

## PALAEOBOTANY

## A re-examination of the type specimens of *Yuania* H.C. Sze 1953 and its junior synonym *Russellites* Mamay 1968 (Noeggerathiales)

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**Abstract** The noeggerathialean fossil names *Yuania* H.C. Sze and *Russellites* Mamay are shown to be synonymous, with the latter being the junior synonym of the former. Examination and re-illustration of the type material of both *Yuania* and *Russellites* shows that they are indistinguishable taxonomically. Both sets of material have pinnules with clasping bases and concave apices in which the veins converge but do not anastomose. Sze's original description of *Yuania* was incorrect in indicating that the leaves were petiolate and that the veins converged. *Yuania* may be the first plant taxon identified in the Permian floras of China and North America with vegetative and reproductive organs represented on both continents.

**Keywords** Noeggerathiales; Permian; *Russellites* Mamay; synonym; *Yuania* Sze

### ■ INTRODUCTION

In the study of the Paleozoic noeggerathialean plants, there has been a long debate on the status of the fossil names *Yuania* H.C. Sze (1953) from China and *Russellites* Mamay (1968) from America. Du & Zhu (1982) transferred *Russellites taeniata* (Darrah) Mamay to *Yuania* as *Y. taeniata* (Darrah) X.M. Du & J.N. Zhu but this was rejected by Mamay (1990, 1995). As none of these researchers had access to the type material of both generic names, the debate was based on published descriptions and illustrations. Thus, Chinese researchers preferred the name *Yuania* (e.g., Shen, 1995; He & al., 1996; Wang & Shen, 2000; Wang & al., 2004) while Euro-American researchers used *Russellites* (e.g., Taylor & Taylor, 1993; Kerp, 2000; Montañez & al., 2007). In order to clarify this, we have re-investigated the original specimens of both Sze (1953) and Mamay (1968), and herewith report our results.

### ■ ORIGINAL DESCRIPTION OF *YUANIA* H.C. SZE (1953)

In reporting a small flora from the Shihchienfeng Series of northwestern Shaanxi, Sze (1953) described two specimens (Figs. 1–3) as a new genus, *Yuania*. Although the morphological nature of the specimens was not clear, Sze named and described them as *Yuania striata* for the purpose of reference. According to Sze (1953: 19),

[t]he specimens are here described under the supposition that they are parts of Megasporophylls [sic]. The fragmentary Megasporophylls [sic] has a rachis about 1 mm. broad which bears some ovoid fruit or seed-like bodies in two rows. The ovoid bodies are well spaced, alternate to opposite about 11 mm. long and 5 mm. in breadth, and near the apex with

a narrow sinus. The surface of the bodies is marked with very fine longitudinal, more or less converging striations or veins. The base of the bodies is usually prolonged into a short attachment stalk. The internal structure is unknown.

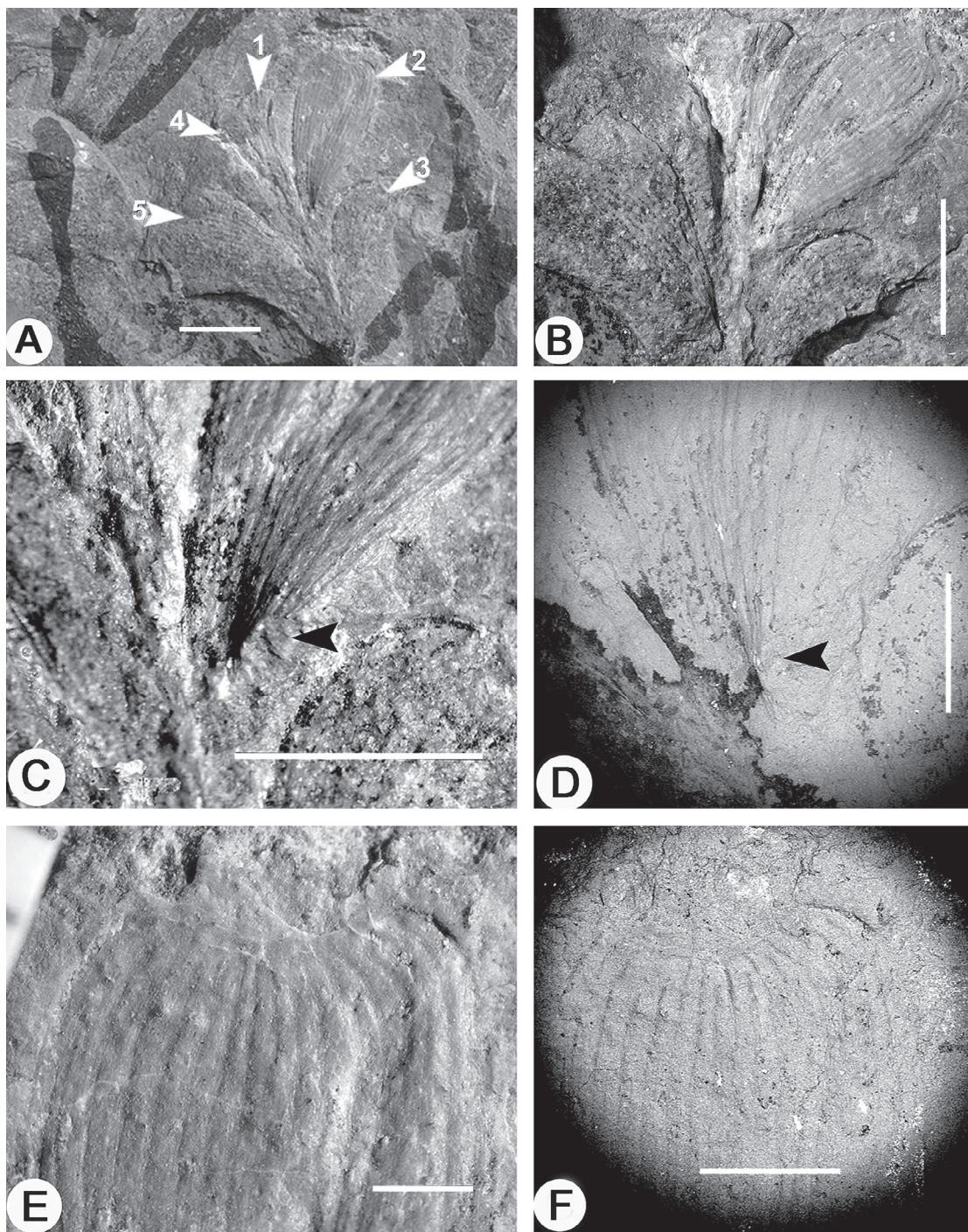
It is not at all certain that these ovoid objects represent seeds or fruits. Granting that the specimens are 'sporophylls', the plant probably belongs to the Pteridosperms, though it is quite different from any known member of that group. There are no clues whatsoever to the plant which bore this sporophylls.

