

ON PLANT MEGAFOSSILS FROM THE LATE TRIASSIC SEDIMENTS OF THE EASTERN PART OF SICHUAN BASIN, CHINA

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ABSTRACT

The paper deals with the plant remains collected from the Late Triassic sediments in the eastern part of Sichuan Basin, China. These remains include *Lobatannularia kaixianensis* sp. nov., *L. hechuanensis* sp. nov., *Pseudoctenis hechuanensis* sp. nov., *Ctenis kaixianensis* sp. nov., *Lobatannularia chuandianensis* (Wang) comb. nov. and *Acthephyllum kaixianensis* gen. et sp. nov.

Key-words — Megafossil, *Lobatannularia*, *Pseudoctenis*, *Ctenis*, *Acthephyllum*, Sichuan Basin, Triassic (China).

सारांश

चीन में सिचुआन द्रोणी के पूर्वी भाग के अनन्तम त्रिअसंधी युगीन अवसादों से गुरुपादपाश्म — दुआन शुइंग एवं चैन ये

चीन में सिचुआन द्रोणी के पूर्वी भाग में स्थित अनन्तम त्रिअसंधी युगीन अवसादों से एकत्रित किये गये गुरुपादपाश्म अवशेषों का वर्णन किया गया है। ये लोबेटेन्नुलेरिया केक्सिअनेन्सिस नव जाति, लो० हैचुआनेन्सिस नव जाति, स्पूडोटीनिस हैचुआनेन्सिस नव जाति, टीनिस कैक्सिअनेन्सिस नव जाति, लोबेटेन्नुलेरिया चुआन्डियानेन्सिस (वांग) नव संयोजन एवं ऐक्थीफिल्लम कैक्सिअनेन्सिस नव वंश व नव जाति नामक गुरुपादपाश्म हैं।

INTRODUCTION

MANY fossil plants were collected from the Mesozoic Coal Formation in eastern Sichuan Province in 1977-78. This coal formation was formerly called as Xiangxi (Hsiangchi) Coal Formation and an Early Jurassic age has been assigned to it by the late Prof. Sze. Thereafter the study of these fossil plants revealed that this formation does not have totally the Early Jurassic deposits. It almost wholly refers to the Late Triassic in west of Daxian County, partly to Early Jurassic and partly to Late Triassic in Daxian County and to east of the County. We call the Early Jurassic Coal Formation as Zhenghuchong Formation to distinguish it from the old Xiangxi Formation. The late Triassic Formation is called Hsuchiahe Formation.

The Hsuchiahe flora consists of 72 species belonging to 37 genera. The important taxa are: *Annulariopsis* sp., *Equisetum sarrani* Zeil., *Neocalamites carrerei* (Zeil.) Halle,

Lobatannularia kaixianensis sp. nov., *L. hechuanensis* sp. nov., *Taeniocradopsis rhizomoides* Szé, *Danaeopsis secunda* Halle, *Clathropteris meniscioides* Brongn., *C. platyphylla* (Goep.) Nathorst, *Dictyophyllum nathorsti* Zeil., *D. gracile* (Tur-Ket.) Chu, *Hausmannia* sp., *Phlebopteris xiangyunensis* Li et Tsao, *Todites denticulata* (Brongn.) Krasser, *T. princeps* (Presl) Gothan, *Cladophlebis asiatica* Chow et Yeh, *C. haiburnensis* (L. et H.) Brongn., *C. ingens* Harris, *C. kwangyüanensis* Lee, *C. raciborskii* Zeil., *C. scariosa* Harris, *C. shansiensis* Sze, *C. williamsoni* (Brongn.) Seward, *Sphenopteris chowkiawanensis* Sze, *Ptilozamites chinensis* Hsü, *P. nilssoni* Nathorst, *Anomozamites* cf. *hartzi* Harris, *A.* sp., *Pterophyllum aequale* (Brongn.) Nathorst *P. angustum* (Braun) Gothan, *P. exhibens* Lee, *P. jaegeri* Brongn., *P. multilineatum* Schirley, *P. ptilum* Harris, *P.* cf. *pinnatifidum* Harris, *P. subaequale* Hartz, *P.* sp., *Nilssoniopteris* cf. *tenuinervis* (Braun) Nathorst, *Ctenis kaixianensis* sp. nov., *Pseudoctenis hechuanensis*

