ON THE SIGNIFICANCE OF SOME NEW FORMS OF *NEUROPTERIS GIGANTEA* STERNBERG FROM THE CARBONIFEROUS OF ANATOLIA (TURKEY)[1]

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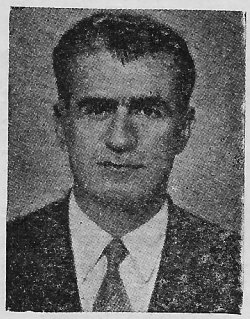
ABSTRACT.—A number of specimens from the Carboniferous strata of Anatolia, are found to be deviating types of *Neuropteris gigantea* as originally described and illustrated by Sternberg. These were distinguished as four new varieties, but subsequent examination revealed evidence sustaining the establishment of a wholly different new genus and species of the local fossil flora. The palaeobotanical and stratigraphic import of these special forms is briefly discussed.

INTRODUCTION

As a result of the paleontological studies sponsored by the M. T. A. Institute, in relation with the detailed geology and exploration of the coal-fields of Turkey, a great number of fossil plants have been gathered. All of these, now preserved in the Museum of the Institute, have been seen, determined and classified by myself, and a big representative collection has been studied and compared with the rich collections of the Geologisch Bureau of Heerlen, Holland, where the vigilant guidance of Prof. Dr. W. J. Jongmans, during my stay there in 1938-40, was a great help. Since then many more specimens have been collected both from field surveys, and from underground explorations in the mines of the Zonguldak Coal Basin and the deep borings in the sectors as yet not opened to exploitation. The accumulated collections offer now ample material for the treatment of many stratigraphic, and palaeontological problems of the Turkish Carboniferous formations as yet unclarified, as set forth in the publications of Zeiller (16), Ralli (9), Wilser, (15), Hartung (21), Jongmans (4), Grancy (3) and Arni (4).



The material on which this paper is based is derived from the various Carboniferous outcrops scattered along the Black Sea coast, between Eregli (Heraclea) and Inebolu (see Text-fig. 1), and comprises several hundred specimens for each of the more abundant forms.

COMPARISON AND DISCUSSION OF THE N. GIGANTEA GROUP

The M. T. A. Collections of this group include numerous specimens deviating from the type as originally described and illustrated

[1]This paper constitues a resumé of section 11. "Palaeobotanical data concerning the derivation and emergence of the earliest known vein meshes", Chapter VI, of an unpublished dissertation by the author entitled: A comparative study on the leaf-architecture of some fossil plant forms, tending to explain the derivation and significance of reticulate venation, with particular reference to the flora of the Anatolian Carboniferous strata; 1941; pp. 1-126; Plates I-XXXIX.

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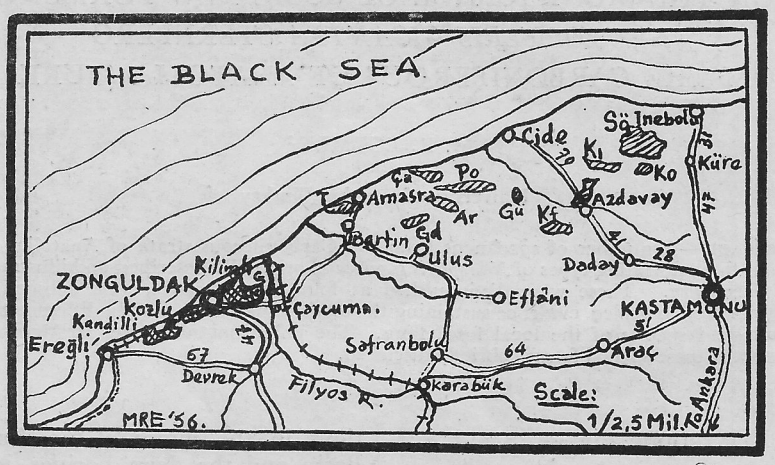
by Sternberg (11), Zeiller (16), Stockmans (12) and Corsin (20), among many other authors to whom reference is impossible here. Such deviating forms or varieties have, as yet, not been reported from elsewhere, and no differentiation has been undertaken of similar types as characterised by the diagnostic features outlined below.