### ■ FIRST REVISION BY GU & ZHI (1974)

Gu & Zhi (1974: text-fig. 12-3; pl. 40, figs. 4–7; pl. 41, fig. 1, refigured herein as Fig. 4A–C) emended the description of *Yuania*. This investigation was not based on the type material but on new specimens from the Upper Permian of Hequ in Shanxi and Shizuishan in Ningxia Autonomous Region. Gu & Zhi (1974: 64) provided a description in Chinese of *Yuania striata* H.C. Sze as the type of the generic name (translated here by senior author):

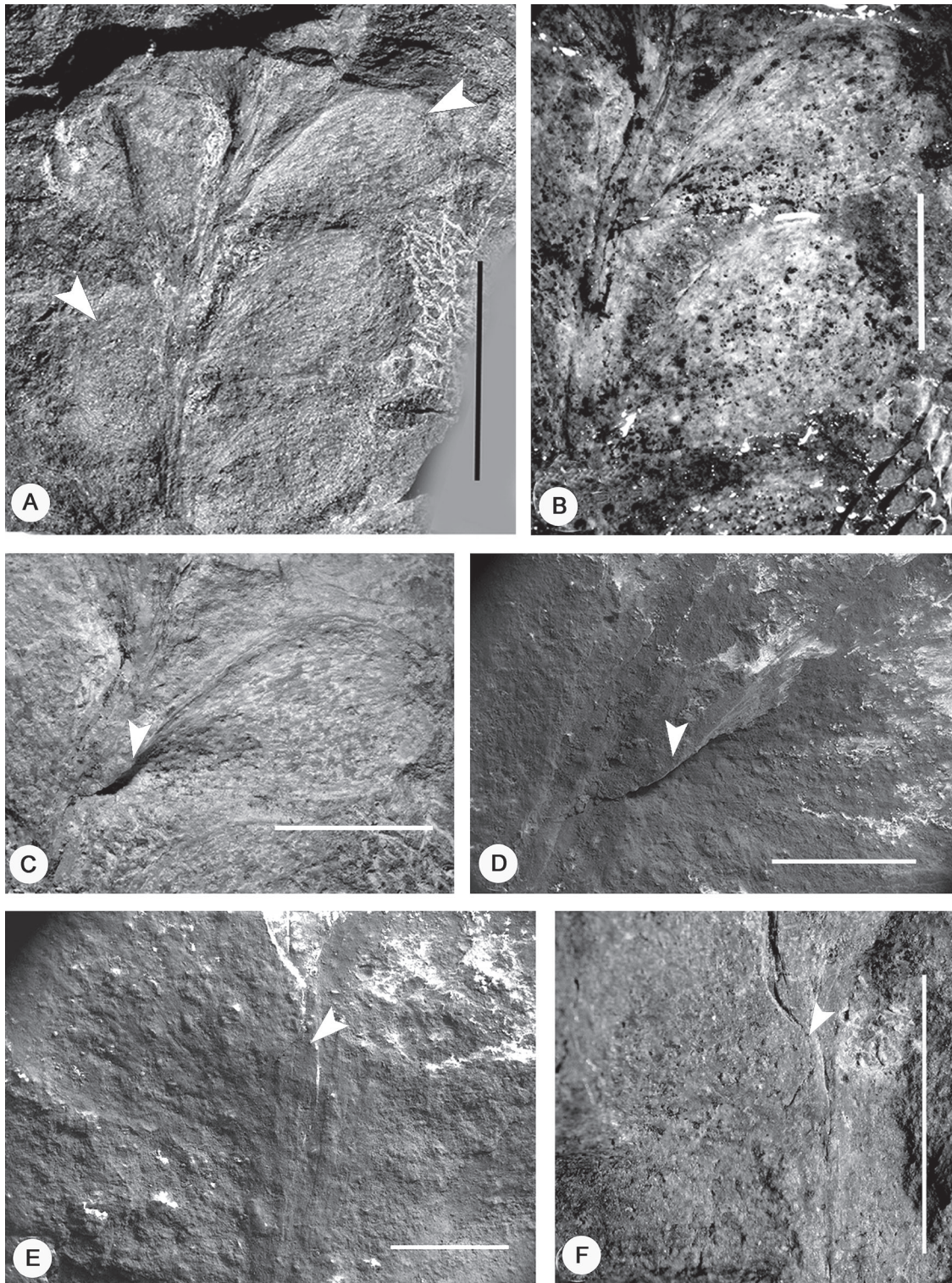
Fronde-like shoot, rachis 1–2 mm thick. Leaves elongate and reversely ovoid, alternate and obliquely attached to the two sides of the rachis. They are well spaced, forming an angle of 60°–70°. Those leaves on the middle part of the shoot are big, usually 1 cm long and 0.5 cm wide; the leaves on the basal part of the shoot are short and small. Leaves are generally clasping the rachis, with entire leaf margin and obtuse apices. Veins are campylodromous and parallel with each other. There are about 6–7 veins at the leaf base. They bifurcate once or twice at the lower and middle part of the leaf, subsequently there are 12–17 veins on the apical part. All veins are gathering toward the apex.





