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CLARIFICATION OF *BELEMNOPTERIS* FEISTMANTEL 1876, AND DESCRIPTION OF A LEAF OF *BELEMNOPTERIS PELLUCIDA* PANT AND CHOUDHURY 1977 FOUND AMONGST A SOUTH AFRICAN ECCA FLORA

by

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"If ... fossils are named without a query they may lead to misleading results, for an error in the age of the strata leads to error in the name of the fossil. The age of the strata should be determined by the contained fossils and not vice versa." Sherlock 1947.

ABSTRACT

A leaf of *Belemnopteris pellucida* Pant and Choudhury 1977 was found for the first time in South Africa amongst an Ecca flora near Hammanskraal, about 30km north of Pretoria. The taxonomic status of *Belemnopteris* Feistmantel 1876 and the biostratigraphic correlation indicated by the presence of this genus is clarified.

INTRODUCTION

This paper examines the systematic position of the genus *Belemnopteris* Feistmantel 1876. The study is necessary because of the discovery for the first time of a *Belemnopteris* leaf in the Ecca Group of the Transvaal, South Africa. There are two schools of thought in the study of *Glossopteris* floras, and both will be highlighted. It is important to understand and evaluate the two approaches because biostratigraphic correlation of floras is directly connected with taxonomic identification of the fossils. Based on taxonomic methods, *Belemnopteris* Feistmantel 1876 is a valid genus (as will be discussed in this contribution). According to "nominalistic palaeobotany" (the alternative approach), *Belemnoperis* is not distinguishable from *Glossopteris* (Lacey *et al.*, 1975; Rigby, 1978). Anderson and Anderson (1985) cite it as a synonym of *Rigbya* Lacey *et al.*, 1975. Comparison of assemblages, based on fossils identified to the level of genus and species, indicates a biostratigraphic correlation of Ecca floras in the Transvaal with the Late Permian floras of Australia as well as the floras of the Raniganj Stage of the Raniganj Coalfield of India (Zeiller, 1896; Kovács-Endrödy, 1983, 1987, and in press). The distribution of *Belemnopteris* in India is restricted to the Raniganj Stage (Feistmantel, 1876, 1880-1881; Pant and Choudhury, 1977). Therefore, *Belemnopteris pellucida* Pant and Choudhury 1977 in a (Middle) Ecca flora, described in the present paper, provides additional evidence for the correlation of South African and Indian Late Permian floras. According to the nominalistic palaeobotany school, the South African Beaufort Group and the Indian Raniganj Stage were contemporaneous (Seward, 1904). The presence of *Belemnopteris* has been one of the elements used to support this correlation (Lacey *et al.*, 1975). *Belemnopteris*, therefore, has significant stratigraphic implications.

In this contribution, the differing concepts of *Belemnopteris* will be presented, evaluated, and the stratigraphic conclusions highlighted.

THE GENUS *BELEMNOPTERIS* FEISTMANTEL - HISTORICAL REVIEW

Feistmantel's work.

Belemnopteris was a monotypic genus when Feistmantel (1876) described it, based on two incomplete leaves from the Late Permian Raniganj Stage of the Raniganj Coalfield, India. According to his illustrations (Feistmantel, 1876, Pl. XX, figs 1, 2: 1880-1881, Pl. XLIIIA, figs 3, 4) only the apex is missing from one of the fragments, and the other specimen is an apical portion. Although the apical portion is without the very tip of the apex, the preserved part of the margin indicates an obtuse apex. Thus, from the two incomplete specimens the shape and venation of the entire *Belemnopteris* leaf was preserved or could be reconstructed. Feistmantel gave the following diagnoses and descriptions of the genus *Belemnopteris* and the type-species *B. wood-masoniana:*

Genus *Belemnopteris* (Feistmantel, 1876, p. 370):

"*Fronde simplici late sagittaefoliosa pedunculata. Nervis primariis tribus, medio crassiore, ceteris anastomosantibus.*" He further recorded that "Amongst Mr. Wood-Mason's specimens are two, of which one is

tolerably complete and has an arrow-like shape; with 3 chief veins, one stronger passing into the leaf, two others a little thinner into the two basal lobes; the other venation is netted."