Text-fig. 1. Sketch-Map of the Carboniferous outcrops of Anatolia, Turkey. The shaded areas indicate the respective coal-fields of Kandilli, Kozlu, Kilimli and Gelik (G) within the limits of the Zonguldak Basin as well as the outcrops east of the Filyos river of Amasra-Tarlaagzi (T), Cakraz (Ca), Gurendere (Gu), Karafasil (Kf), Azadavay, Kirmaci (Ki), KoZluviran (Ko) and Sogutozu (So).

Among the numerous specimens studied, four different forms of *N. gigantea* have been distinguished at the outset. These were:

1. *Neuropteris gigantea* forma A (n. var.)
2. *Neuropteris gigantea* forma B (n. va
3. *Neuropteris gigantea* forma C (n. var.
4. *Neuropteris gigantea* forma D (n. var.)

1. NEUROPTERIS GIGANTEA FORMA A (N. FA.)
(Plate 30, fig. 1, 1a)
2. NEUROPTERIS GIGANTEA FORMA C (N. FA.)
(Plate 30, fig. 3)
3. NEUROPTERIS GIGANTEA FORMA B (N. FA.)
(Plate 30, figs 2, 2a)

A comparative analysis of the morphological features revealed a progressive succession from comparatively more primitive to more advanced ones, this sequence being based on the following criteria of systematic evaluation and diagnosis :

(*a*) the degree of differentiation in respect of the orientation of pinnules on the fronds, and the development of falcated habit of leaflets;

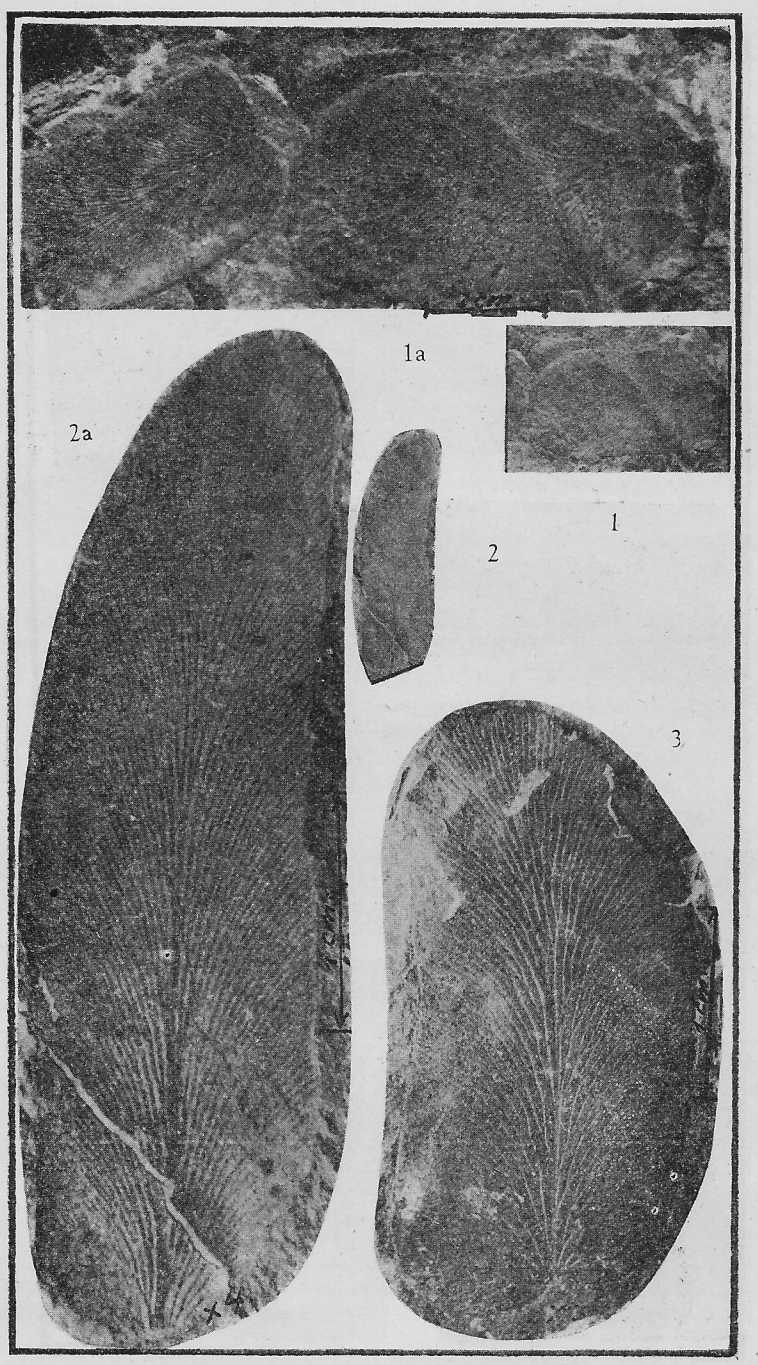
(*b*) the degree of elongation of the individual pinnules, varying from 1:2 in the rather primitive (typical) cases, and increasing to the ratio of 1:4 in the most advanced forms;

