibres.

The second foliar unit displays features of lower frond levels and consists of a primary axis bearing 7 alternately arranged penultimate axes (Pl. 6, fig. 1). Each of these in turn gives rise to small ultimate axes (pinnules). Lower units of this foliar segment bear alternately arranged, decurrent, obovate pinnules, each of which is subdivided into 3–6 spatulate lobes (Pl. 6, fig. 2). Lobes are uniform in size and each bears a single fructification on its abaxial surface.

Each penultimate axis is supplied by a single prominent vein that departs from the primary rachis, enters the foliar unit, and is further subdivided into smaller veinlets. Whether the individual veins continue to the margin of the lamina cannot be determined from the material. No pinnule lobe contains more than a single vein.

At some levels of the specimen it appears that both fertile and sterile pinnules are present. This, however, is not the case when one carefully removes the matrix surrounding these units. From the present material on hand it appears that fructifications were produced on all of the foliar units.

Fructifications. The fructifications of *R. kidstonii* consist of elliptical bodies partially embedded in the abaxial surface of marginal foliar lobes (Pl. 6, fig. 4; Pl. 7, figs. 2–3). Each unit measures approximately 2·0 mm long and 1·0 mm wide in its greatest dimension. Externally each fertile structure is marked by a single conspicuous longitudinal

EXPLANATION OF PLATE 6

Figs. 1–4. *Radstockia kidstonii*. 1, One half of ironstone concretion showing upper (left) and lower (right) portions of two leaves; ×1. 2, Pinna showing lobed configuration of individual pinnules ×3; note striated rachis and pinna base. 3, Fertile pinna near tip illustrating marginal position of synangia, ×3·5. 4, Surface view of two synangia showing linear arrangement of sporangia, ×22.

EXPLANATION OF PLATE 7

Figs. 1, 4. *Marattia alata*. 1, Fertile pinnule; nearly all of the sporangia at the right have dehisced, while those at the left are still intact, ×6. 4, Fertile pinna, ×3; compare with Plate 6, fig. 3.

Figs. 2, 3, 5. *Radstockia kidstonii*. 2, Single pinnule showing marginal position of the synangia, ×13. 3, Tip of fertile pinna showing partial fusion of sporangia (arrow), ×12. 5, Spore showing numerous folds of the thin-walled exine, ×1000 (Slide No. 17).

furrow that appears to divide the entire unit (Pl. 6, fig. 4). Arising at right angles from this median cleft are smaller furrows that give the entire unit a segmented appearance.

Because of the almost complete replacement of the original organic material nothing is known of the structure of the fructifications. In his description of *R. sphenopteroides*, Kidston (1923) regarded the entire unit as a single sporangium. According to this interpretation the longitudinal and transverse furrows that mark the surface represent features involved in sporangial dehiscence.

An examination of the Mazon Creek specimens produced evidence for another interpretation. This author regards the fructifications of *R. kidstonii* as clusters of partially fused sporangia in a linear arrangement. Figure 3 (Pl. 7) shows one of these synangia slightly flattened in a lateral plane and illustrates the partial fusion (arrow) of the individual sporangia. Additional support for this point of view can be obtained from the nature of the longitudinal furrow on the surface of each fructification. Figure 4 (Pl. 6) clearly demonstrates that the furrow is in fact a suture formed by the linear arrangement of the individual sporangia, and is not itself a structural feature of a sporangium.

Spores. Isolated spores and fragments of spore masses were obtained by chipping away several synangia and subsequently macerating these in dilute hydrochloric acid. Spores of *R. kidstonii* are spherical, smooth-walled, and range in size from 40 to 60 μ. In the fossilized condition (Pl. 7, fig. 5) they are distinctly flattened and appear circular to subcircular in outline, but they are typically distorted owing to the numerous folds of the very thin spore wall. Haptotypic features are absent. If encountered in the dispersed state, spores of *R. kidstonii* would most closely correspond to forms presently placed in the genus *Laevigatosporites* (Schopf, Wilson, and Bentall 1944).

Discussion. At present the systematic position of *R. kidstonii* is debatable. There are, however, several striking similarities to be found between *R. kidstonii* and certain genera placed in the Marattiaceae, both fossil and living. The discussion that follows serves to illustrate several of these comparisons, while at the same time demonstrating the unique position presently occupied by this form.