Belemnopteris wood-masoniana (Feistmantel, 1876, p. 371, Pl. XX, figs 1-2) - Figure 1 in the present paper.

"*Fronde simplici, late sagittaefolia, apice obtusa, margine integerrima, tota ad 10.5cm longa, lobis obtuse acuminatis longioribus (5.3cm longis); nervis primariis tribus; uno crassiore in folii superficiem excurrente, duobus aliis tenuioribus, in lobos currentibus, omnibus tribus apicem versus attenuantibus; nervis secundariis sub angulo subacuto eggredientibus, anastomosantibus, retia plerumque hexagonalia, sed etiam polygonalia, formantibus. Fructificatione ignota.*" ... nothing like it being known amongst fossils.

He further noted that " The frond is simple, is shaped like a broad arrow, at the apex obtuse; the margin entire, slightly arcuate, the total length 10.5cm; the basal lobes obtusely acuminate, pretty long (5.3cm). The chief characters lie in the veins: there are three chief veins, one passing into the surface of the leaf, the two others, a little thinner, into the two basal lobes. The secondary veins pass out at a subacute angle so as to form a net-venation with hexagonal or polygonal meshes."

Feistmantel later (1880-1881, p. 112) mentioned that no other specimens had been found since he described and figured the two fragments in 1876. At that time he presented the following description of *B. wood-masoniana:*

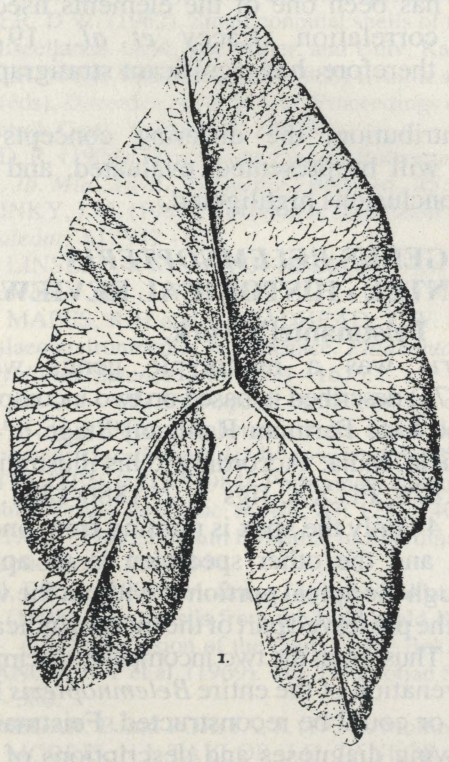
"The fossil has the shape of a broad arrow-head; the lobes directed downwards, large; margin entire; three chief veins, one of which passes into the leaf towards the apex, while of the two others one passes down into each lobe. The secondary veins between form a nice net venation of conspicuous meshes."

In a foot-note Feistmantel explained the derivation of the generic name: "Belemnon (Gr.) = the arrow: pteris= fern."

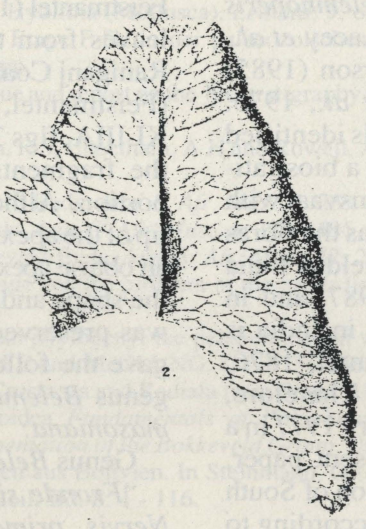
In 1881 Feistmantel (Pl. XLIIIA, figs 3, 4) illustrated the apical portion above the basal fragment to indicate the reconstruction of a complete *Belemnopteris* leaf. The set of diagnostic characters of *Belemnopteris* is:

i) the arrow-headed shape of the leaf; ii) the tri-partite main venation; and iii) the anastomosing secondary venation.

O. FEISTMANTEL Journ. Asiat. Soc. Bengal. Vol. XLV. P^{t} II. 1876. PLATE. XX.



1.



2.

BELEMNOPTERIS WOOD-MASONIANA, n. sp., Pl. XX, Figs. 1—2.