(*c*) the degree of development of the mid-rib; and,

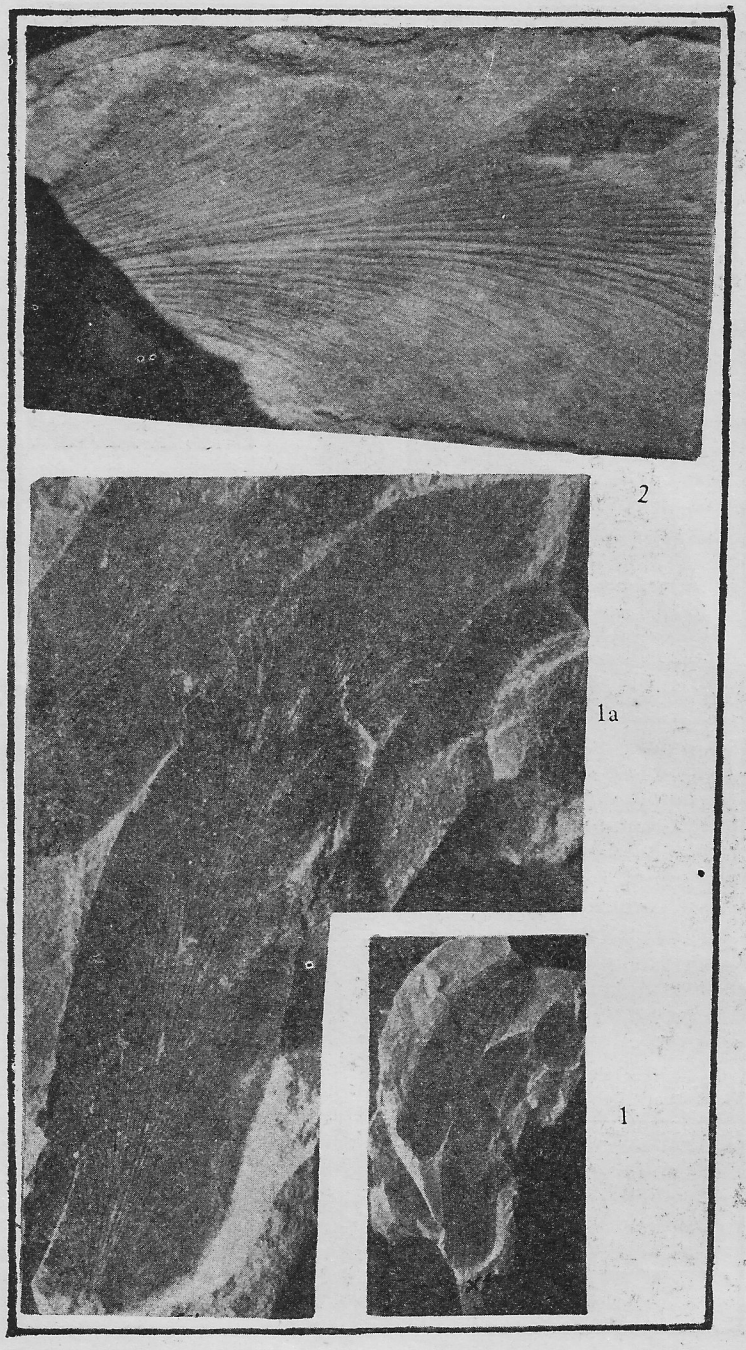
(*d*) the degree of conspicuousness and density of venation, so that there are 30-35 veinlets in Forma A, in comparison to 45-55 veinlets, in Forma D, per centimetre of leaf-margin.

