Several Species of *Schizolepis* and Their Significance on the Evolution of Conifers [1]

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(Manuscript received 27 January 1997; accepted 23 March 1997)

ABSTRACT: Four species of *Schizolepis* including three new species from west Liaoning province and Inner-Mongolia have been described. As the seeds with wings were found in cones for the first time, their relationship to Pinaceae was closer than it had been thought. With the characters observed on fossil as well as evidence from palaeobotanical works and teratology, the authors have discussed the propinquity and possible evolutionary relationship with other families of Pinaceae as well as other groups of conifers and thought: 1) there was a series starting from *Pseudovoltzia*, through *Tricanolepis* and *Schizolepis*, leading into extant conifers; 2) the different parts of scale and bract have been undergoing a coalescence; 3) seed wings have undergone a process from non-existence, advent to fully development; and 4) more attention should be paid to the Lycopsida for the consideration of ancestral conifers.

KEY WORDS: China, Conifer, Inner-Mongolia, Liaoning province, Lycopsida, *Pseudovoltzia, Schizolepis, Tricanolepis.*

INTRODUCTION

The genus *Schizolepis* has been established for more than one hundred years. Since its establishment, its phylogenetic position has been in controversy (Florin, 1939, 1954; Sze and Li, 1963; Schweitz, 1963; Miller, 1976, 1977; Harris, 1979, Krassilov, 1982; Stewart and Rothwell, 1993). As more evidence collected, its position becomes clearer, but its direct connection with extant Conifers remains doubtful (Sze and Li, 1963; Schweitz, 1963). On the basis of preceding works (Florin, 1939; Roselt, 1958; Schweitz, 1963; Miller, 1976, 1977 Harris, 1979) and new evidence in this paper, the authors would try to give some discussion on the evolution of Conifers.

MATERIALS AND METHODS

The fossils were collected by S. Y. Duan *et al*. in 1988 and later J. Z. Cui from west Liaoning province and Inner-Mongolia respectively. Lots of reproductive organs as well as vegetative organs were collected. It was recognized by Pan, G. (personel communicotion in 1976) as *Selaginellites, Equisetites, Coniopteris, Cladophlebis, Pterophyllum, Nilssonia, Anomozamites, Zamites, Ctenis, Cycadolepis, Taeniopteris, Ginkgoites, Baiera, Sphenobaiera, Phoenicopsis, Czekanowskia, Solenites, Swedenburgia, Larix, Pseudolarix,*

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1. This paper is part of the program supported by NSFC, and special support of Palaeontological & Palaeoanthropological Investigation from Chinese Academy of Sciences.

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Araucarites, Cephalotaxopsis, Podocarpites, Brachyphyllum, Pagiophyllum, Pityospermum, Pityophyllum, Cupressiocladus, Carpolithus and by us as *Stachyotaxus, Leptostrobus, Schizolepis* etc. In this paper, attention was mainly paid to the genus *Schizolepis*. The specimens were observed under stereomicroscope, photographed under Zeiss microscope, SEM with Nikon camera, and also drawn with hand.

The fossils were collected from strata of Haifanggou Formation, Middle Jurassic of west Liaoning and Huolinhe Formation, Early Cretaceous in Huolinhe coal mine of Inner-Mongolia, and are deposited in Laboratory of Palaeobotany, Institute of Botany, Academia Sinica, Beijing, China.

RESULTS

The taxonomic treatment is as followed.

Genus *Schizolepis* C. F. W. Braun 1847 (Type species: *Schizolepis liasokeuperianus* C. F. W. Braun 1847)

Female cones, cylindrical when mature, 10-25 mm broad, covered with helically arranged seed-scale complexes. These complexes are about 10-15 mm long, narrowed into a stalk below, readily falling as one unit form cone; in the upper third divided into 2 rounded or pointed lobes. Bract scale delicate, probably small, round, free to its base but closely pressed to ovuliferous scale. Seeds two, one on each surface near the base of each rounded or triangular lobe, ovule with micropyle pointing to the cone axis, chalazal region embedded in the scale tissue. Outer part of ovuliferous scale rather thin but including strands of longitudinal fibres, slightly concave on the upper side. Leaves of twigs attributed to *Schizolepis* needle-shaped, up to 15 cm long, helically arranged, distantly attached on the long shoot but covered on the short shoots. " Stomata of leaves, scale leaves of dwarf shoot and ovuliferous scale monocylic, with long very shallow pit, poles of guard cells reaching surface. " (after Harris, 1979, p. 98)