Fronde simplici, late sagittaefolia, apice obtusa, margine integerrima, tota ad 10·5 *cm longa, lobis obtuse acuminatis longioribus (*5·3 *cm longis); nervis primariis tribus; uno crassiore in folii superficiem excurrente, duobus aliis tenuioribus, in lobos currentibus, omnibus tribus apicem versus attenuantibus; nervis secundariis sub angulo subacuto eggredientibus, anastomosantibus, retia plerumque hexagonalia, sed etiam polygonalia, formantibus. Fructificatione ignota.*

Of the relations of this fern I have already spoken when discussing the genus; they are only in the living flora, nothing like it being known amongst fossils.

The frond is simple, is shaped like a broad arrow, at the apex obtuse;

Figure 1. The original diagnosis and illustration of the type-species of *Belemnopteris* by Feistmantel.

The anastomosing secondary venation was known in Feistmantel's time to be a character common to both *Belemnopteris* and *Glossopteris*. Species of *Glossopteris* discovered later proved that the tri-partite main venation was also a common character of the two genera (e.g. Holmes, 1981). The only distinguishing generic character of *Belemnopteris* that remained was the shape of the leaf.

The diagnostic value of a character based on a single specimen (Feistmantel, 1876, Pl. XX, fig. 1) is justifiably questionable. Furthermore, this specimen was lost (Pant and Choudhury, 1977, p. 153). However, several leaves tapering towards apices from bases with large lobes have been found in the Raniganj Stage of the Raniganj Coalfield, from where Feistmantel's (1876) material originated. Among these leaves, two further species of *Belemnopteris*, distinct from *B. wood-masoniana* were recognised (Pant and Choudhury, 1977). About eighty specimens and three species render evidence in support of the validity of the genus *Belemnopteris*.

BELEMNOPTERIS LEAVES DESCRIBED BY PANT AND CHOUDHURY (1977)

The leaves of *Belemnopteris sagittifolia* Pant and Choudhury 1977 differ from the type specimens of *B. wood-masoniana* in having a more elongated lamina in which the base may be sagittate or hastate and the apex acuminate or obtuse. The meshes of *Belemnopteris pellucida* Pant and Choudhury 1977 are linear, polygonal, and longer than those in *B. wood-masoniana* (Pant and Choudhury, 1977, pls 1, 2, 5). In their emended generic diagnosis the hastate base, acuminate apex and the epidermal characters were mentioned as characters additional to those described by Feistmantel (1876).

In their emended diagnosis, Pant and Choudhury (1977, p. 154) omitted mention of the shape of the leaf, which is the most important distinguishing character of *Belemnopteris*. Pant and Choudhury (1977, p. 153) thought that Feistmantel applied the binomen *Belemnopteris wood-masoniana* "to a single complete leaf and a few small fragments." They also appear to have interpreted the shape of the fragment without the apex preserved as the shape of an entire leaf (p. 158). Perhaps they omitted to state the shape of the *Belemnopteris* leaf because they re-emended the emended diagnosis of *Belemnopteris* of Lacey *et al.* (1975), being evidently unaware of the erroneous concept of the genus formed by the latter authors (see below).

DEFINITION OF MORPHOLOGICAL TERMS RELEVANT TO *BELEMNOPTERIS* AND TO LEAVES REFERRED TO AS *BELEMNOPTERIS*

It seems desirable to define some morphological terms that deal with leaf shape because the error that led to synonymization of *Belemnopteris* was due to a failure to distinguish between a leaf which is "sagittate" in its overall shape, and one which has a sagittate base.

Feistmantel (1876, p. 370) defined the *Belemnopteris* leaf as "sagittaefoliosa", or "arrow-like shape". The generic name also indicates the shape of an arrow (Feistmantel, 1880-1881, p. 112). The head of an arrow gradually tapers towards its tip for the purposes of entering a target. Its basal lobes are large.

Definition of the arrow-headed or "sagittatus" shape of a leaf (fig. 2) is as follows: "gradually enlarged at the base into straight lobes, like the head of an arrow" (Stearn, 1978, p. 327). Comparison of the modern definition and the illustration of the arrow-headed shape which appeared with Feistmantel's diagnosis, description and illustration of *Belemnopteris wood-masoniana* in 1876 discloses the same meaning of the terms "arrow-like" and "arrow-headed".