sp. nov., *Anthrophyopsis leeiana* (Sze) Florin, *Sinoctenis calophylla* Wu et Lih, *Sphenozamites* sp., *Baiera multipartita* Sze et Lee, *Ginkgoites* cf. *sibiricus* (Heer) Seward, *Glossophyllum shensiensis* Sze, *Podozamites distans* (Presl) Braun, *P. lanceolatus* (L. et H.) Braun, *P. schenki* Heer, *P. sp.*, *Cycadocarpidium erdtmanni* Nathorst, *Ferganiella podozamioides* Lih, *F. sp.*, *Elatocladus* sp., *Pityophyllum* sp., *Taeniopteris* cf. *sterophylla* Kryshstofovich, *T. richthofeni* (Schenk) Sze, *T. sp.*, *Strobilites* sp., *Carpolithus* sp., *Schizolepis gracilis* Sze, *Stenorachis lepida* (Heer) Seward, *Swedenborgia* sp. and *Actephyllum kaixianensis* gen. et sp. nov. Most of these species and genera are typical in the Late Triassic flora and have also been reported from many other places of southern China, for example, in Ipinglang flora of Yunnan Province and Anyuan flora of Jiangxi Province. The coal formation has been compared with the Hsuchiahe Formation of Kwangyüan in northern Sichuan Province. It is also comparable with the Tonkin flora of Vietnam and the Nariwa flora of Japan. It has been thought to be the Middle-Late Stage of the Late Triassic. The climate at that time was subtropical or tropical, hot and humid.

Zhenghuchong flora consists of 44 species belonging to 25 genera. The main species are: *Annulariopsis inopinata* Zeil., *Equisetum* sp., *Neocalamites* sp., *Marattia asiatica* (Kaw.) Harris, *M. hoerens* (Schimper) Harris, *Coniopteris hymenophylloides* (Brongn.) Seward, *C. murrayana* (Brongn.) Brongn., *C. sp.*, *Clathropteris meniscioides* Brongn., *C. obovata* Ôishi, *C. sp.*, *Thaumatopteris* sp., *Hausmannia* sp., *Todites denticulata* (Brongn.) Krasser, *T. princeps* (Presl) Gothan, *Cladophlebis asiatica* Chow et Yeh, *C. kwangyunensis* Lee, *C. raciborskii* Zeil., *C. scoresbyensis* Harris, *Pterophyllum decurrens* Sze, *P. macrodecurrens* Duan, *P. sp.*, *Tyrmiia nathorsti* (Schenk) Ye, *Anomozamites* sp., *Nilssonia* spp., *Ctenis* sp., *Ptilophyllum contiguum* Sze, *P. pecten* (Phillips) Morris, *Baiera minuta* Yabe et Ôishi, *B. pseudogracilis* Hsü, *B. spp.*, *Czekanowskia rigida* Heer, *C. sp.*, *Ginkgoites* cf. *marginatus* (Nathorst) Florin, *G. sp.*, *Sphenobaiera hungi* (Sze) Hsü, *S. sp.*, *Podozamites lanceolatus* (L. et H.) Braun, *P. sp.*, *Elatocladus* sp., *Pityophyllum* sp., *Schizolepis gracilis* Sze, *Williamsonia* sp., *Taeniopteris* sp. and *Carpolithus* sp. The Zhenghuchong

Coal Formation is similar to Baitianba Coal Formation of Kwangyüan in northern Sichuan and Xiangxi Coal Formation in west Hubei Province. It is probably Early Jurassic in age. No distinct discontinuity has been found between Zhenghuchong Formation and Hsuchiahe Formation in this area.

DESCRIPTION

Lobatannularia kaixianensis sp. nov.

Pl. 1, figs 2-6

Diagnosis — Stem about 1 mm with 12-17 mm long (usually 15 mm) internodes; whorls divided symmetrically into two leaves, each half usually consisting of 12-16 leaves, toothed, slightly split into leaves; leaf oblanceolate to spatulate, 8-25 mm long and 2 mm wide at the widest part, mostly slightly curved upwards but the uppermost ones curved downwards, unequal in length, with the lowest one the shortest, successively getting longer upwards but getting shorter again after the middle one, each with a median vein; vein extending from the base to top. The distal whorl not divided into two leaves, fan-shaped.