The type species was originally called *Voltzia schizolepis* Braun, renamed later by Braun (1847) as *Schizolepis liasokeuperianus*. Roselt (1958) transferred some species of the genus into *Tricanolepis* (Schweitz, 1963). Harris (1979) added new features to the genus. Zhang and Zheng (1987) added some new species to the genus, before and after it others also did so. Up to now no description or diagnosis of the genus was found with winged seeds. The absence of seed wing made palaeobotanists hesitate to regard it as member of Pinaceae. In our fossil specimens, many seeds were found with wings while other characters coincided with previous diagnosis. Thus more features could be added to the diagnosis of the genus:

The scale (seed scale complexes) bilobate or trilobate, with or without a stalk. Seeds with triangular or fan-shaped wings. The inner margin of wing straight, while the outer margin somewhat convex or straight, with longitudinal and/or somewhat radial striation on the surface of wing. Bract sometimes bifid or bilobate.

The seed-scale complex of female cone coincide with those of extant Pinaceae in their separated scale and bract, pair of ovules with their micropyle pointing towards the cone axis (Harris, 1979) and winged seed. The absence of latter character and the forking of scale made Harris hesitating to confirm it belonging to Pinaceae. Sze and Li (1963) casted doubt over its systematic position for shortage of strong evidence of seeds. The association with *Pityocladus* and *Pityophyllum* made Krassilov (1982) confident that the genus belongs to

Pinaceae. The authors on account of the newly found winged seeds, were confident that it belonged to Pinaceae.

About 19 species were previously recorded from the late Triassic to the Early Cretaceous of northern hemisphere, but 3 new species and 1 old species are described in this paper.

Key to species

1. Fossil female cone consist of seed scale
   2. Seed wing minute .... 1. *S. micropetra*
   2. Seed wing triangular .... 3. *S. planidigesita*
1. No fossil female cone found, except seed scale
   3. Scale 2-lobed .... 2. *S. moelleri*
   3. Scale trilobate .... 4. *S. trilobata*

1. Schizolepis micropetra Wang, *sp. nov.* 小翅裂鳞果 Plate I, Figs. 1-7; Plate II, Fig. g.

Female cone, cylindrical, over 6.5 cm long, over 2.5 cm wide (Plate I, Figs.1,2). Seed scale complex closely and helically arranged around the cone axis at an angle of about 70-80 degree to the cone axis, relatively sparsely in the lower part of cone (Plate I, Fig. 1). The cone axis 2-3 mm wide. Seed scale complex short of evident petile, 8 mm wide and 13 mm long, bilobate (Plate I, Fig.1). Each lobe 13 mm long and 4 mm wide, with a pointed apex, separated near to the base, with longitudinal and somewhat radial striations on its surface. Bract was hard to see for the close arrangement of seed scale complex. Seed almost round, about 3 mm in diameter, with ripples on its surface, armed around by wing (Plate I, Figs. 3-6). Seed wing is an extension at the upper margin of seed (Plate I, Fig. 4).

Holotype: 8877b

Type-location: Sanjiaocun, Baimashi Xiang, Jinxi Shi, Liaoning.

Stratigraphic horizon: Haifanggou Formation, Middle Jurassic.

Depository: Laboratory of Palaeobotany, Institute of Botany, Academia Sinica, Beijing.

Derivatio nominis *micropetra* for the small wing of the seeds.

Remark: Similar to *S. planidigesita* Wang, the present new species was different from all old species in the presence of winged seed. The peculiar character of present species was its minute wing. This was not found in any other species up to now. Compared with the two preceding species, the species might be more close in propinquity with extant Pinaceae.

2. Schizolepis moelleri Seward 谬勒裂鳞果 Plate II, Figs. 1, 2, a, b.

Single scale. Scale dissected into 2 lobes, the notch between lobes reaching the middle way of its length, 13 mm wide and 11 mm long (Plate II, Figs. 1, 2). Each lobe 6 mm wide and 11 mm long. Bract bilobate, each lobe ovoid, 5 mm long and 4 mm wide (Plate II, Fig. 2)

Holotype: 9225

Type-location: Huolinhe coal mine, Inner-Mongolia.

Stratigraphic horizon: Huolinhe Formation, Early Cretaceous.

Depository: Laboratory of Palaeobotany, Institute of Botany, Academia Sinica, Beijing.

Remark: The specimen with clear bilobate outline of the bract, and similar to *S. moelleri* Seward in other features.