**Fig. 1.** *Yuania striata* H.C. Sze 1953, original material from Shihchienfeng Series of northwestern Shaanxi, Upper Permian. **A–F**, Sze's pl. 1, figs. 6, 6a, designated as the lectotype by Zhang & al. (1992). Registration no. PB2157. Scale bars: A–B, 5 mm; C, 4 mm, D & F, 2 mm; E, 1 mm. **A**, Fragmentary shoot with five leaves (arrows 1–5) recognizable, two (arrows 4, 5) on the left side of the rachis and three (arrows 1–3) on the right side. Leaves 2 and 5 are well preserved, and leaf 5 is the best-preserved one with the leaf margin and venation well defined, but the base is broken. The plant remain is hardly notable so that it was circled by black ink line presumably by Sze. Photographed by normal camera and stereoscopy, showing the fragmentary specimen as a whole. **B**, Magnification of **A**, showing leaves 2 and 5. Photographed by normal camera and stereoscopy, respectively. **C–D**, Magnifications of the base of leaf 2 showing the clasping attachment; arrow indicates the basal attachment, which is incomplete due to damage. At the very base of the leaf, 10–14 veins are visible along the fracture line. The leaf arises plagiotropically from the rachis. The orientation of the leaf suggests that the viewed surface of the leaf is its adaxial side. **C** is photographed by light stereoscopy; **D** is by Scanning Electron Microscopy (SEM). **E–F**, Leaf apex. The obtuse apex is concave (described as a narrow sinus by Sze, 1953). At least 16 veins, probably more, extend to the apical margin, rather than joining at the apical center as interpreted by Sze (1953: fig. 1). **D**, SEM photograph; **E**, stereoscopy photograph.





**Fig. 2.** *Yuania striata* H.C. Sze 1953, original material from Shihchienfeng Series of Northwestern Shaanxi, Upper Permian. **A–F**, Specimen figured in Sze, 1953: pl. 1, figs. 7, 7a. Registration no. PB2158. Scale bars: A, 10 mm; B–C & F, 5 mm; D–E, 1.5 mm. **A**, Light photograph showing the specimen as a whole. There are three leaves on each side of the rachis. Those on the right are more completely preserved. Lower-left arrowhead indicates a leaf that is magnified to show the basal claspings attachment in E and F; upper-right arrowhead indicates a leaf that is magnified to show the gross morphology in C, and the basal claspings attachment in C and D. **B**, Photograph with specimen immersed in alcohol; the outlines of the upper two leaves on the right side are well demonstrated. **C–D**, Stereoscopic and SEM photographs respectively showing the uppermost leaf of the right side. The leaf lamina is oriented with the surface plane representing the abaxial side. Arrowheads indicate the basal claspings attachment. **E–F**, SEM and stereoscopic photographs, respectively, showing the basal claspings attachment of the left-side lowermost leaf.



Essentially, Gu & Zhi (1974) modified the description of *Yuania* in several ways. They interpreted the specimens as a shoot bearing leaves instead of megasporophylls as suggested by Sze (1953) with veins extending to and converging at the apex instead of ending in the central point of the apex as shown in Sze's reconstruction (Sze, 1953: 13, fig. 1); and attachment of leaves oblique and clasping instead of elongated into a short stalk as Sze (1953) stated.

