

RHAMNACEOUS PLANTS FROM MIDDLE JURASSIC OF YANLIAO REGION, NORTH CHINA

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ABSTRACT

This paper reports the fossil fructifications of *Paliurus* and *Zizyphus* occurring in the Middle Jurassic flora found in Haifanggou formation which is located in the eastern part of Yanliao region (Lat. 40°58'N, Long. 120°21'E), North China. In level of evolution they may compare with their Tertiary and extant counter parts. Their occurrence manifests that the family Rhamnaceae had been in China during Jurassic period, its early evolution was performed there, and it may perhaps originate there. The time of origin should be prior to Mesozoic.

Keywords Jurassic, Rhamnaceae, *Paliurus*, *Zizyphus*, North China

FOREWORD

The problem concerning the existence of angiosperms previous to Cretaceous, in Jurassic or earlier geological times, has been argued long due to lack of fossil evidence such as seen in Andrews (1961)⁽¹⁾, Asama (1975)⁽²⁾, Axelrod (1960)⁽³⁾, Beck (1976)⁽⁴⁾, Chang (1980)⁽⁵⁾, Eames (1960)⁽⁶⁾, Hughes (1976)⁽⁷⁾, Lu and Zhang (1978)⁽⁸⁾, Retallack and Dilcher (1981)⁽⁹⁾, Takhtajan (1969)⁽¹⁰⁾, Taylor (1988)⁽¹¹⁾, Wang (1984)⁽¹²⁾, etc. The author had reported briefly in 1984⁽¹³⁾ and presented afterwards in different extent to several conferences* the discovery of Middle Jurassic precursors of angiosperms from Haifanggou formation (海房沟组) in the

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- * The Conference commemorating the 60th anniversary of the Geological Society of China (1982, Beidaihe); The Second International Organization of Paleobotanical Conference (1984, Edmonton); and the 14th International Botanical Conference (1987, Berlin, West)

eastern part of Yanliao region (Lat. $40^{\circ}58'N$, Long. $120^{\circ}21'E$), North China. The fossil angiospermous flora determined to be of Middle Jurassic is in reasons of (1) It is associated with about 30 genera known already in Middle Jurassic, including ferns, sphenopsida, Bennettitales, Cycadales, Ginkgophytes and conifers⁽¹³⁾, some of these plants are preserved together with the angiosperms on same specimen; (2) The assemblage of spores and pollens associating in the same horizon is diagnosed to be of Middle Jurassic^{**}; (3) The pelecypods^{***} and insects⁽¹⁴⁾ accompanying in the same bed are identified of Middle Jurassic; (4) Regionally the Haifanggou formation in which the mentioned floras and fauna buried is superposed continuously by Lanqi formation bearing a Late Jurassic fossil flora.

The fossil angiospermous flora collected from Haifanggou formation is represented by many families and genera of both dicots and monocots in which the magnolian and amentiferan associate together and the woody and herbaceous present as well. In level of evolution they approach the Tertiary and extant flowering taxa. Among them two genera of Rhamnaceae, *Paliurus* and *Zizyphus*, are described and discussed here. All specimens of the fossil flora were gathered by the author in different years since 1971 from same horizon in same locality and now preserved personally.

Previously the majority of the fossils of *Paliurus* and *Zizyphus* were found largely from the Tertiary in North Hemisphere, seldom seen in Cretaceous beds, and never been recorded in Jurassic. The present fossils represent the first appearance of Rhamnaceous plants from Jurassic, which may be significant in exploring the origin and early evolution of this family and even the whole flowering taxa.

I express my gratitude to Mr. Young Jianmin for mailing me the fruitful specimens of *Paliurus ramosissimus* (Lour.) Poir from the hill Jiufengshan in Wuhan, Hubei province; to the Forest Research Institute of Hubei province for sending me the fruits of *Paliurus hemsleyanus* Rehd.; to Mr. Chen Aiguo and the National Geological Library in Beijing for

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mailing me several copies of references cited, and also to Ms. Zhang Gui-zhi for drawing the insets of the fruits of both fossil and extant *Paliurus*.

DESCRIPTION OF FOSSILS

ANGIOSPERMAE

DICOTYLEDONEAE

RHAMNACEAE

Paliurus Tourn. ex Mill.