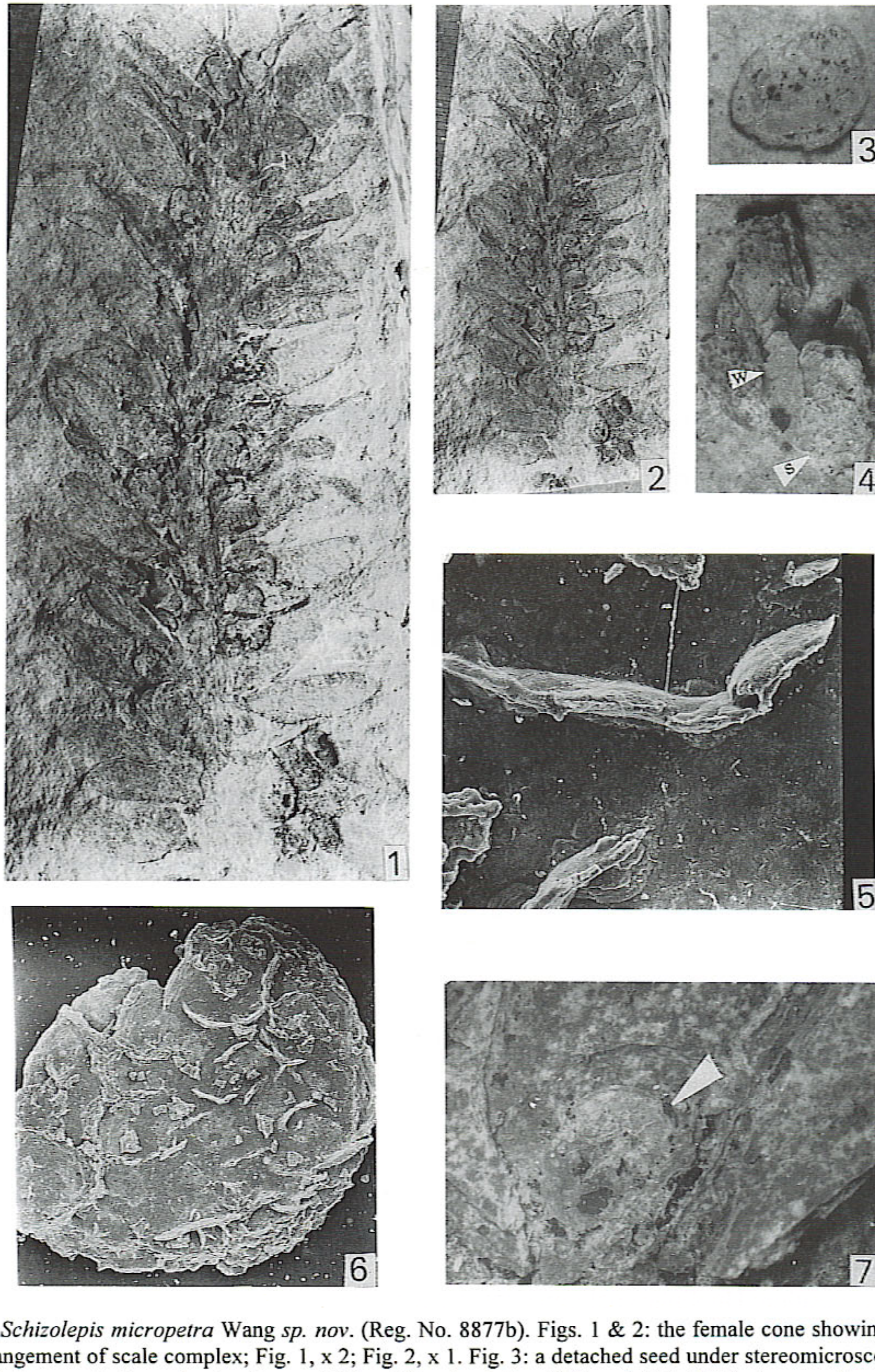

Plate I. *Schizolepis micropetra* Wang *sp. nov*. (Reg. No. 8877b). Figs. 1 & 2: the female cone showing outline and arrangement of scale complex; Fig. 1, x 2; Fig. 2, x 1. Fig. 3: a detached seed under stereomicroscopy, x 10. Fig. 4: bottom part of a scale showing seed (s) and its wing (w), x 6. Figs. 5 & 6: SEM views on the surface of seed, showing the outline and wrinkles on its surface; Fig. 5: detail of a wrinkle in the center of Fig. 6, x 210. Fig. 6, x 24. Fig. 7: bottom part of a scale, showing seed *in situ*, x 12.