Although the truncated apex of the leaf was not mentioned in the description of Gu & Zhi (1974), their figured specimens (pl. 40, fig. 7, refigured here as Fig. 4A; and pl. 41, fig. 1 refigured here as Fig. 4C) clearly demonstrate truncated apices. Gu & Zhi (1974) only highlighted the obtuse form of the leaf apices, an obvious feature on one of their specimens (pl. 40, fig. 4 refigured here as Fig. 4B).

Although Gu & Zhi (1974) did not mention it, they actually emended the description of the species that included the type of *Yuania* H.C. Sze 1953 and thus that of the genus itself.

### ■ SECOND REVISION BY DU & ZHU (1982)

On the basis of an investigation of the specimens from the Late Permian (Guadalupian-Lopingian) Upper Shihho-tse Formation, Eastern Hill of Taiyuan, Shanxi, Du & Zhu (1982: 5) emended the description of the genus *Yuania* H.C. Sze as follows:

Genus *Yuania* H.C. Sze emended

Leaf dimorphic. Sterile leaf pinnatisect, stipitate. Stipe stout with base expanding and forming pulvinus. Lobe alternate, ovate, elongate-oblong, even spinecent [sic] or spatulate, base contracting and clasping, unequally contorted, apex truncately cuneiform or obtuse. Venation parallel, bifurcate once or twice, gathering and forming cartilaginous margin at lobe apex.

Leaf-scale inserted around the stem base of sterile leaf.

The emendation of Du & Zhu (1982) adds new information on the morphology of the whole shoot, not provided by Gu & Zhi (1974), based on a specimen showing the very basal part of the shoot (Du & Zhu, 1982: pl. 1, fig. 3, refigured here as Fig. 4D). With respect to the similarity to extant cycads through the presence of an expanded base with a pulvinus and spines on the basal part of their axis, *Yuania* was considered to be a cycad by Zhu & al. (1982) when they erected the species *Yuania gigantea* Hu, Du, Zhu & Xiao 1982.

Du & Zhu (1982) proposed the type of their new species name *Y. chinensis* as the type (neotype) of *Yuania*. However, as recognized by Wang & Wang (1987) and Gao & Thomas (1989), such a designation is inadmissible because the original specimens of Sze (1953) are still available in Nanjing. According to the *International code of botanical nomenclature* (*Vienna Code*; Art. 9.6) "a neotype is a specimen or illustration selected to serve as nomenclature type if no original material is extant, or as long as it is missing" (McNeill & al., 2006). Zhang & al. (1992) correctly designated a lectotype

from Sze's original material (Sze's pl. 1, figs. 6, 6a, refigured here as Fig. 1A).

After the above-mentioned emendations, the diagnosis of the genus *Yuania* contains the following conflicting elements:

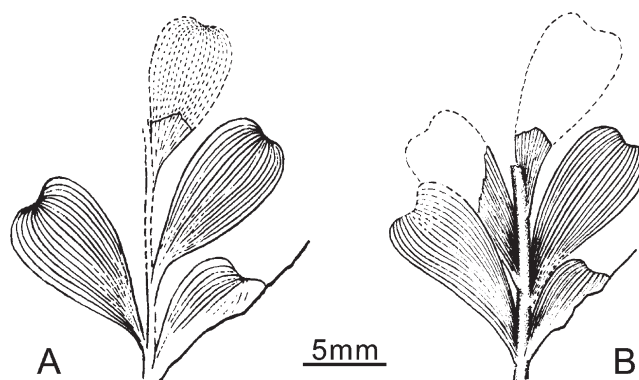
- (1) It represents a frond-like shoot (Gu & Zhi, 1974), or is a pinnatisect leaf with entire margins (Du & Zhu, 1982).
- (2) The attachment of the leaf (lobe) is oblique (Sze, 1953) or clasping (Gu & Zhi, 1974).
- (3) The apex of the leaf (lobe) is obtuse (Sze, 1953) or truncate (Du & Zhu, 1982).
- (4) The veins of the leaf (lobe) are gathering toward the apex (Sze, 1953) or parallel (Du & Zhu, 1982).

### ■ RUSSELLITES MAMAY (1968)

Mamay (1968) proposed the generic name *Russellites* as a correction for Darrah's (1938) misapplication of the name *Tingia* Halle, with *Russellites taeniata* (Darrah) Mamay as the type (here Fig. 5). The generic diagnosis was as follows (Mamay, 1968: 19):

Plant with large, pinnate, bilateral cycadlike frond. Pinnae elongate, alternate, with clasping bases; lateral margins entire, apical margins sharply truncated, with concavely crescentic outlines. Veins numerous to sparse, parallel, sparsely dichotomous, rarely anastomosing, each terminating at apical margin of pinna. Fructifications, cuticular details, and internal anatomy unknown.