In its linear soral organization *R. kidstonii* differs markedly from other fossil forms regarded as having marattiaceous affinities (e.g. *Asterotheca*, *Ptychocarpus*, *Scolecopteris*). There are, however, several linear soral arrangements in forms of approximately the same age as *R. kidstonii*.

Pecopteris marattiatheca Grand'Eury (1877, pp. 77–78, pl. 7, figs. 6, *k–o*) is characterized by linear synangia partially embedded in the abaxial surface of pecopterid foliage. Each fertile unit consists of eight partially fused sporangia which are believed to have opened by an apical pore. No information is provided about the spores.

Two other forms displaying the linear soral arrangement are *Danaeites* Goeppert (1836, pl. 19, figs. 4–5) and *Parapecopteris* Grand'Eury (1890, pl. 5, figs. 2–5). In *Danaeites saraepontanus* Stur (1885, fig. 33) each synangium is composed of 8–16 ovoid sporangia organized in two series on the lower surface of pecopterid foliage. In *Parapecopteris neuropteroides*, on the other hand, the pinnules are described as intermediate between pecopterid and neuropterid types. Here, as in *Danaeites*, the synangia are partially embedded in the lamina and located along the lateral pinnule veins. It should be noted that in a recent paper *Danaeites saraepontanus* and *Parapecopteris neuropteroides* are regarded by Corsin (1951) as synonyms.

Superficially the petrifaction genus *Eoangiopteris* Mamay (1950, p. 440, pl. 9, figs. 47–53) resembles *R. kidstonii* in the organization of the sorus. Unlike the synangiate condition of *R. kidstonii*, the fructifications of *Eoangiopteris* consist of clusters of 5–8 free sporangia. Moreover, the sorus is borne on a small fleshy receptacle on pecopterid foliage. Spores are reported as spherical (45–60 μ), thick walled, and conspicuously pitted on the exine.

In addition to the similarities shared with several fossil forms, *R. kidstonii* closely resembles such living members of the Marattiaceae as *Marattia alata* (Pl. 7, figs. 1, 4) and *M. excavata*. In these forms the synangia are borne on small fleshy receptacles along the veins. No indusium is present (which may or may not be the case in *R. kidstonii*). At maturity the synangium splits into two valves (Pl. 7, fig. 3), each sporangium subsequently forming a pore at its tip.

At present comments concerning evolutionary trends within the Marattiaceae are provisional at best. Notwithstanding, the marginal synangial position illustrated by *R. kidstonii* may be regarded as additional support for the ideas presented by Mamay (1950) concerning the 'phyletic slide' of the fructification to a superficial position on the lamina. According to this interpretation the coenopterid fern *Chorionopteris* with synangia attached to the tips of marginal pinnule lobes illustrates a condition that may have been found in the prototype of the Marattiaceae. In this series the 'phyletic slide' of the synangium (illustrated by forms both actual and hypothetical) culminates with the fructification in a superficial position.

Whether *R. kidstonii* represents an intermediate form in the 'shift' of the sorus from a marginal to superficial position on the lamina is still a matter of conjecture. The discovery of additional more complete specimens, hopefully displaying structural features of the fructification, should help to answer this question.

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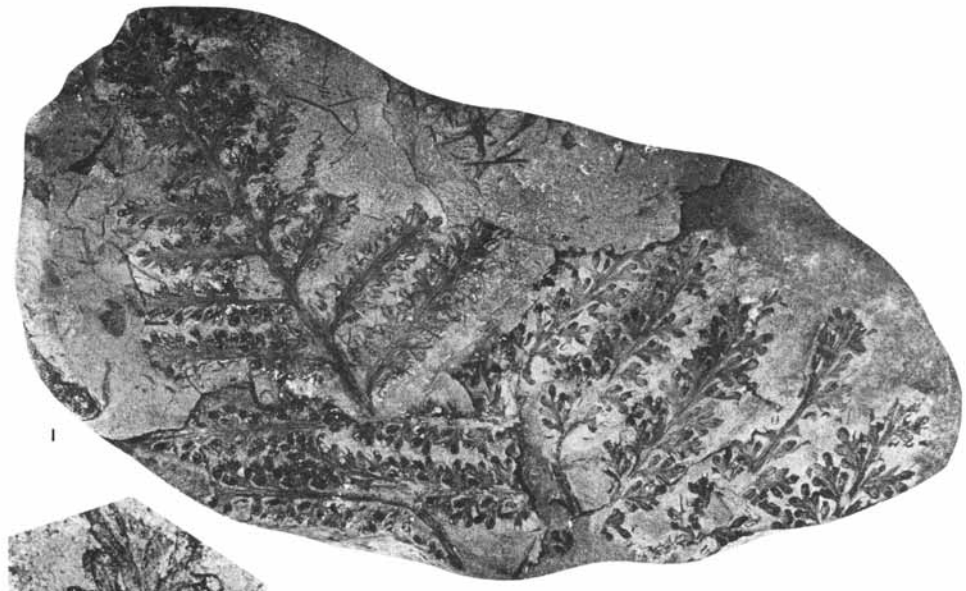