1. *Paliurus jurassinicus* sp. nov.

Zizyphus Mill.

2. *Zizyphus liaoxijujuba* sp. nov.

1 *Paliurus jurassinicus* sp. nov.

(Pl. I—1, 1a, 1b; Fig. 1—a, b)

Material

Holotype LSJ0743(A, B) whole mold of a fruit, including a flat circular impression of fruit top and a cup-like cast of fruit body.

Description

Fruit cup-shaped, 4mm long with top truncated. Its top flat and circular, disc-like, winged narrowly, 10 mm across, etched irregularly on the margin. Veins develop radially in the outer zone (about 2mm wide) of the circular top. Few of them split or converge as approaching the margin. Most of them, however, become faint as stretching inwards. The style is 1mm in diameter, 4-lobed, persisting at the centre of the flat circular top, which is encircled by a shallow groove forming a ring measured 2.5mm across. The fruit contracts gradually downward from the top. The funnelled surface surrounding it is striated densely with vertical parallel lines, fine and stout, which are crossed by several horizontal wrinkles. The base of the fruit is nearly flat and circular, about 4mm across. Calyx persistent, lobed, about 2mm across. The trace of the pedicle centered on the calyx, nearly 1mm in diameter.

Discussion

The carbonaceous compression of the fossil fruit has been lost in field collection due to careless knocking. However, a fresh integral mould of the fruit preserved well (Pl. I—1, 1a). It is the best one preserved so fine amongst the known fossil fruits of *Paliurus*. Not only the impression of the winged disc-like top (the lower in figs 1 and

1a, Pl. I) is unique, the cup-shaped cast of the fruit body (the upper in figs 1 and 1a, Pl. I) is distinct as well, 4-lobed status of the persisting style is obvious (Pl. I-1b), and the print of the persisting calyx and the trace where the pedicle attached are discriminatable also. Therefore the fossil fruit could be identified exactly and ascribed to the genus *Paliurus* though it was dug out from the bed of Middle Jurassic. But the fossils of the drupes of *Paliurus*, known from Cenozoic of different areas in Northern Hemisphere, are represented largely in prints of the winged disc-like top, and none of the mold of the drupe body is preserved together.

The extant *Paliurus* belongs to the family Rhamnaceae, of 6 species, distributing over Eastern and Southern Asia and Southern Europe. In China there are 4 species known: *Paliurus ramosissimus* (Lour.) Poir., *P. hirsutus* Hemsl., *P. hemsleyanus* Rehd. and *P. orientalis* (Franch.) Hemsl.⁽¹⁵⁾ The species *Paliurus Spina-Christi* Mill., introduced into Shandong province and adjacent areas, distributes now in Southern Europe and Western Asia with many synonyms.⁽¹⁶⁾ We had gathered the specimens of this plant in late November 1986 in the outskirts of the town Lodeve which is located near the Mediterranean in South France.

P. ramosissimus (Lour.) Poir. is the major species of *Paliurus* in China and Eastern Asia. It has many popular names in China such as 'White thorns' (in 'The book of Materia Medica'), 'Iron fence', 'Coin tree' and 'Saddle tree' (in Sichuan province), 'Spine of the male tiger' (in Fujian province) and 'Spinose disc' (in Guangdong province). It distributes in Eastern China, Taiwan, Central-Southern and Southern China, Shenxi province, and seen also in Korea, Japan and Vietnam. The circular top of its drupe is nearly flat, winged narrowly, 10-18mm in diameter, often marked with 3 streaks or gaps and incised irregularly along the margin. The radiate veins develop obviously in the outer zone of the winged flat top. In *Paliurus hemsleyanus* the broad wing extends quadrilaterally and horizontally from the wrist of the drupe, 25mm across or larger. Veins develop densely, radiating from the centre. In *Paliurus spina-christi* the size of the 'winged disc' and the radiate veins developed are similar as in *Paliurus hemsleyanus*.