It is clear that the features of *Russellites* are extremely similar to those of *Yuania* as emended above. The main similarities include the attachment of the leaf (lobe) base, the form and margin and venation pattern.



**Fig. 3.** Restoration of *Yuania striata* based on the lectotype specimen (Sze, 1953: pl. 1, figs. 6, 6a, refigured here as Fig. 1A). **A**, restoration by Sze (1953: 13, fig. 1); **B**, according to the current re-examination.

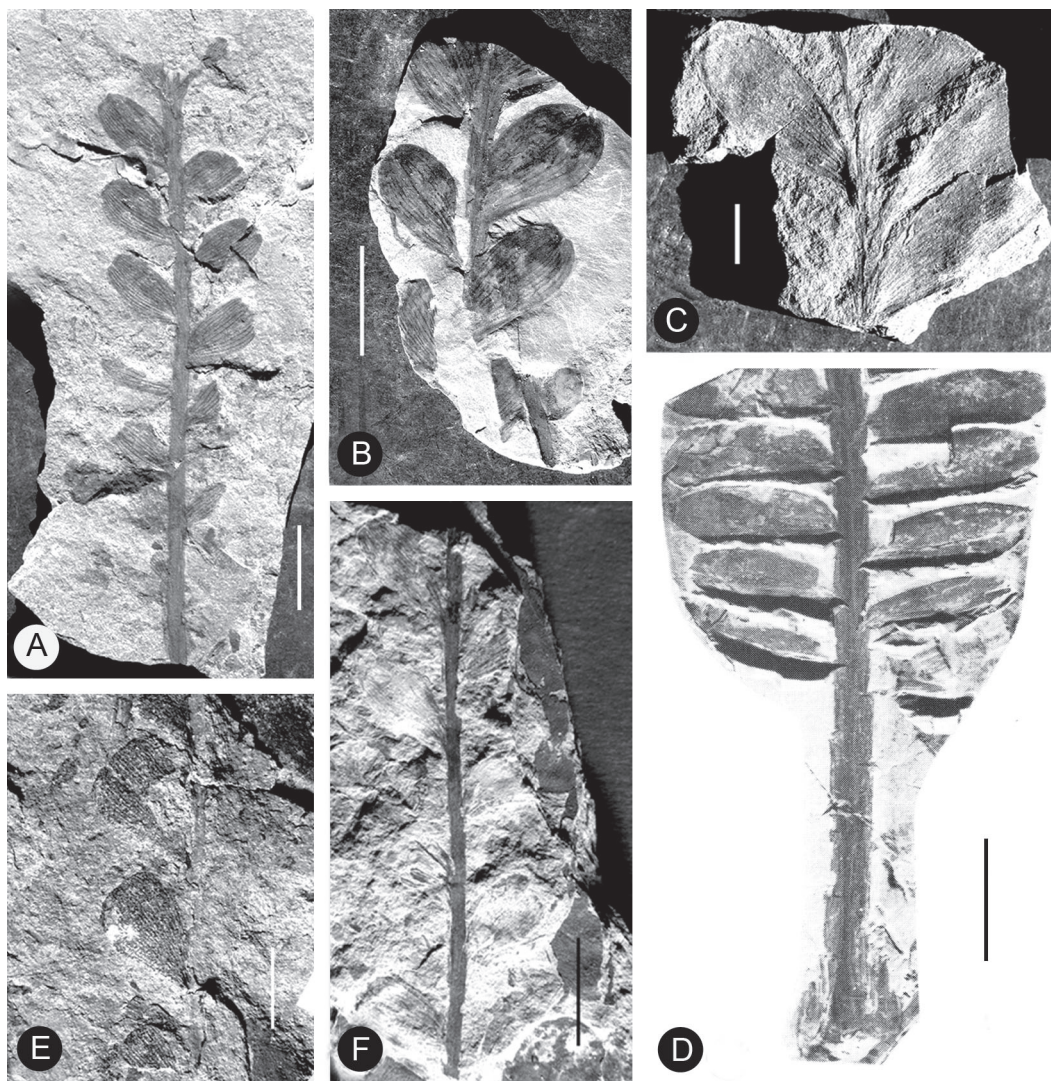
### ■ THE DEBATE BETWEEN DU & ZHU (1982) AND MAMAY (1968)

While emending *Yuania*, Du & Zhu (1982) synonymized it with *Russellites*. However, Mamay (1990, 1995) objected to their emendation because based on Sze's (1953) description and illustration the two taxa were reportedly distinct, as Mamay outlined in a comparison table (Mamay, 1995: 45).

It is clear that Mamay (1995) using the original diagnosis of Sze (1953) could not accept the proposed synonymy of *Russellites* and *Yuania* based on material from other localities referred by Gu & Zhi (1974) and Du & Zhu (1982) to *Yuania*. Thus, in order to resolve this issue it has been necessary to examine the original material of Sze (1953) that was not available to Mamay (1968, 1990, 1995).