A halbert-headed, or hastatus, leaf also attenuates towards the apex from a broad base with large lobes. The main difference between arrow-headed and halbert-headed leaves is in the nature of the basal lobes: a halbert-headed leaf is "abruptly enlarged at the base into two acute diverging lobes, like the head of a halbert" (Stearn, 1978, p. 327).

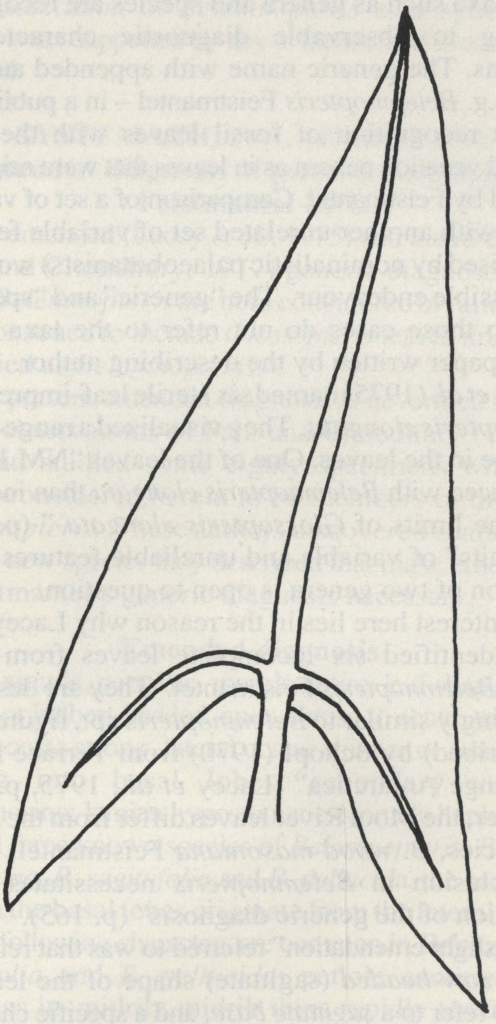


Figure 2. The arrow-headed leaf, tapering towards apex from a base with two large lobes directed downward.

Regardless of overall leaf shape, the base of a leaf may be sagittate or hastate (Stearn, 1978, p. 330). A leaf with arrow-headed shape necessarily has a sagittate base, and the base of a halbert-headed leaf is hastate. However, leaves of many other shapes may also have sagittate or hastate bases.

If in describing the venation of a leaf with a "sagittate base" (Lacey *et al.*, 1975, p. 365), or "sagittate to hastate base" (Pant and Choudhury, 1977, p. 154), the *shape of the leaf* is omitted, then the diagnosis might apply either to *Belemnopteris* or to leaves of certain species of *Glossopteris* (Pant and Choudhury, 1977, p. 158; Anderson and Anderson, 1985, p. 127). The citation of diagnoses that omit one or more of the three characters diagnostic for *Belemnopteris* must inevitably lead to considerable confusion.

GLOSSOPTERIS LEAVES NAMED AS *BELEMNOPTERIS*

Lacey *et al.* (1975, p. 360) believed the leaf shape, size and venation pattern to be variable, and therefore unreliable, macroscopic features. Nevertheless, they assigned generic and specific names to leaves in which only these "features" were preserved. In taxonomy, the various taxa such as genera and species are recognised according to observable diagnostic characters in specimens. The generic name with appended author's name – e.g. *Belemnopteris* Feistmantel – in a publication indicates recognition of fossil leaves with the same shape and venation pattern as in leaves that were originally described by Feistmantel. Comparison of a set of variable features with another unrelated set of variable features (as practised by nominalistic palaeobotanists) would be an impossible endeavour. The "generic" and "specific" names in those cases do not refer to the taxa in the original paper written by the describing author.

Lacey *et al.* (1975) named six sterile leaf-impressions *Belemnopteris elongata*. They visualized a range of size and shape in the leaves. One of the leaves "NM 1772 is better placed with *Belemnopteris elongata* than included within the limits of *Glossopteris elongata* " (p. 373). The "limits" of variable and unreliable features in the distinction of two genera is open to question.