In basic morphological and structural features of the fruit the Jurassic fossil may compare with each species of the extant *Paliurus*. However, the Jurassic drupe is relatively small with its top flattened and winged narrowly, and the radiate veins develop mainly near the margin

of the 'winged disc', they become obscure as extending towards the centre. Such respects render it to resemble closely *Paliurus ramosissimus* (Fig.1—a, b, c). Again, owing to the style of the fossil fruit is 4-lobed it resembles more closely *P. hirsutus*. But it differs obviously from *P. hem-sleyanus* and *P. spina-christi* for they possess a broader wing with compact nerves radiating from the centre. Hence, the fossil *Paliurus jurassinicus* sp. nov. may likely be the lineal ancestry of *P. ramosissimus* and *P. hirsutus* in Jurassic.



Fig. 1 Comparison of the fruits of Middle Jurassic and extant *Paliurus*

a. Reconstruction of the fruit of *Paliurus jurassinicus* sp. nov., $\times 3$.

b. Impression of the winged disc-like top of the same fossil fruit, $\times 3$.

c. Sketch of the fruit of *Paliurus ramosissimus* (Lour.) Poir. from Jiufangshan, Wuhan, $\times 2$

Two kinds of fossil impressions in Mesozoic, the impressions of isolated nodal diaphragms of Equisetales and that of detached fructifications of *Peltasperum*, which resemble superficially in some extent that of the circular flat top ('winged disc') of *Paliurus jurassinicus* sp. nov. should be mentioned. In diaphragms of Equisetales the radiating ribs arranged evenly, they are equal in length, stretching straightly, never being dichotomous or contacting each other. However, the radiating veins in the winged disc of *Paliurus jurassinicus* developed unevenly and unequal in length. Some of them crooked slightly, dichotomous or two adjacent veins contacting as near the margin of the winged disc. Again, *Paliurus jurassinicus* has a 4-lobed persistent style at the centre of its circular flat top, which is encircled by a shallow furrow as seen in the extant species *P. ramosissimus* and *P. hirsutus*. But these are absent in diaphragms of Equisetales. Besides, the diaphragms of Equisetales are preserved either isolate or on the nodes of the plant stems; and in the fossil fruit of *Paliurus jurassinicus* the winged disc of fruit top attached matchably on the cup-shaped fruit body.

Peltaspermum, the seed-bearing organ referred to *Lepidopteris* (Harris, 1932a, 1935; Thomas, 1933), consisting of an axis with lateral branches terminating in peltate discs which are 3~5mm or 10~12mm in diameter in different species. Under surface of discs bearing a ring of seeds counted less than ten to about twenty. Such peltate discs differ obviously from the winged disc of *Paliurus jurassinicus* in lacking of radiating veins, a persistent style and a furrow-ring encircling it on the upper surface and bearing a ring of seeds at the under surface. Further, the peltate discs of *Peltaspermum* borne on a slender stalk and the winged disc of *Paliurus jurassinicus* attached on the cup-shaped stone body. As discussed above the fossil winged disc of *Paliurus jurassinicus* could be discriminated from the other two even in impressions, and confusion would be avoided.

Fossils of *paliurus* had been discovered repeatedly from the Tertiary sediments in Northern Hemisphere, in which 2 species known from China. One, *Paliurus miosinicus* Hu et Chaney from the Miocene Shanwang formation in Shandong province⁽¹⁷⁾, the other, *Paliurus* sp. from the Miocene of Jianchuan in Yunnan province.⁽¹⁸⁾ They are both preserved in circular disc-like impressions of the winged flat top of the fruits, and both are imperfect. The Jurassic fossil drupe is much alike to that from Jianchuan.

Cretaceous records of *Paliurus* are scanty. Kryshstofovich (1957)⁽¹⁸⁾ mentioned that 'Basing on the unique fruit the genus *Paliurus* could be exactly identified, possibly it had begun to appear during the potomac epoch in United States of America'. We do not see, however, the original literature he mentioned. For in the past the fossil of *Paliurus* has never been found in Jurassic strata. It is beyond our expectation that in morphology and structure the fruit of *Paliurus jurassinicus* sp. nov. from the Middle Jurassic of Yanliao region is so much alike to that of the extant species *P. ramosissimus* (Lour) Poir.. This fact suggests that *Paliurus* develops highly in Jurassic, in evolutionary level it approaches its Tertiary and modern counter parts and that from Middle Jurassic to the present, as long as about 150 m. y., variation of *Paliurus* in morphological and structural features is relatively minor and negligible.