### ■ RE-EXAMINATION OF THE TYPE MATERIAL OF SZE (1953)

The specimens of Sze (1953) were collected by T.Y. Tien and L.M. Yang of the Northwest Petroleum Administration Bureau. The exact stratigraphic information of the plant-bearing bed was not recorded, only mentioned as “from the Shihchienfeng Series at the Locality Motzekou of Linyu district, N. W. Shensi [sic]”. The specimens occur in gray, fine-grained siltstone and are preserved as impressions of the same color as the surrounding matrix, making photography difficult. During our examination of the material, in addition to normal light photography, the specimens were examined and photographed under a stereotype microscope and a Scanning Electron Microscope. Other observations were made with the specimen immersed in ethanol.



**Fig. 4.** Selected Chinese specimens referred to the emendation of the genus *Yuania* H.C. Sze. Scale bars: A–B, E–F, 10 mm; C, 5 mm; D, 20 mm. **A–C**, The specimens of Gu & Zhi (1974) based on which *Yuania* was emended for the first time. **A**, their pl. 40, figs. 6, 7; registration no. PB 4931; **B**, their pl. 40, figs. 4, 5; registration no. PB 4932; **C**, their pl. 41, fig. 1; registration no. PB 4930. **D**, One of the specimens of Du & Zhu (1982: pl. 1, fig. 3; registration no. B.378; ) showing the very base of the shoot (reproduced with kind permission from Prof. Zhu). **E, F**, Previously unpublished specimens of *Yuania* from the Late Permian of Shanxi, housed in the Swedish Museum of Natural History.



Our re-investigation of the type material shows that Sze (1953) incorrectly interpreted the specimens on two points: (1) the attachment of the leaf base is clasping not petiolate; (2) the veins are equally spaced at the apex, they do not converge to a central point. Our new reconstruction and a reproduction of Sze's (1953: fig. 1) original reconstruction are presented here for comparison (Fig. 3). Due to the poor quality of Sze's photographic images (his figs. 6, 6a, 7, 7a), Mamay (1995) could only check the features of *Yuania* according to Sze's reconstruction. With only Sze's reconstruction to rely on it is not surprising that Mamay would treat the two as distinct taxa.

### ■ VARIATION OF THE LEAF MORPHOLOGY OF *YUANIA* H.C. SZE

So far, *Yuania* H.C. Sze has been recorded throughout the Permian of north, northwest and south China, the Lower Permian of Texas and New Mexico, and mostly from the Upper Permian of north China. The numerous specimens make it possible to characterize the general variation of the leaf form. Figures 4 and 5 illustrate some critical specimens related to the emendation of *Yuania* H.C. Sze. Figures 1A, 2A (specimens of Sze, 1953), 4B (specimen of Gu & Zhi, 1974), and 4E (unpub. specimen in the Swedish Museum of Natural History) may represent the early juvenile-stage leaf form; Fig. 4D, a re-illustration of material of Du & Zhu (1982) and Fig. 5A–F, a re-illustration of material of Mamay (1968) represent the mature leaf form; whereas Fig. 4A, a re-illustration of material of Gu & Zhi (1974), and Fig. 4F (unpub. specimen in the Swedish Museum of Natural History) may reflect the leaf form of a transitional stage. Other published specimens from the Upper Permian of south China (He & al., 1996), and north China (Du & Zhu, 1982; Zhu & al., 1982; Xiao & Zhang, 1985; Wang & Wang, 1987; Zhang & al., 1992; Wang & al., 2004), and northwest China (Wang & al., 1986) probably represent the mature stage of this genus. It is worthy of mention that the specimens from the Early Permian of Texas (Mamay, 1968) showed rarely anastomosing venation. This had also been recognized from *Yuania longifolia* Xiao (Xiao & Zhang, 1985: 549, pl. 175, fig. 2) from the Late Permian Upper Shihhotse Formation of Taiyuan, Shanxi.

### ■ CONCLUSION

The re-investigation of the original specimen of the *Yuania* H.C. Sze (1953) indicates that *Russellites* Mamay (1968) has to be treated as a junior synonym of *Yuania* H.C. Sze. Because

Mamay's (1995) argument that *Russellites* and *Yuania* are distinct genera was based on Sze's inaccurate reconstruction, this is thus no longer tenable following this reinvestigation.

The species now included in the genus *Yuania* are summarized as follows:

***Yuania*** H.C. Sze in Acta Palaeontol. Sin. 1: 13. 1953 – Type: *Yuania striata* H.C. Sze (1953).

= *Russellites* Mamay in U.S. Geol. Surv. Prof. Pap. 593-I: 19. 1968 – Type: *Russellites taeniata* (Darrah) Mamay.

***Yuania striata*** H.C. Sze in Acta Palaeontol. Sin. 1: 13–14, 18–19. 1953 (Figs. 1–2) – Lectotype (designated by Zhang & al., 1992: 182): specimen illustrated by Sze (1953: figs. 6, 6a). Registration number: PB 2157 Nanjing Institute of Geology and Palaeontology, Chinese Academy of Sciences, Paleobotanical collection. Linyou, Shaanxi, China, Late Permian Shihchienfeng Series.