The interest here lies in the reason why Lacey *et al.* (1975) identified six incomplete leaves from Mooi River as *Belemnopteris* Feistmantel. They are described as "strikingly similar to *Belemnopteris* sp., figured (but not described) by Schopf (1970) from Terrace Ridge, Ohio Range Antarctica" (Lacey *et al.*, 1975, p. 373). "However, the Mooi River leaves differ from the Indian type-species, *B. wood-masoniana* Feistmantel, ... and their inclusion in *Belemnopteris* necessitates slight emendation of the generic diagnosis" (p. 165).

The "slight emendation" referred to was that reference to the *arrow-headed* (sagittate) shape of the leaf was altered to refer to a *sagittate base*, and a specific character evident in *B. wood-masoniana* was added to the generic characters, namely the possession of hexagonal and polygonal meshes. Furthermore, the meshes were now interpreted to be "large open" (Lacey *et al.*, 1975, p. 365).

The authors probably considered the diagnoses of *Belemnopteris* and *B. wood-masoniana* by Feistmantel insignificant because they believed the meshes were merely variable features in the venation pattern. The authors also seem to have exempted themselves from the requirements of their own emended generic diagnosis (Lacey *et al.*, 1975, p. 365) – it seems that such features are not obligatory in specimens they recognise as *Belemnopteris*. A "narrower reflexed branch ... (of the strong midrib)" obviously could not be present in any of the tiny lobes of specimens NM 1741 and NM 1772 (pp. 374, 375). But the most significant alteration in the diagnosis of *Belemnopteris* is the replacement of sagittate *shape* with sagittate *base*.

Although in semantic terms this alteration may seem "slight", in reality it made it possible to include *Glossopteris* leaves from both Antarctica (Schopf, 1970) and Mooi River (South Africa) into *Belemnopteris*. Following this alteration, the name "*Belemnopteris*" no longer denotes the same genus as described and named by Feistmantel in 1876. Lacey and co-authors effectively adjusted the generic definition of *Belemnopteris* based primarily on a fragment from Antarctica which was misidentified as *Belemnopteris*. *Glossopteris* leaves similar to that fragment, assumed to be *Belemnopteris*, were then used to support the correlation of the South African Beaufort Group and the Indian Raniganj Stage.

Pant and Choudhury (1977) noticed the generic difference between genuine *Belemnopteris* leaves and the leaves named by Lacey *et al.* (1975) as *Belemnopteris*. Nevertheless, they tried to interpret the leaves of *Belemnopteris elongata* Lacey *et al.* (1975) according to the name, and not according to the characters evident in the leaves. Pant and Choudhury (1977) mentioned that the leaves of *Belemnopteris elongata* "show very small basal lobes which sometimes look like mere outgrowths of the midrib at the base of an otherwise typical *Glossopteris* type of leaf". They concluded that *B. elongata* then may be "a transitional stage ... between typical leaves of *Glossopteris* and *Belemnopteris*". Pant and Choudhury (1977) also wrote about "similar sagittate leaves in Antarctica, Africa and ... India", referring to the *Glossopteris* leaves in Antarctica and South Africa named by Schopf (1970) and Lacey et al., (1975) as *Belemnopteris*, and the genuine Indian *Belemnopteris* leaves as described by Feistmantel (1876) and themselves (Pant and Choudhury, 1977, pp. 155, 158). Although Pant and Choudhury noticed that "the various leaves described ... under the same name *B. elongata* may ... belong to more than one species", they nevertheless compared their *Belemnopteris sagittifolia* with *B. elongata*, accepting that the latter was a well defined species of *Belemnopteris* (Pant and Choudhury, 1977, p. 155, 158, 161, 164).

Pant and Choudhury (1977) identified about eighty

leaves as *Belemnopteris* and also recognised two new species of the genus according to diagnostic characters in the leaves. It is interesting to note that they did not conclude that the Antarctic and South African leaves were misidentified as *Belemnopteris* by Schopf (1970) and Lacey *et al.* (1975), and that the misidentification and erroneous emended generic diagnosis needed correction.