Association of *Paliurus jurassinicus* sp. nov. with the warm-habituated plants such as Gnetales, Bennettitales and cycadales, etc. in Yanliao region during Middle Jurassic implies *Paliurus* was originally a member of tropic or subtropic flora, it adopted to temperate environments after-

wards as the climate of middle latitudes in Northern Hemisphere changed gradually to mild and cold.

Fossil drupe, characterized distinctly of *Paliurus*, discovered from the Middle Jurassic Haifanggou formation in Yanliao region testifies surely the existence of this genus in North China during Jurassic period and its early evolution was performed there. Again, highly perfectible development of its drupe exhibits it had experienced a long evolution before Jurassic. Thus, time of its origin could not be considered in Triassic, and ought to be earlier, i. e. prior to Mesozoic. Again, the birth place of *Paliurus* remains unknown. As now *Paliurus jurassicus* sp. nov. occurs in Jurassic sediments of North China, which resembles closely the major living species, *P. ramosissimus* and *P. hirsutus*, in China and Eastern Asia, and also that more extant species of this genus are native to China, it seems possible that *Paliurus* may rise at China.

2. *Zizyphus liaoxijujuba* sp. nov.

(Pl. I—2, 2a, 3)

Material

Holotype LSJ 0531 Impression of a fruit stone. LSJ 0744 (A, B) Impressions of both sides of another fruit stone.

Description

Fruit stone fusiform, 10mm long and nearly 5 mm wide, pointed on both ends. There are about 10 longitudinal ribs developed on its surface, straight or gently curved, roughly parallel, stretching from the navel to the apex. Side sutures distinct.

Discussion

The genus *Zizyphus* comprises about 100 species distributing in tropic Asia, tropic America and temperate regions of both Hemispheres, only few species seen in Africa. In China there are 12 species and 3 varieties⁽¹⁶⁾ among which *Zizyphus jujuba* Mill. is the major representative (holotype), it scatters through out the whole country and disperses to southeastern Asia and Southern Europe.

The fruit stone of *Zizyphus jujuba* formed by two symmetrical or sub-symmetrical nuclear valves sutured tightly together, fusiform or elongated ellipsoidal with both ends pointed, and the apex often more sharp. Occasionally it becomes somewhat stout or slender, or slightly flattened or bended. Sutures on both sides closed tightly or split faintly at one or

two ends. Down from the sharp apex one or two little pits or caves, of different forms and depths, often developed along the suture lines. The surface of both valves of the stone covered with longitudinal ribs, stretching continuously upwards and concentrating at the apex, or breaking and alternating with variable lengths, or almost granulated. Two Jurassic fossil stones diagnosed here to be of one species are both represented by the impressions of stone valves. The striations representing the longitudinal ribs on valve surface are distinct, their lower ends limited by a short concave curve. Side sutures obvious. In morphological and structural characteristics (Pl. I—2, 2a, 3) they resemble closely the fruit stone of the extant species *Zizyphus jujuba* Mill. (Pl. I—4, 5), especially its miniature varieties known in several provinces of North China on account of they are smaller sized. Therefore the author classifies them directly into the genus *Zizyphus* Mill. The reliability that *Zizyphus* had been in North China during Middle Jurassic is strengthened by the occurrence of two fruit stones of same species of *Zizyphus* in same horizon at same habitate, and particularly by association of *Paliurus*.

Literatures dealing with *Zizyphus* such as Yu Tetsun (1979)⁽²⁰⁾ and Guo Yuxin (1982)⁽²¹⁾ often hold that *Zizyphus jujuba* Mill. was bred out in long cultivation by the ancient Chinese people who selected the best variety of the wild plant *Zizyphus jujuba* Mill. var. *spinusus* Hu as the mother stock. They hold also that so many extant varieties of *Zizyphus jujuba* Mill. appearing in China can be ascribed to the same cause. However, that the existence of the genus *Zizyphus* in Middle Jurassic and that except the shrubs of *Zizyphus jujuba* Mill var. *spinusus* Hu usually seen in the field there are also gigant arborescent trees of the same species survive in Shenxi, Shanxi and Beijing, which are 6.7~21.3 m in height, 3~4.25m in girth and 300 to more than 1000 years old⁽²²⁾, suggest *Zizyphus jujuba* Mill. and *Zizyphus jujuba* Mill. var. *spinusus* Hu may be two species which had already been existing parallelly both in the geological history. They might originate from a co-ancestry, but it could not be ascertained that the later is the ancestral stook of the former. Thus, it seems reasonable to agree to emend *Z. jujuba* Mill. var. *spinusus* Hu to be a full and independent species as *Zizyphus spinusus* Hu, and do not maintain to treat it again as a variety of *Z. jujuba* Mill.