EXPLANATION OF PLATE 30

FIG. 1 —*Neuropteris gigantea forma* A. Zonguldak, coll. 347, A. E. (×1).
1a—Idem. (×2).
2 —*Neuropteris gigantea forma* B. Zonguldak, coll. 349, A. E. (×1).
2a—Idem. (×4).
3 —*Neuropteris gigantea forma* C. Zonguldak, coll. 317, A. E. (×4).



EGEMEN : NEW FORMS OF NEUROPTERIS GIGANTEA



EGEMEN : NEW FORMS OF NEUROPTERIS GIGANTEA

Further evidence as to the stratigraphic distribution of the different types has shown a general trend of parallelisation of the forms with more advanced characteristics to be younger in their stratigraphic positions and vice versa. We thus observe the following parallelism in the stratigrahpic succession of the forms in question; in all instances these are accompanied by floral associations which definitely characterise the respective stratigraphic horizons and stages as given here blow:

(*i*) *Neuropteris gigantea* forma A generally met in layers of upper Namurian to lower Westphalian A.

(*ii*) *Neuropteris gigantea* forma B generally encountered in layers of upper Westphalian A and Westphalian B.

(*iii*) *Neuropteris gigantea* forma C also of the same statigraphic position as *N. gigantea* forma B.

(*iv*) *Neuropteris gigantea* forma D is generally a late comer in the Westphalian and is exclusively found in strata of Westphalian C or even D stage[3].

This evidence points to the generally accepted view that the morphogenesis of certain features is nothing but a reflection of the prevailing and compelling changes in the biological milieu. The trend in the development of this group of fossil forms as a whole, points to a certain change in the ecological, and particularly climatic conditions during the early stages of the upper Carboniferous period, as is further supported by still more evidence.

THE EMERGENCE OF PRIMITIVE ANASTOMOSES IN NEUROPTERID VENATION

When the venation of the varieties of *N. gigantea* put, until now, under (Forma D) is examined more carefully, there appears a new and wholly different characteristic in their leaf-architecture, i.e. the presence of very fine, irregular and occasional anastomoses between the adjacent veins. This fact was not noticed at the beginning of our distinction of the four different types of *N. gigantea*, but was detected later on and a revision of the numerous specimens proved that this new feature, in conjunction with the rest of the diagnostic characters, was of such an import as to enhance the institution of a new genus and species instead of the (Forma D) in question. Since such a type was never encountered among the innumerable specimens described and illustrated thus far, I propose to give a brief description of this nova of the Turkish carboniferous flora as well as the related *N. gigantea* forms mentioned above, and to hint to their significance from the palaeobotanical as well as stratigraphic angles in the concluding remarks.