Rigby (1978, p. 27, figs 25c, 26c) illustrated a basal portion of a fossil leaf from Australia, and named the specimen *Belemnopteris elongata* Lacey et al., 1975. This specimen has no indication that the leaf was arrow-shaped or that there were any basal lobes present - i.e. the diagnostic characters of *Belemnopteris* as defined by Feistmantel were not present. Rigby (1978, p. 27) cited *Belemnopteris wood-masoniana* as the type-species of the genus, although he found it "conceivable that both leaf species..." (viz. *Belemnopteris elongata* and *Glossopteris elongata*) "grew on trees of the same, or closely related species". He explained the differences in terms of leaves of two distinct genera growing on trees which belonged to the same or closely related species. In that situation *B. wood-masoniana*, as a "type-species", would obviously be meaningless.

The interpretation of *Glossopteris* leaves named as *Belemnopteris* has therefore shown a progression: firstly, instead of the overall leaf shape, only the shape of the base of the leaf was considered; secondly, Lacey *et al.* (1975, pp. 374-375) illustrated a range of leaves showing relatively large to tiny basal lobes; and finally, the "*Belemnopteris*" leaf figured by Rigby (1978, figs 25, 26) had neither the basal lobes nor the arrow-shape.

Pant and Choudhury (1977, p. 155) postulated a transition between *Glossopteris* and *Belemnopteris* leaves, and Rigby (1978, p. 27) found it conceivable that leaves of the two genera grew on trees of the same species.

CONTRIBUTION OF ANDERSON AND ANDERSON (1985)

A further step in the history of this genus was that, according to Anderson and Anderson (1985), a range of morphological variation exists, from weakly sagittate to cuneate leaf base. Anderson and Anderson (1985, p. 127) cited the genus *Belemnopteris* Feistmantel 1876 as a synonym of the genus *Rigbya* Lacey *et al.* 1975, which was based on a female fruit. Several factors suggest that there is no evidence or justification for this action:

i) the genus *Belemnopteris* was described from India and has since not been reported from other continents. As has been discussed above, the *Belemnopteris elongata* of Lacey et al. (1975), the *Belemnopteris elongata* of Rigby (1978) from Australia, and the *Belemnopteris* sp. of Schopf (1970) from Antarctica, are misidentifications.

ii) species assigned to *Rigbya* have never been reported from India (see Lakhanpal et al., 1976; Anderson and Anderson, 1985, p. 127).

iii) according to Anderson and Anderson (1985, p. 127), "The polysperms, microsporoclads and leaves grouped together here as *Rigbya* have not been found in organic connection, but from their distribution in the Estcourt Fm. assemblages a strong claim for their affiliation is justified." There is a distinct difference between evidence, e.g. organic connection, and a highly speculative "strong claim for their affiliation".

iv) according to Anderson and Anderson's (1985, p. 127) generic diagnosis of *Rigbya*, the leaf characters are known only for *Rigbya arberoides* Lacey *et al.*, 1975. According to them (p. 127) *R. arberoides* is a palaeospecies with a range restricted to the South African Upper (late) Permian. They cite *Belemnopteris* as a synonym of *Rigbya*, and should then include India within the range of *Rigbya*.

v) to finally confuse matters, Anderson and Anderson (1985, p. 421) recorded that "the leaf genus *Glossopteris*, ... is congeneric with several distinct female fruit genera – *Lidgettonia, Arberia, Rigbya* ..." This directly implies that *Glossopteris* is also a synonym, along with *Belemnopteris*, of *Rigbya*. *Glossopteris* does not, however, appear in their list of synonyms.

Consideration of *Belemnopteris* as a synonym of *Rigbya* is not supported by any evidence, and is accordingly rejected.

SYSTEMATIC PALAEOBOTANY

Emended diagnosis of genus *Belemnopteris* Feistmantel 1876.

The emended (Lacey *et al.*, 1975) and the re-emended (Pant and Choudhury, 1977) generic diagnoses of the genus *Belemnopteris* are here considered invalid as they were construed to include *Glossopteris* leaves mistakenly identified as *Belemnopteris*.

The present emended diagnosis is nevertheless based on the observations of Pant and Choudhury (1977) as they had studied some eighty specimens which are indeed considered herein to be members of the genus *Belemnopteris*. These authors discovered characters in the two new species they described that make emendation of Feistmantel's generic diagnosis necessary.