3. Schizolepis planidigesita Wang, *sp. nov.* 平列裂鳞果 Plate II, Figs. 5-7, c-e.

Part of female cone, cylindrical, over 6.5 cm long, over 3.0 cm wide (Plate II, Fig. 5). Seed scale complex helically arranged around the cone axis, relatively sparsely, at angle of about 60 degree to the cone axis, probably deciduous when mature (Plate II, Fig. 5). The cone axis 2.5 mm wide. Seed scale complex constricting to the base, 12 mm wide and 18 mm long, dissected deeply into 2 lobes, the median notch almost reaching to the base of scale (Plate II, Fig. 6). Each lobe about 17 mm long and 5 mm wide, asymmetrically ligulate, the inner margin almost straight and the outer margin arched, with longitudinal and somewhat radial striations on its surface, with bluntly pointed apex and two lobes appearing almost in the same plane. Bract small, separated from and adnated closely to the abaxial surface of scale, probably bifid, about 1.5 mm long. Seed on the adaxial surface at the base of scale, probably deciduous when mature (Plate II, Fig. 6), 3-6 by 1-3 mm, 6-8 mm long when including seed wing. Seed wing triangular (Plate II, Fig. 7), arming around the seed, with spongy tissue at the attachment between wing and seed.

Holotype: 8822b

Type-location: Sanjiaocun, Baimashi Xiang, Jinxi Shi, Liaoning.

Stratigraphic horizon: Haifanggou Formation, Middle Jurassic.

Depository: Laboratory of Palaeobotany, Institute of Botany, Academia Sinica, Beijing.

Derivatio nominis *planidigesita* for the two lobes positioned in nearly the same plane.

Remark: The new species was similar to *S. acuminata* Turutanova-Ketova in size and form and to *S. liasokeuperianus* Braun, but different in that the latter have two lobes merging more along the inner margin. It was different from *S. brauni* Schenk in the lobing, position of seeds as well as shortage of evident petiole (Stewart and Rothwell, 1993), different from *S. drepanoides* Krassilov (Krassilov, 1982) and *S. gracilis* Sze (Sze and Li, 1963) in shortage of evident petiole, different from *S. dabangouensis* Zhang and Zheng (Zhang and Zheng, 1987) in pointed apex of the scale and widest in the middle rather than upper part of the scale. The scale of new species had similar configuration with *S. jeholensis* Yabe and Endo, but the size of its scale was 2 times more than that of *S. jeholensis* Yabe and Endo (Sze and Li, 1963). Significantly, the new species was different from all old species in the presence of winged seed.

Only one of seeds was found *in situ*, and the scale lobe associated with the seed was somewhat distorted during petrifaction (Plate II, Fig.7). Someone might think the outline of wing was formed by the overlapping of scale lobe, but this possibility was obviated after careful examination. If the outline of the wing was formed by the overlapping, then the margin of the wing should be depressed when compared with the lobe. But the fact was that the margin of wing was prominent when compared with lobe. In addition, the spongy tissue found at the base of wing was much similar to that found in seeds of extant Conifers, thus also contribute to certainty of nature of seed and wing.

4. Schizolepis trilobata Wang, *sp. nov.* 三瓣裂鳞果 Plate II, Figs. 3, 4, f.

Only one seed scale was found which was 15 mm long and 18 mm wide, trilobate bilaterally symmetrical (Plate II, Figs. 3, 4). The three lobes unequal in size, with the median one slim while the two broad lateral ones are with serrate distal margin.