Comparison & discussion — The characters of this species mostly resemble the other species of the genus *Lobatannularia*. Some authors consider *Lobatannularia* synonymous with the genus *Annulariopsis* which was established in 1903, but this is not accepted by most authors because the latter has only the distal whorl whose leaves are free to near base. Our specimens also differ from the genera *Neocalamites* and *Schizoneura*. The whorls in *Neocalamites* are not divided into two leaves, instead have radiate and entirely separate leaves; the whorls in *Schizoneura*, though divided into two leaves, they are equal in length. The species described here is closest to *Lobatannularia heianensis* and *L. multifolia*, but differs from them in fewer and shorter leaves in a whorl. The genus *Lobatannularia* is usually considered to be restricted to Palaeozoic but several species of this genus are known from Mesozoic of Sichuan, Yunnan and Shanxi Provinces.

Holotype — Specimen no. 7154 (Pl. 1, fig. 3).

Locality & Age — Tongshuhe Ba of Kaixi County, Sichuan Province, People's Republic of China; Late Triassic.

Lobatannularia hechuanensis sp. nov.

Pl. 1, fig. 1

Description — Specimen having only the upper part of a thin stem with two nodes; internode 16-18 mm long. Whorls not perfectly preserved, apical part missing, relatively small, divided into two lobes, each lobe consisting of 8-12 leaves. Leaves uninerved, united for their most part. The distal whorl not divided into two lobes, fan-shaped.

Comparison — The leaves of the present specimen are smaller and narrower than those of *L. kaixianensis* and thus has been described as a new species.

Holotype — Specimen no. 7102.

Locality & Age — Tan Ba of Hechuan County, Sichuan Province, People's Republic of China; Late Triassic.

*Lobatannularia chuandianensis** (Wang) n. comb.

Pl. 1, figs 7, 8

1977 *Neoannularia chuandianensis* Wang, p. 187, pl. 1, fig. 10; text-fig. 1.

1978 *Lobatannulariopsis yunnanensis* Yang, p. 472, pl. 158, fig. 6.

1980 *Annulariopsis lobatannularioides* Huang et Zhou, p. 69, pl. 23, figs 8-10; pl. 24, fig. 1.

Emended diagnosis — Stem thin, about 1-1.5 mm wide with 12 mm long internodes. Whorls divided into two leaves, each one usually consisting of 6-10 leaves; leaf lanceolate or oblanceolate, 7-15 mm long and 1 mm wide, unequal in length, with the lowest one shortest, successively getting longer upwards but getting shorter again after the middle one, each with a median vein; the vein extending from the base to the top.

Comparison & discussion — The species differs from *L. kaixianensis* and *L. hechuanensis* in having whorls which divide into deeply splitted two leaves. It resembles *L. sinensis* collected from the Palaeozoic, but the leaves in the latter are larger and more and more oblanceolate.

The characters of *Neoannularia chuandianensis* (Wang, 1977, p. 187, pl. 1, fig. 10)

from south-west of Sichuan Province, *Lobatannulariopsis yunnanensis* Yang (Yang, 1978, p. 472, pl. 158, fig. 6) from Yunnan Province and *Annulariopsis lobatannularioides* Huang et Zhou (Huang & Zhou, 1980, p. 69, pl. 23, figs 8-10; pl. 24, fig. 1) from the Yenchang Formation of northern Shenxi Province are very similar to this species. It is also similar to *Lobatannularia* than *Annularia* and *Annulariopsis*. Thus a new combination, viz., *L. chuandianensis* (Wang) n. comb., has been established.

Holotype — Specimen no. 7544 (Pl. 1, fig. 7).

Locality & Age — Qinghe Formation of south-west of Sichuan Province and Ipinglang Formation of Yunnan Province, People's Republic of China; Late Triassic.

Pseudoctenis hechuanensis Chen et Duan sp. nov.

Pl. 3, fig. 14

Diagnosis — Leaf pinnate, leaf substance thin, 22 cm in length and 15 cm in width (estimated length more than 40 cm). Rachis about 1 cm wide with longitudinal striations on its surface. Pinnae opposite or sub-opposite, arising at an angle of 70°-80° from the rachis, linear, entire, at the basal part the lower margin being slightly decurrent on its rachis, but on meeting the base of adjacent pinnae, apex of pinnae obtusely rounded to rounded. Veins slender and closely set, most of them unforked, a few branched once near the rachis, 7-8 veins per cm at the middle parts of pinnae.