Emended diagnosis

Leaf simple, petiolate, margin entire, leaf shape arrow-headed or halbert-headed, apex obtuse to acute; tricostate, median costa strong, lateral costae thinner or evanescent, passing into basal lobes; secondary venation anastomosing; lamina hypostomatic, stomata haplocheilic.

In all three known species of *Belemnopteris*, *B. wood-masoniana*, *B. sagittifolia* and *B. pellucid*a, the secondary veins in the basal lobes originate from the lateral costae.

The following characters are common in *Belemnopteris sagittifolia* and *B. pellucida*: petiole continues into lamina as its midrib; midrib thins rapidly towards the apex; lateral costae are much thinner than the midrib.



Figure 3

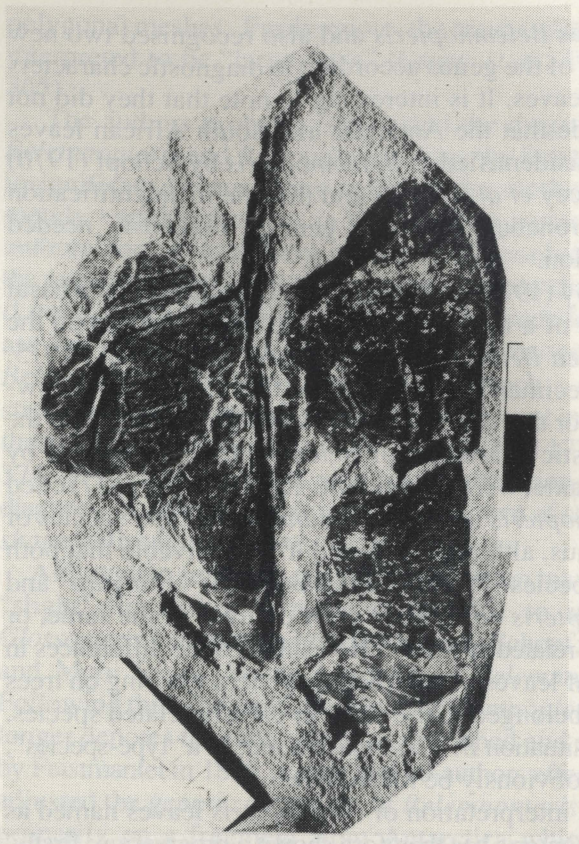


Figure 4



Figure 5



Figure 6

Figure 3. *Belemnopteris* pellucida Pant and Choudhury from an Ecca flora, near Hammanskraal.
Figure 4. *Belemnopteris pellucida* Pant and Choudhury - the basal portion of the leaf in Figure 3.
Figure 5-6. *Belemnopteris pellucida* Pant and Choudhury -enlarged photographs of the leaf in Figure 3 to show the venation.

Comments:

Some of these *Belemnopteris* leaves have a halbert-headed shape (Pant and Choudhury, 1977, text figs 1D, 2 B-C; Pl. 1, fig. 5, Pl. 2, figs 7, 9, 10). The halbert-headed shape appears, however, not to be a specific character. In one specimen (text fig. 2A, pl. 1, fig. 2) the one basal lobe may be directed downward whilst the other may point outwardly. The arrow-headed to halbert-headed shape comprises individual variation within the species *Belemnopteris sagittifolia* Pant and Choudhury, 1977. With regard to the apex in leaves of *B. sagittifolia*, this is described as "acuminate to obtuse". Following the terminology presented by Stearn (1978, p. 328-329) the apex of *B. sagittifolia* is defined as "acute to obtuse". "Midrib with a number of longitudinal strands" was noted by Pant and Choudhury (1977, p. 154). A midrib by definition is a central and principal vein (e.g. Hill *et al.*, 1960, p. 603) and consequently the longitudinal strands cannot be termed "midrib" (see discussion in Kovács-Endrödy, 1979). Longitudinal "strands" instead of a midrib in the leaves seem to be a characteristic of pteridosperms. In the illustrations of *Belemnopteris* leaves presented by Pant and Choudhury (1977), the presence of longitudinal strands is not unequivocally evident. Emendation of the generic character in this matter is, therefore, omitted. Pant and Choudhury (1977) examined and described the epidermal characters of *Belemnopteris* leaves, providing additional knowledge of the genus.