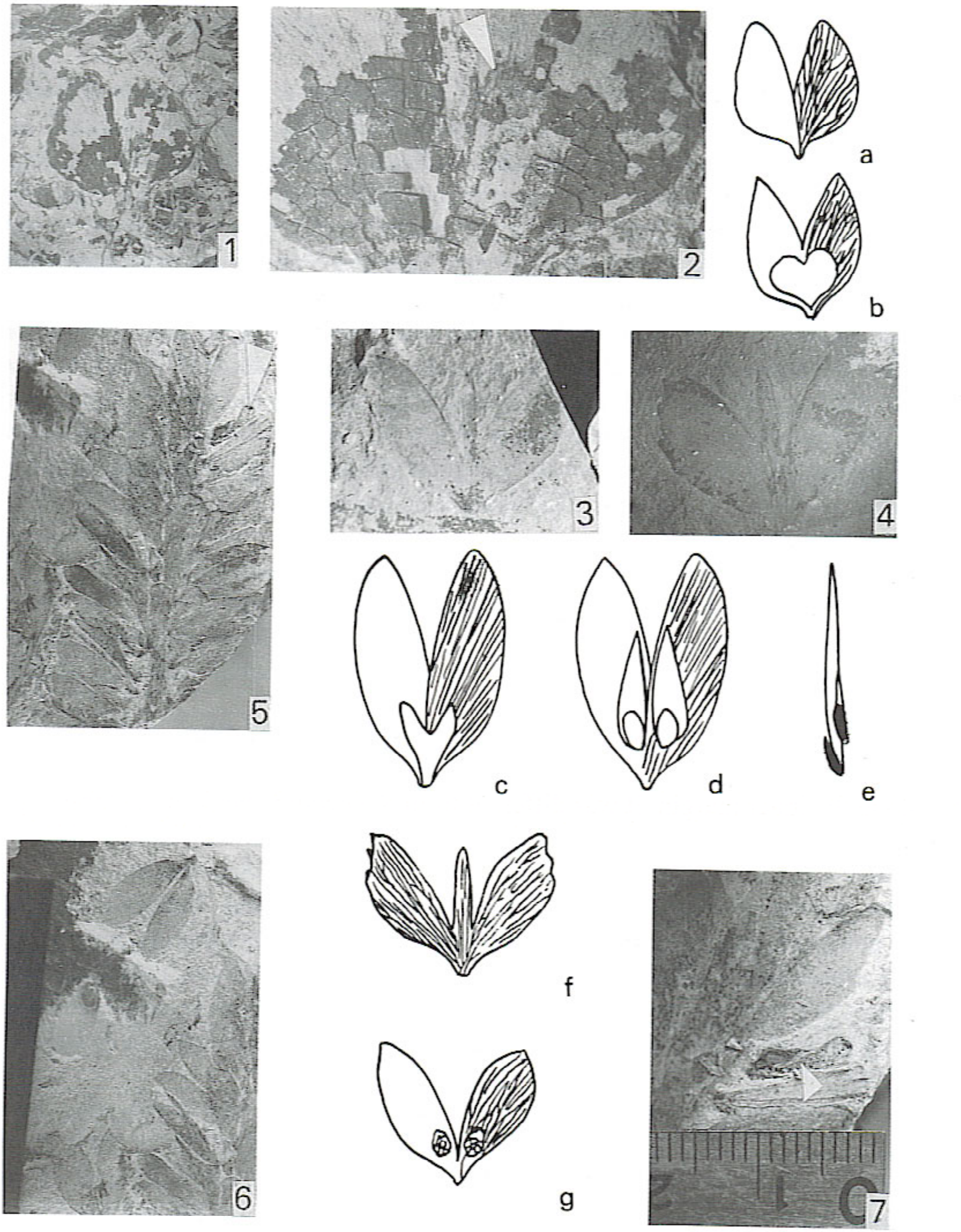

Plate II. Figs. 1 & 2. *Schizolepis moelleri* Seward (Reg. No. 9225), a single scale complex showing 2 lobes of scale, x 2; Fig. 2: the separate bilobate bract behind scale lobes, x 8. Figs. 3 & 4: *Schizolepis trilobata* Wang *sp. nov*. (Reg. No. 8774), two facing parts of the same scale, showing the trilobate outline of scale, x 2. Figs. 5-7: *Schizolepis planidigesita* Wang *sp. nov*. (Reg. No. 8822b); Fig. 5: the outline of the cone and the arrangement of the scale-seed complexes, x 1; Fig. 6: detached single scale and seed, x 1; Fig. 7: detail view of seed scale (arrow head) in Fig. 5, showing seed and wing, x 2. Figs. a & b: reconstructed scale complex of *Schizolepis moelleri* Seward, x 2; Fig. a: dorsal view; Fig. b: ventral view. Figs. c-e: reconstructed scale complex of *Schizolepis planidigesita* Wang *sp. nov*. x 2; Fig. c: dorsal view; Fig. d: ventral view; Fig. e: lateral view. Fig. f: profile of reconstructed scale complex of *Schizolepis trilobata* Wang *sp. nov*. x 2. Fig. g: reconstructed scale complex of *Schizolepis micropetra* Wang *sp. nov*., ventral view, x 1.

Holotype: 8774 a, b
Type-location: Sanjiaocun, Baimashi Xiang, Jinxi Shi, Liaoning.
Stratigraphic horizon: Haifanggou Formation, Middle Jurassic.
Depository: Laboratory of Palaeobotany, Institute of Botany, Academia Sinica, Beijing.

Remark: The new species was represented only by one seed scale. But it was important in that it had three lobes while the median one smaller, which probably used to be equal with the two remaining, having constriction. Therefore the authors believed that it might play a transitory role between *Schizolepis* and *Tricanolepis* (Roselt, 1958).