= *Russellites minor* Mamay in Taxon 44: 50. 1995 (Fig. 4A–B).

***Yuania taeniata*** (Darrah) X.M. Du & J.N. Zhu in Mem. Beijing Nat. Hist. Mus. 17: 4. 1982 ≡ *Tingia taeniata* Darrah 1938: 180 ≡ *Russellites taeniata* (Darrah) Mamay in U.S. Geol. Soc. Prof. Pap. 593-I: 19. 1968 (Fig. 5) – Lectotype: BMHU 19720 (designated by Mamay, 1968: 19): Botanical Museum of Harvard University, Paleobotanical Collection, illustrated by Darrah (1938) as the upper specimen on plate facing page 176; Paratypes: BMHU 19721, BMHU 19722, and BMHU 19723 (designated by Mamay, 1968: 19): from “Emily Irish”, Baylor County, Texas, Lower Permian Series, Leonard (?) Provincial Series, Approximately the middle of the Belle Plains Formation (presumably correlative with Valera Shale Member).

***Yuania chinensis*** (Mamay) J. Wang & D.S. Chaney, **comb. nov.** ≡ *Russellites chinensis* Mamay in Taxon 44: 49. 1995 (“*Yuania chinensis* X.M. Du & J.N. Zhu” 1982: 2–3, 6, non rite publ., Art. 37.1) – Holotype: specimen illustrated by Du & Zhu (1982: pl. 1, fig. 3). Registration number: 378 Paleobotanical Collection B, Institute of Botany, Chinese Academy of Sciences, Taiyuan, Shanxi, China, Early Permian Shihhotse Series.

***Yuania gigantea*** Y.F. Hu, X.M. Du, J.N. Zhu & S.Z. Xiao in Acta Bot. Sin. 24: 78. 1982 – Holotype: specimen illustrated by Zhu & al. (1982: pl. 1, fig. 6). Registration number: 76 Paleobotanical Collection B, Institute of Botany, Chinese Academy of Sciences, Taiyuan, Shanxi, Late Permian Upper Shihhotse Formation.

**Fig. 5.** Selected specimens of *Yuania taeniata* (Darrah) X.M. Du & J.N. Zhu from the Lower Permian of Texas (Mamay, 1968). Scale bars: A, C–D, 10 mm; B, E–F, 20 mm. **A**, Distal part of leaf showing concavely crescentic apical margin, parallel veins converging toward apex. USNM 42704 (Mamay, 1968: pl. 1, fig. 4). **B**, Specimen showing a relatively short, broad leaf with abrupt narrowing of apex. USNM 42707 (Mamay, 1968: pl. 2, fig. 3). **C**, Specimen showing details of venation and obliquely clasping leaf base. USNM 42711 (Mamay, 1968: pl. 3, fig. 3). **D**, Terminal part of a shoot showing small leaves with narrow angles of insertion and apical truncations. USNM 42710 (Mamay, 1968: pl. 3, fig. 2). **E**, Terminal part of a shoot showing the gradational spacing of leaves, consistently truncated leaf apices and overlapping of leaves. USNM 42708a (Mamay, 1968: pl. 2, fig. 4). **F**, Typical shoot fragment showing distant spacing, alternate insertion and broad angles of decurrence of leaves. Venation and truncate apices are shown well in leaves at left. USNM 42703 (Mamay, 1968: pl. 1, fig. 3).