Comparison & discussion — Although the leaf is incomplete both at the base and apex, the new species resembles *P. gigantea* (Hsü et al., 1975, p. 73, pl. IV) from Baoding of Sichuan Province. The pinnae of *P. gigantea* are broader (about 2.8-3 cm wide) and veins very closely 30-36 per cm. In general shape of leaf, this new species closely resembles *P. spectabilis* (Harris, 1932, p. 20, pl. 2, figs 1, 4; pl. 3, fig. 6; text-figs 11, 12) and *P. depressa* (Harris, 1932, p. 25, pl. 2, figs 3, 5; text-fig. 14) from East Greenland, but the veins of *P. spectabilis* and *P. depressa* thinner than those of our new species *P. hechuanensis*.

Holotype — Specimen no. 7125.

Locality & Age — Tan Ba of Hechuan County, Sichuan Province, People's Republic of China; Late Triassic.

*This species n. comb. is not from the Eastern part of Sichuan Province.

Ctenis kaixianensis sp. nov.

Pl. 1, fig. 9; Pl. 2, fig. 13

Diagnosis — Leaf pinnate, estimated at 30 cm in length and 18 cm in width, rachis slender, 2-5 mm wide, pinnae linear, sub-opposite, 6-9 cm long and 1-1.7 cm wide, apex of pinnae rounded, arising at an angle of 70°-90° from the rachis, base of pinnae extending but not contacting the adjacent pinnae. Veins slender and thinner, fairly conspicuous, about 10 veins arising from the rachis, simple or once forked, at variable distance and forming elongate meshes, 6-22 mm long, 12-15 veins per cm at the middle part of pinnae.

Comparison & discussion — Full shape of this new species unknown, but its shape and venation differ from other species of this genus. *C. pterophylloides* (Chen *et al.*, 1979, p. 270, pl. 3, fig. 2) and *C. reguloria* (Chen *et al.*, 1979, p. 187, pl. 1, fig. 3) from Yanbian County, South-west of Sichuan Province rather resemble our new species, but both of them differ in closer pinnae and closer and regular meshes.

Holotype — Specimen no. 7178 (Pl. 2, fig. 13).

Locality & Age — Tongshuhe Ba of Kaixi County, Sichuan Province, People's Republic of China; Late Triassic.

Genus — *Acthephyllum* gen. nov.

Diagnosis — More than 10 leaves look like foliage at the top of stem. Leaf taeniopteroid, tapered to the apex, gradually slendered to the base with a thin petiole,

12-22 mm wide at middle part (the widest part) several to more than 10 cm in length, entire. Midrib prominent, extending to the apex, 1-1.5 mm wide, lateral veins thin, arising nearly at an angle of 80° to the midrib, less at the base with about 16-17, more at the middle part with 21-23, simple or bifurcating once at any position, branch sometimes forward back and form a circle, sometimes crossing or meeting.

Comparison & discussion — This plant often preserves simple leaf, which looks like the leaf of genus *Taeniopteris*, but the different types of lateral veins and attachment of leaves distinguish it from *Taeniopteris*. It closely resembles *Mironeura dakengensis* Zhou (Zhou, 1978, p. 114, pl. 25, figs 1, 1a, 2; text-fig. 4), but the leaf of *M. dakengensis* is much bigger and leaf membrane attached on the top of the leaf, and the leaves of new genus look like foliage at the top of stem. Because there is not any cuticle preserved on specimens, we can't identify the natural family of the new genus.

Genotype — *Acthephyllum kaixianensis* sp. nov.

Acthephyllum kaixianensis sp. nov.

Pl. 2, figs 10-12

Diagnosis — See the diagnosis of the genus.

Holotype — Specimen no. 7221 (Pl. 2, fig. 10).

Locality & Age — Tongshuhe Ba of Kaixi County, Sichuan Province, People's Republic of China; Late Triassic.

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EXPLANATION OF PLATES

(All figures. $\times 1$. All specimens are deposited in the Institute of Botany, Academia Sinica.)

PLATE 1

1. *Lobatannularia hechuanensis* sp. nov.
- 2-6. *Lobatannularia kaixianensis* sp. nov.
- 7-8. *Lobatannularia chuandianensis* (Wang.), n. comb.
9. *Ctenis kaixianensis* sp. nov.