DISCUSSION

The Evolutionary Significance of *Schizolepis* is here presented. In the history of the genus *Schizolepis*, it had been mixed or misinterpreted as *Tricanolepis* and *Voltzia*. The two erroneous ways assessing the genus were not unreasonable. *Voltzia* was a female cone of scales with 5 lobes and 2 seeds attached to the lobes. *Tricanolepis* had scale with 3 lobes and 3 inverted seeds/ovules (Roselt, 1958). Their configurations were much similar to that of *Schizolepis*, which had 2 or 3 lobes with inverted seeds. Antevs (1919) reported one kind of fossil named *Schizolepis hoerensis* Antevs, which has trifid scale form and is hard to make out from *Tricanolepis,* hence they were easily to mistaken. The authors thought the reason for the mistaking was natural rather than manmade for there exists transition between them.

The authors regarded that *Schizolepis* and *Tricanolepis* were of great significance in the evolution of Conifers. Florin and Schweitz (Schweitz and Rothwell, 1963) agreed about that fossils and extant Conifers (except *Palissya, Stachyotaxus, Cephalotaxus*) were of the same phylo-genetic line in evolution. Starting from *Pseudovoltzia*, the genera of the line must undergo some modification, such as the reduction in number of telomes, of seeds on the trusses, seeds in total dwarf shoot etc. (Florin, 1939; Stewart and Rothwell, 1993).Based on the evidence of vascular distribution and others, Aase (1915) asserted that, in spite of the striking modification, the origin of megasporophyll is homologous throughout Conifers; in the ovulate strobilus in members of Coniferales, two general tendencies are apparent: 1) the reduction in number of sporophylls in the strobilus; 2) the modification of compound sporophyll into an apparently simple one, the latter appears in diverse disguise, but in general implies loss of one of the sporophyll members or welding of the two. Teratology of Conifers done by modern botanists (Guedes and Dupuy, 1974; Su, 1993) also showed us the same tendency, which the authors regarded as reasonable. In modern Conifers, evolutionary advancement in ovulate strobilus is shown by various degree of fusion between parts of scale as well as scale and bract (Foster and Gifford, 1974). Wilde and Eames (Florin, 1954)regarded the single ovule of *Araucaria bidiwillii* was a survivor of three ovules, and might be derived from Mesozoic *Schizolepis*. Celakovsky pointed out (Florin, 1954) ontogeny and teratology of scale proved that the scale , of nature of axillary shoot, is mainly reduced to prophylls, fusing along the posterior margin, sometimes a third sterile lobe united between them, or only one developed to make uniovulate scale. Arber (Florin, 1954) was inclined to regard the scale (of Conifers) as made up of 2 fused leafy outgrowths (lobes or pinnae) from the axillary shoot. The authors thought that the above points of view was suitable to interpret the modification starting from *Pseudovoltzia*, through *Voltzia, Tricanolepis, Schizolepis*, to extant Conifers (especially Pinaceae) (Even though some scales of *Picea* are made up of more than 2 parts, the authors did not regard as rival to present interpretation: it might introduce the extant situation directly from *Tricanolepis* or even *Pseudovoltzia*). The transition from *Pseudovoltzia* to *Voltzia* had been accounted by Florin (1944/54), Schweitz (1963), Guedes and Dupuy (1974), Miller (1977) and Stewart and Rothwell (1993).

As for *Tricanolepis*, its mixture with *Schizolepis* (and *Voltzia* with *Schizolepis*) itself alone was accountable for the close propinquity between *Schizolepis* and *Trianolepis* (and *Voltzia* and *Schizolepis*). Through the reduction in numbers of lobes and sporophyll in *Voltzia*, the trilobate *Tricanolepis* might be derived, and further reduction might introduce *Schizolepis*. The new species described in this paper *S. trilobata* showed transition in the extent of their lobe fusion. *Pseudolarix erensis* Krassilov (Krassilov, 1982) showed us different degree of lobe fusion: the scale is ranging from slightly notched to deeply split to its base (Krassilov, 1982, Plate 13, Figs. 152, 153). Another species of *Pseudolarix* from Baikal area (Krassilov, 1982), along with the new species of Krassilov, also showed great resemblance to *Schizolepis*, which character Krassilov regarded as atavistic for the genus. Teratology of *Picea* by Guedes and Dupuy (1974 and also Su, 1993) showed the gradual transition from normal whole scale to deeply notched or splitting scale, the latter showed great similarity or equality to *Schizolepis*. Even though the rare teratology is of little significance for interpreting the evolutionary trend, the gradual transition is of some significance which we should not neglect (Guedes and Dupuy, 1974). Teratological research work showed that in *Larix, Pinus, Picea, Tsuga* and probably all members of Pinaceae, there are only two scale components (Geudes and Dupuy, 1974). Townrow (1969) speculated that since Triassic and Jurassic the scale complex of *Podocarpus* have three-parted arrangement, *Tricanolepis* Roselt might be better regarded as a forerunner of Podocarpaceae than Taxodiaceae (Miller, 1977). He also contended that three-parted arrangement in latter was derived, more typical being five-parted (Miller, 1977). *Pityocladus* attached to *Schizolepis* and two seeds in scale were reminiscent of Pinaceae (Miller, 1977). Voltziaceae cluster (*Pseudovoltzia, Pachyolepis, Schizolepis, Aethophyllum, Swedenburgia, Tricanolepis, Voltzia*) is close to Taxodiaceae, the latter might evolved from the cluster with little modification (Miller, 1982). Therefore the authors were confident that the genus *Schizolepis* was the precursor of extant Pinales, at least Pinaceae, and probably other groups (such as Podocarpales and Taxodiaceae).