DESCRIPTION OF A LEAF OF *BELEMNOPTERIS PELLUCIDA* PANT AND CHOUDHURY 1977 FOUND IN THE ECCA GROUP OF THE TRANSVAAL (FIGURES 3 -6)

A leaf (cat. no. M. I. 60a in the collection of the Geological Survey, Pretoria) was found in a (Middle) Ecca flora, in the Hammanskraal Quarry of Verref Mining Co (Pty) Ltd, previously known as Marico Mineral Co (Pty) Ltd, about 30km north of Pretoria. Identification of the South African leaf is based on comparison with macroscopic diagnostic characters in the diagnosis, description and illustrated specimens of *Belemnopteris pellucida* (Pant and Choudhury, 1977, text fig. 4A, Pl. 5, figs. 30, 32, Pl. 6, fig. 39; pp. 161, 162). *B. pellucida* was originally established on the observation of three almost complete leaves and two basal portions found in the Raniganj coalfield (Raniganj Stage), West Bengal, India (Pant and Choudhury, 1977, p. 161). The leaf can be described as follows: Shape of the leaf is arrow-headed, the leaf is broadest above the basal lobes: basal lobes are obtuse. Margin is slightly thickened. Petiole is 4mm broad where it enters the lamina; (in the South African leaf the preserved part of the petiole is 22mm long). Secondary veins leave the midrib at an acute angle, then run almost perpendicularly to the margin; distance between two secondary veins near midrib is 1.5-2mm, diminishes slightly towards margin (cf. photograph Pl. 5, fig. 32 in Pant and Choudhury, 1977). First meshes near midrib are short (3-5mm), trigonal, rhomboidal and polygonal, may be curved where secondary veins alter their course from steep to perpendicular; following meshes are polygonal, linear, 6-8 mm long; some of the meshes may be longer; near margin the meshes are 2-4 mm long. Size of the Indian *B. pellucida* leaves is up to 16 cm long, and 5-7.5 cm wide. The South African leaf is 6 cm wide at its broadest part. Extrapolating the margins, the length of the leaf is estimated as 14 cm. The apex is not preserved in the 12 cm long South African fragment.

COMPARISON

The South African leaf differs from the Indian *B. pellucida* leaves in the position of the lateral costae in the basal lobes. Lateral costae run at the basal margins of lobes, and not at a distance in from the margins. The well preserved lobe of the South African specimen is 2.5 cm long measured from midrib to the tip of the lobe; the lobes of the Indian leaves are 3 to 5 cm long. The position of the lateral costae is variable in the Indian *Belemnopteris* leaves, and in some of the illustrated leaves they are almost marginal (Pant and Choudhury, 1977: Pl. 2, figs 7, 9). On the evidence of the many common diagnostic characters in the South African leaf and in the Indian *B. pellucida* leaves, the position of or difference in the lateral costae is considered to be due to individual variation.

SIGNIFICANCE OF *BELEMNOPTERIS* IN THE CORRELATION OF FLORAS

Biostratigraphic correlation is based directly on fossils and is therefore directly dependent on the correct, reliable and repeated identification of organisms. The taxonomic method appears at present to be the only approach that fulfills this requirement. When plant fossils are identified to generic and species level according to the traditional taxonomic method, they indicate a correlation of the Ecca flora in the Transvaal with Late Permian Indian and Australian floras (Zeiller, 1896; Kovács-Endrödy, 1983, 1987, and a paper in press). The presence of *Belemnopteris* in the (Middle) Ecca is especially significant when correlating with the Indian Raniganj Stage. Feistmantel (1876) described the genera *Belemnopteris*, *Palaeovittaria* and a species *Glossopteris communis*, as new taxa from the Raniganj Stage of the Raniganj Coalfield. These came from one locality. According to Plumstead (1958), Kovács-Endrödy (1976, 1987) and Anderson and Anderson (1985), *Palaeovittaria* leaves and *G. communis* occur in (Middle) Ecca floras. The presence of *Belemnopteris pellucida* in a (Middle) Ecca flora would then offer additional evidence for a correlation with the Late Permian Raniganj flora. The distribution of the *Scutum* fructification in South Africa and India (Lakhanpal *et al.*, 1976, p. 226) and the presence of *Cyclodendron leslii* (Chandra and Rigby, 1981) offers further support of this correlation.

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