DESCRIPTION OF THE MENTIONED FORMS

NEUROPTERIS GIGANTEA forma A (n. fa.)
(Pl. 30, fig. 1, 1a)

The distinguishing features of this form are summarised as follows:

Margins of individual pinnules are almost parallel with bluntly rounded tips. They are the least falcate of all the types studied, and as such may well be compared to the type forms of Sternberg.

There is no distinctly traceable midrib, the veins making the impression as though they come out from the point of attachment of the pinnule, and radiate in all possible directions. This gives a conspicuous flabelliform aspect to the pinnules.

Venation of individual pinnules is coarse and distinct, the veinlets running with very slight curvatures before touching the margins. The number of veinlets on each cm. of leaf margin fluctuates between 33 and 36, being the least in comparison to the other types. Veins fork once or twice and remain relatively distant from each other.

EXPLANATION OF PLATE 31

FIG. 1—*Linopteridium densenervosa* (n. gen., n. sp.)
Amasra, Tarlaagzi, coll. 556, A. E. (×1).
1a—Idem. (×4).
2—*Linopteridium densenervosa* (n. gen. n. sp.)
Amasra, Tarlaagzi, coll. 556. (×8).

[3]For a revision of the stratigraphic divisions of the Anatolian coalfields as compared to those in other lands, see Jongmans (5).

Localities: From numerous points in Zonguldak (Kozlu, Kilimili and Gelik) and from the Carboniferous outcrops in Amasra, Azdavay and Sogutozu. The respective layers correspond to Namurian C and Westphalian A.

NEUROPTERIS GIGANTEA forma C (n. fa.)
(Pl. 30, fig. 3)

This form is distinguished from the previous one mainly by the repeated forking of veins which increases the number of veinlets abutting on the leaf margins. The number of veinlets touching the margins of the pinnules varies between 36-42 per cm. of leaf border.

In general habit the leaflets are more falcate in appearance and the midrib is more pronounced, proceeding almost till the middle part of the leaflets.

Some types of *N. gigantea* as published by Stockmans (12) resemble this form. There is some resemblance between this form and some specimens in the Heerlen Museum which are put aside by Jongmans as (*N. gigantea fa. falcata*) and (*N. gigantea fa. subfalcata-latenervosa*). Many more specimens originating from the dutch Wilhelmina group, i.e. lower Westphalian A, are quite comparable to this form, so far as the number of bifurcations of the venation is concerned.

Localities: This type is relatively scarce. It comes from the Kozlu layers of Zonguldak, Azdavay and Sogutozu, which correspond to the upper part of Westphalian A, and the lower part of the B.

NEUROPTERIS GIGANTEA forma B (n. fa.)
(Pl. 30, fig. 2, 2a)

The main distinguishing features of this may be summarised as follows:

Pinnules less falcate than the previous form (C), attached almost perpendicularly to the rachis, in general habit shorter than the normal type of Sternberg (11) the ratio of length to width of the pinnules being about 2 :1.

The tips of pinnules are, generally speaking, rounded, so that the leaflets as a whole leave a blunt and dwarf impresssion. The midrib can be traced clearly till about the middle part of the pinnules where they diffuse into radiating veinlets.

Venation quite distinct and in general comparable to the *N. gigantea* var. *abbrevita* F. Stockmans as referred to above. In the material studied the number of veins ending on the leaf margins fluctuated between 45 and 55 per centimeter.

Localities: Zonguldak, Azdavay and Sogutozu. The stratigraphic position of the layers where they were encountered is Westphalian B.

LINOPTERIDIUM DENSENERVOSA (n. gen. n. sp.)
(Pl. 31, figs. 1, 1a. 2)

As referred to above, this new form was originally considered to belong under the *N. gigantea* group, and was set aside under the provisional notation of (Forma D.)

It turned out to possess some characteristics which made imperative the institution of a new genus which I denote as *Linopteridium*, being co-ordinated with Gothan's *Lonchopteridium*, in the case of the Lonchopterid group.

The main distinguishing features of this new species and genus are collectively given below.