In the genus *Schizolepis*, bract has been reported previously (Florin, 1944). Bract is of importance for some palaeobotanists (Schweitz, 1963) to regard it as a key character in interpreting the phylogenetic significance of *Schizolepis*. The bract may be bifid or bilobate in outline. In Cordaitales, the foliage leaves repeated bifurcation (Florin, 1939; Schweitz, 1963); some foliage leaves of Lycopsida in the geologic time also have bifid tip (Stewart and Rothwell, 1993). The bifid configuration of bract might imply something on the forking of the forerunners' leaf. For the bract was observed intergrading to vegetative leaf in extant plants, *Tsuga chinensis* var. *tchekiangensis* (Klaus and Hu, 1989) showed us bract homologous to foliage leaves in epidermal cell, stomata, hypodermis as well as resin canals, and Schweitz (1963) pointed out that bract is made up of foliage leaf, therefore it was not surprising to find bract bifid, considering bifurcation of leaf in Cordaitales and Lycopsida.

The bracts in the species described here were separated from and oppressed to the abaxial surface of scale. The situation was much similar to that in Pinaceae.

Seeds were in pair in most of the scales, on the adaxial surface at the base and sometimes in the middle or upper part of scale (such as in *Schizolepis brauni* Schenk). In the past seed was not observed attached with wing, so some palaeobotanist hesitated to put *Schizolepis* in close relationship with Pinaceae (Harris, 1979), for in most extant members of Pinaceae and other neighbouring families seed is usually found with wing. *Compsostrobus*, which is regarded similar to modern pine cones (Miller, 1977), born 2 inverted wingless seeds. It appeared almost concurrently with *Schizolepis* (Upper Triassic). In the specimens described here, most were with seeds, and important point is that in at least 2 specimens seeds were found with a wing. In *Schizolepis micropetra sp. nov.* the seeds were with much smaller wings. These seeds were much similar to those of *Schizolepis* with wingless seed. In *Schizolepis planidigesita sp. nov.* the seed was with a small triangular wing. The small wings might play transitory role between no wing and large wing, so a series from no wing through small wing to fully developed wing could be introduced, and the series might represent the evolutionary steps of seed and wing in the geologic time. In the past, atropous ovule has been reported in the genus *Schizolepis*, the authors regarded that the ovule of *Tricanolepis* and *Schizolepis* which might lead to extant Pinales must have undergone the inversion from atropous to anatropous. This point of view could find support in teratology of *Picea* (Guedes and Dupuy, 1974): In *Picea* the ovule of most members is anatropous, but transitory to upright to the scale and atropous gradually, and finally disappears completely leaving only a slim ridge on the surface of scale reminding us of the original position of ovule on the scale while the scale gradually transitory to more and more notched till splitting completely into two lobes. Schweitz (1963) in his paper on *Pseudovoltzia* showed us a diagram of possible ways of seed and scale evolution, in one of the way one status (the status (e) in the diagram of Schweitz) after that of *Tricanolepis* and *Schizolepis* is short of fossil example hence appears to be merely a hypothesis. In this way the status of extant Pinaceae seed was derived, and the two specimens with winged seeds were just of the status, and the genus *Schizolepis* was just on the way to Pinaceae. This also contributed to the certainty of Schweitz' s hypothesis.

Among the genus *Schizolepis*, the configuration of the scale was great variable: in number of lobes, the degree of splitting, the seed position as well as the presence and length of petiole (or stalk). The petiole sometimes influenced the configuration of scale greatly, but never the basic composition and its nature. Considering the situation in fossils and extent plants, the authors regarded that in the phylogenetic way leading to extant Pinales the petiole has been on reducing.