PLATE 2

- 10-12. *Acthephyllum kaixianensis* gen. et sp. nov.
13. *Ctenis kaixianensis* sp. nov.

PLATE 3

14. *Pseudoctenis hechuanensis* sp. nov.

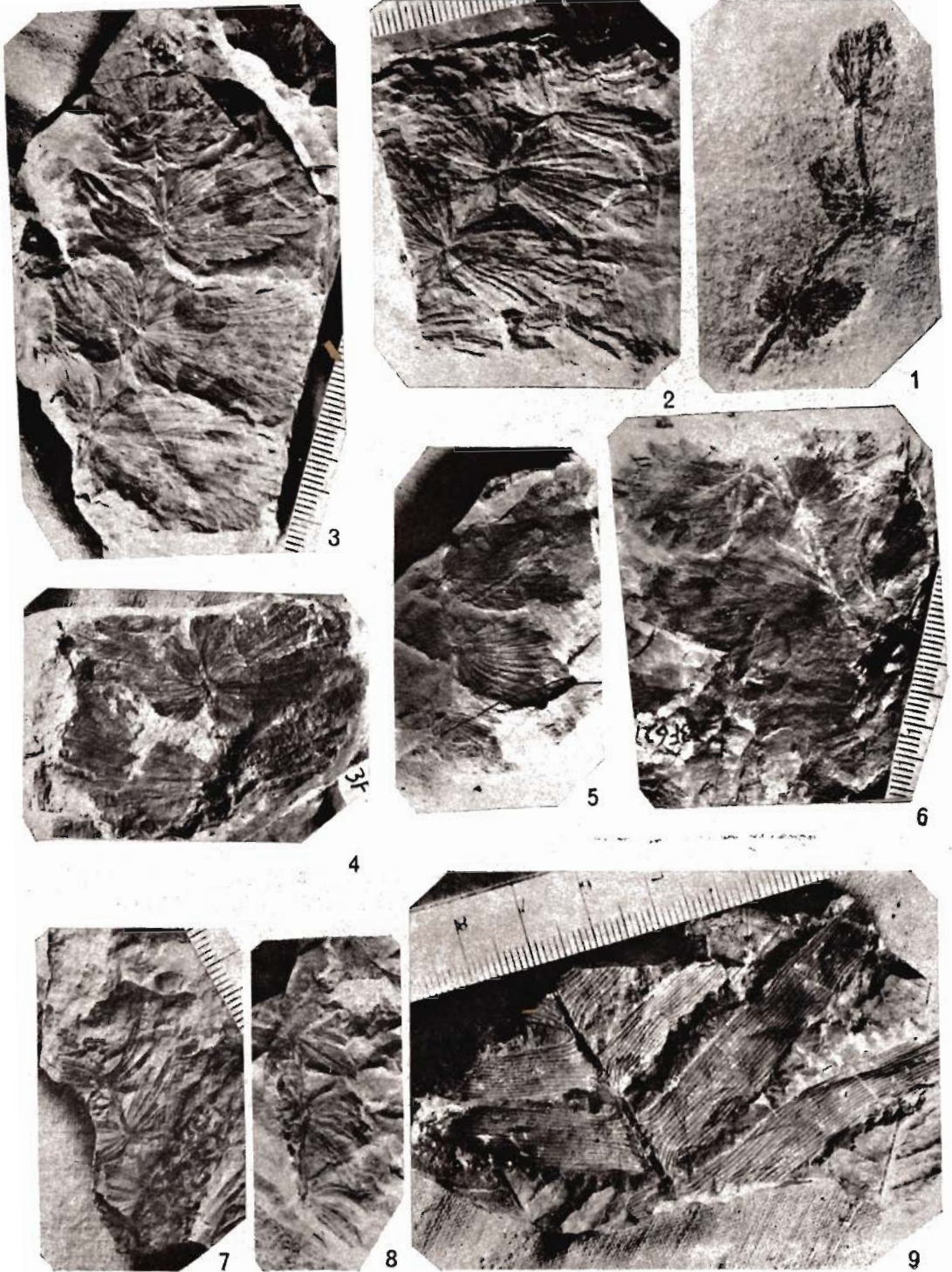


PLATE 1



10



11



13



12



14