The pinnules are conspicuously falcate, ending obliquely and tapering so that they mostly seem to be pointed in their tips.

The size of the average pinnules is about 3-5- 1-1, 5 cm., so that the ratio of length to width is about 4:1.

There is no distinct or pronounced midrib, but instead a median trace from which the arching lateral veins depart and follow a course forming an acute angle with the midrib.

The veinlets are very fine and dense, and are only visible with a 6-10x magnification. This congestion of veinlets resulting from the repeated forking of veins culminates in numerous false and occasional real anastomoses, the leaf-architecture thus leaving the general impression of "fingerprints", particularly towards the marginal regions of the leaflets. The number of veinlets abutting on the leaf border varies between 55 and 65 per cm. of pinnule margin.

Localities: Zonguldak (Karadon), Amasra, Azdavay and Sogutozu. Stratigraphic position of the respective layers where they are met corresponds to the Westphalian B (upper part), Westphalian C and D. They are very abundant in the upper part of of Westphalian C, and are encountered in a number of instances with a floral assemblage

including *Neuropteris ovata* Hoffmann. I picked some typical specimens myself in the Karadon stage of Kozlu, in association with *Sphenophyllum majus* Bronn, *Pecopteris cf. arborescens* Schlothein, *Pecopteridium cf. devillei* Zeiller, *Dicksonites Pluckeneti* Schlotheim, *Neuropteris scheuchzeri* Hoffmann, *N. ovata* Hoffmann, *Cordaites sp.*, and *Renaultia sp.*, indicating a typical Westphalian-D-flora. In the revision of many floral assemblages including this nova of the Turkish Carboniferous strata, I came to the general conclusion that this form transcends the N. gigantea group in the upper Westphalian (C-D) or the upper Karadon Series, and may likely subsist as a transformed survival in the Stefanian or Westphalian E of the carboniferous outcrops east of the Filyos River.

CONCLUDING REMARKS

A comparative study of the various types of the *N. gigantea* group, encountered so abundantly among the coal-measure plants of Anatolia, has led to the discrimination of some new varieties, and the institution of a new generic form.

The progressive development of finer and denser veins and of the emergence of the reticulate type of venation in the successive forms, is of significance both from the purely palaeontological (morphogenetic) as well as the stratigraphical (phylogenetic) viewpoints. The adaptive value of reticulate venation itself, was already demonstrated experimentally by H. Potonié (7) at the close of the last century, proving the physiological as well as mechanical advantages of reticulate venation, against rigorous ecological and climatic circumstances, over that of the parallel or open type of venation in the blades of foliage leaves.

The evaluation of the adaptiveness of reticulate venation may thus be brought into bearing with the advent of changing ecological conditions with dominating land habitats, and with the consequent adaptations in the subsisting plant forms to less and less hygrophytic surroundings. From the palaeogeographical as well as the palaeoclimatological angles, such circumstances involving a sudden (or even gradual) diminuation of the available amount of water and humidity, are considered to have been predominant in the Northern Hemisphere, during the late Palaeozoic times, so that the development of the reticulate venation being accepted to be of greater adaptive value in arid or semi-arid conditions of life, may thus be easily brought in relation with the gradual transformation of the upper Carboniferous scenery and atmosphere from the hygrophytic (P aralic) to the meso-hygrophytic (paralo-lymnic) and to the more exerophytic (lymnic or inland) conditions of life. As is well established for the Permian as a whole, this transformation which must have started during the upper Carboniferous must have brought about very dry or steppe and desert-like ecological environments and habitats in certain regions, and most certainly on the Pontid landmass, which occupied the area now covered by the Black Sea.

The progressive development in more complex leaf-textures with the successive stages of the upper Carboniferous, as demonstrated by many forms of *Linopteris*, *Lonchopteris* and *Lonchopteridium*, is thus extended with still another newer form, all of which go to support the same complex and many-sided evolutionary process.

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