In addition, there are or use to be two hypothesis on the forerunner of Conifers: one in favor of derivation from Cordaitales, another in favor from Lycopsida. The former is prevalent now, but still impotent for hypothesizing the preceding forerunner of *Pseudovoltzia* (Schweitz, 1963). The latter is left to negligence for long time, for it is still hard to imagine from single sporangium subtended by leaf to derive the multiovulate scale such as that in *Pseudovoltzia*. Some attention would hereby be called to the second point of view. *Endosporites*, microspore of the lycopod *Polysporia*, showed us profile similar to Pinaceae (Rothwell, 1982, Pl. I, Fig. 2). Sometimes *Lycopodium* might born a pair of sporangia on the adaxial surface of subtending leaf (Bower, 1903). If this situation were a atavistic, we perhaps could courageously to hypothesize that in the geologic time some members of Lycopsida could borne more sporangia on the adaxial surface on leaf, and from this type of plants could derive plants similar to *Pseudovoltzia*. As the fact is, there are indeed some members of Lycopsida (such as *Fleminites*) (Stewrt and Rothwell, 1993) which have two or more sporangia subtended by leaf during geologic time. Krassilov (1978) described a new genus and species *Synlycostrobus tyrmensis* Krassilov, which have "inflorescence" bearing strobili laterally in axils of bracts, the stalks of the strobili were fused with bracts and dichotomous at the sporophyll apice. The assemblage of characters is regarded as unique and unknown in extant plants (Krassilov, 1978). "The inflorescence of this plant are like a prototype of the coniferous compound strobilus. Elementary strobili partially fused with subtending bracts are analogous to the coniferous seed scale complex." (Krassilov, 1978). Even though it is regarded as parallelism of evolution in remotely related groups (Krassilov, 1978), and the plant appeared during Late Jurassic and Early Cretaceous, it might suggest us that some conifer prototype might be derived from Lycopsida, for the "elementary strobilus" might reduce to a scale complex. Since no direct evidence of transition between Cordaitales and Pseudovoltziales exists, and the major (or single) character that connects the Cordaitales and other conifers is that "the secondary shoot in the axil of a bract of *Cordaitanthus* is homologous with the bract and the axillary ovuliferous scale of a conifer seed cone" (Stewart and Rothwell, 1993), the authors, in view of *Synlycostrobus tyrmensis* Krassilov and *Lycopodium ridium* Gmel. (Bower, 1903), do not find any reason to exclude Lycopsida from the possible ancestral groups of conifers. However more work has to be done before we could give any definitely conclusion on it.

In short, the newly described specimens and older works of others led us to conclude the following:

1. The extant Conifers (Pinales and probably other neighbouring classes) might have evolved from Pseudovoltziales, through *Voltzia, Tricanolepis, Schizolepis*.
2. In the process leading to extant Conifers, the scale had been undergoing fusion between lobes and reduction in the numbers of lobes as well as seeds (ovules).
3. In the process leading to extant Conifers, the seed had been gaining and enlarging its wing.
4. In the process leading to extant Conifers, the petiole of scale had been undergoing reduction.
5. The total number of scales in a cone might also had undergone reduction, and thus introducing those with fewer fertile scale (such as Podocarpaceae).

ACKNOWLEDGEMENT

While compiling this paper we got lot of help from Jianan Zhu on the nomenclature of new species and valuable advice from Baoyin Geng. The preparation of illustrations was assited by Ms. Xin Xu. To all of them the authors would extend sincere thanks.

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裂鱗果屬的幾個種及它們對松柏類植物演化的意義[1]

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（收稿日期：1997年1月27日；接受日期：1997年3月23日）

摘　　要

本文描述了來自遼寧省和內蒙古的裂鱗果屬的 3 個新種(小翅裂鱗果、平列裂鱗果、三瓣裂鱗果)和 1 個老種(謬勒裂鱗果)。由於首次發現其毬果中的種子具翅，使之與松科的關係比原先所想的要近些。根據觀察到的化石性狀、古植物資料及時形學資料，作者討論了其與松科中及松柏類中其它類群的親緣關係及可能的演化路線，認為 (1) 有一條從假伏脂松屬，經過三瓣裂果屬，裂鱗果屬，演化到現代松柏類的演化路線。(2) 種鱗、苞片及其各個組成部分一直在發生愈合。(3) 種翅經歷了從無到有，從小到大的發展過程。(4) 考慮松柏類祖先類群時也應注意石松類。

關鍵詞：裂鱗果屬(*Schizolepis*)，假伏脂松屬(*Pseudovolzia*)，三瓣裂果屬(*Triconolepis*)，松柏類，石松類，遼寧省，內蒙古。

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1. 該項研究得到部份國家自然科學基金和中國科學院古生物、古脊椎動物與古人類學科特別支持費的贊助。

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