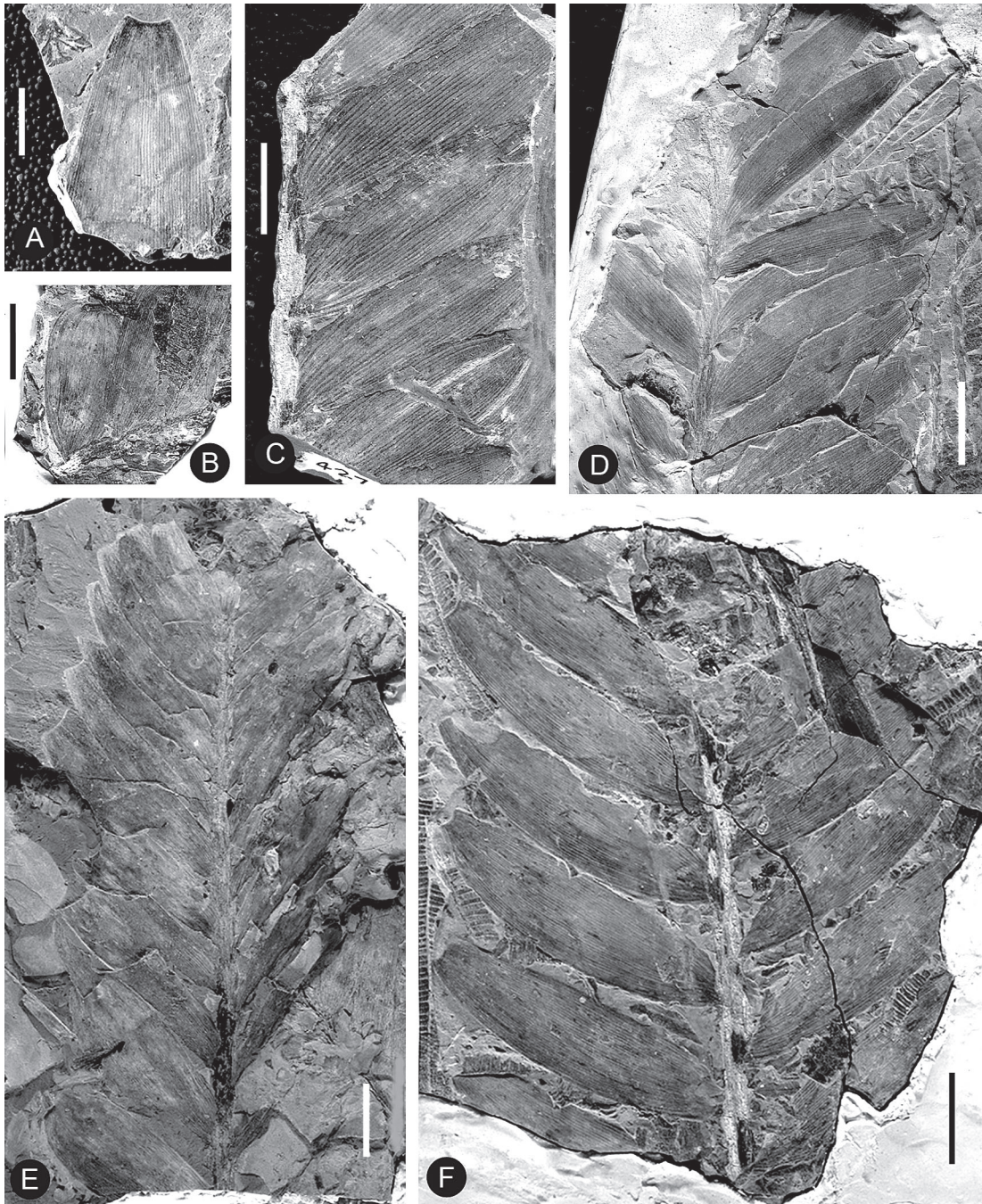


*Yuania magnifolia* (Mamay) J. Wang & D.S. Chaney, **comb. nov.** ≡ *Russellites magnifolius* Mamay in Taxon 44: 49. 1995 (“*Yuania magnifolia* Z.Q. Wang & L.X. Wang” 1987: 16, non rite publ., Art. 37.1) – Syntypes: specimens illustrated by Wang & Wang (1987: pl. 2, figs. 2–3; pl.3, fig. 2). Registration numbers: 8501-1, 8402-302 Paleobotanical Collection Tianjin Institute of Geology and Mineral Resources, Liulin, Shanxi, China, Late Permian Sunjiagou Formation.

*Yuania wudensis* J. Wang, H.W. Pfefferkorn, Z. Feng & G.L. Shen in Int. J. Pl. Sci. 165: 1111. 2004 – Lectotype:

PB20267, specimen illustrated by Wang & al. (2004: fig. 6a); Paratypes: PB20259–20266, 20268–20271m specimens illustrated by Wang & al. (2004: figs. 5a–5h, 6b–6d, 7a). Specific description in Wang & al. (2004: 1111). All registration numbers of Nanjing Institute of Geology and Palaeontology, Chinese Academy of Sciences, Paleobotanical Collection. Wuda, Inner Mongolia, China, Early Permian Shanxi Formation.

Additionally, *Plagiozamites oblongifolius* (Čtyroký, 1973: fig. 4) may be *Yuania taeniata* (Middle-Late Permian Ga’ara Sandstone Formation; Ga’ara Area, W. Iraq).





## ■ REMARKS

It is noteworthy that the foliage of *Yuania* have been found closely associated with a noeggerathialean strobilus *Discinities* Feistmantel from the Early Permian Texas (Mamay, 1968), and Inner Mongolia, China (Wang & al., 2004). Such an association may be significant because during the Permian Texas and Inner Mongolia were widely separated. Although some authors suggested that *Yuania* might be the foliage of *Crossozamia* Pomel (Cycadalean) (Gao & Thomas, 1989), it could be that *Yuania* and *Discinities* represent organs of the same plant as suggested by Mamay (1968) and Wang & al. (2004). If so, this may be the first plant taxon identified in the Permian floras of both China and North America, and with vegetative and reproductive organs. In addition, several form genera of the gigantopterids (*Cathaysiopteris* Koidz., *Gigantonoclea* Koidz., *Gigantopteridium* Koidz., *Zeilleropteris* Koidz.), peltasperms such as *Comia* Zalesski, and elements of coal-swamp ecosystems identified based on coal balls and volcanoclastic tuffs are recorded from both continents (Hilton & al., 2002). All these taxa common to the Permian of East Asia and Euramerica presumably were part of the Amerosinian Realm (Havlena, 1970; Cleal & Wang, 2002; Hilton & Cleal, 2007).

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