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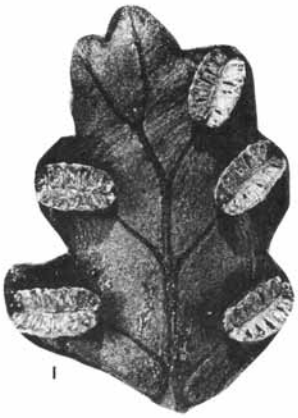
TAYLOR, Carboniferous fern *Radstockia*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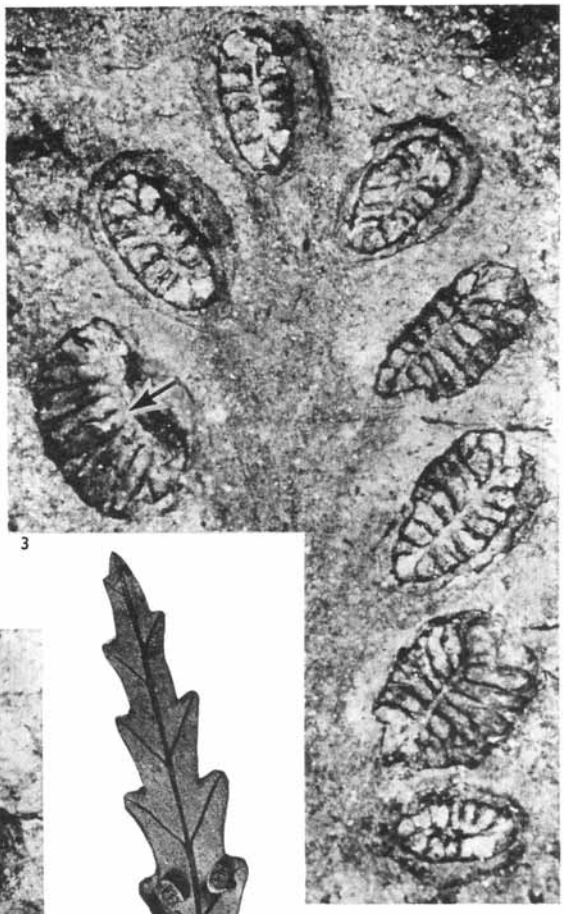
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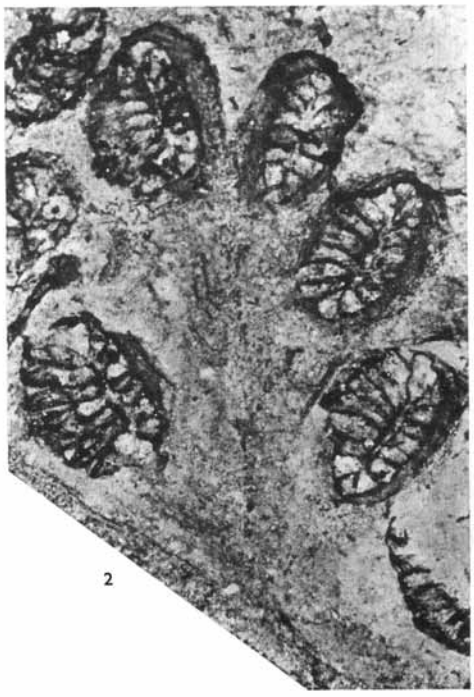
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