Much varieties of *Zizyphus jujuba* Mill. living in China may not be necessarily an outcome of breeding in the past thousands of years in

human history, but perhaps a result of natural evolution of the plant in geological development. Fossils of *Zizyphus* had been discovered in Tertiary beds in China (in Linqu of Shandong and in Fushun of Liaoning), Japan, Alaska, Greenland, Europe and United States of America^(17,18). Kryshstofovich⁽¹⁹⁾ stated yet the genus *Zizyphus* presented also in Late Cretaceous floras from East Asia, Urals and North America. The fossil stones of *Zizyphus*, resembling closely those of the extant species, now occur in Middle Jurassic sediments of Yanliao region manifests *Zizyphus* had evolved in China at least for 150 m. y.. By the way for the carpolithuses reported by Sze(1949, Pl. 15, figs 20, 21; 23) from Early Jurassic Xiangxi coal series in Hubei province are comparable to the prints of fossil stones of *Zizyphus* mentioned here, it seems worthy to check whether they were impressions of fossil stones of *Zizyphus* as well.

High graded development of *Z. liaoxijujuba* sp. nov. from Middle Jurassic implies the genus *Zizyphus* had experienced as *Paliurus* a long evolution before Jurassic. Thus, it could not originate in Triassic, and possibly rises prior to this period.

Occurrence of *Zizyphus liaoxijujuba* sp. nov. in Middle Jurassic suggests the early evolution of *Zizyphus* succeeded in China. In connexion with that much species and more varieties of *Zizyphus* are native to China it is conceivable to consider it arises likely at China as well.

CONCLUSIVE WORDS.

Though a claim on Cretaceous origin of angiosperms was emphasized usually and propogandaed widely in recent 30 years, the fossils of two major genera, *Paliurus* and *Zizyphus*, of Rhamnaceae occur in the Middle Jurassic of North China confesses directly the flowering plants did not originate in Cretaceous Period.

Perfect development and high graded evolution of *Paliurus* and *Zizyphus* in Middle Jurassic, and in addition to the fact that they variate little in morphological and structural features in so long an interval from Middle Jurassic to the present as a whole exhibites the family Rhamnaceae had undergone a long evolution and enough differentiation previous to Jurassic. Therefore, obviously it does not originate in Jurassic, and the Triassic period, lasting for about 45 m. y. appears also scanty to ensure this family to perform its development so high. Then, if it were not effected by some unknown factors or suffered a mutation the

originating of Rhamnaceae on the Globe must be considered to have taken place before Mesozoic era, probably happened in Late Palaeozoic. And as discussed above it might arise perhaps in China. The Conclusions acquired in researching other angiospermous families associated in the Middle Jurassic flora are essentially similar.

According to the view points of current systematics^{(23),(24)} the family Rhamnaceae can not originate alone. Its presence during Middle Jurassic hints the existing of the allied and related families meanwhile. Again, more Jurassic angiosperms accompanying it, which will be reported successively, may likely offer available data and information, whether Rhamnaceae had to evolve by following the systematic relations as shown in modern taxonomics or not.

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华北燕辽地区侏罗纪鼠李科植物

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摘 要

报道了发现于华北燕辽地区东段(北纬 $40^{\circ}58'$, 东经 $120^{\circ}21'$)中侏罗世地层海房沟组化石植物群中的马甲子属(*Paliurus*)与枣属(*Zizyphus*)的果实化石。二者的进化水平可与其第三纪及现代属种相比较。它们的出现说明鼠李科存在于中国侏罗纪, 早期演化在中国, 并可能起源于中国。起源时间当在中生代之前。

关键词 侏罗纪, 鼠李科, 马甲子属, 枣属, 华北

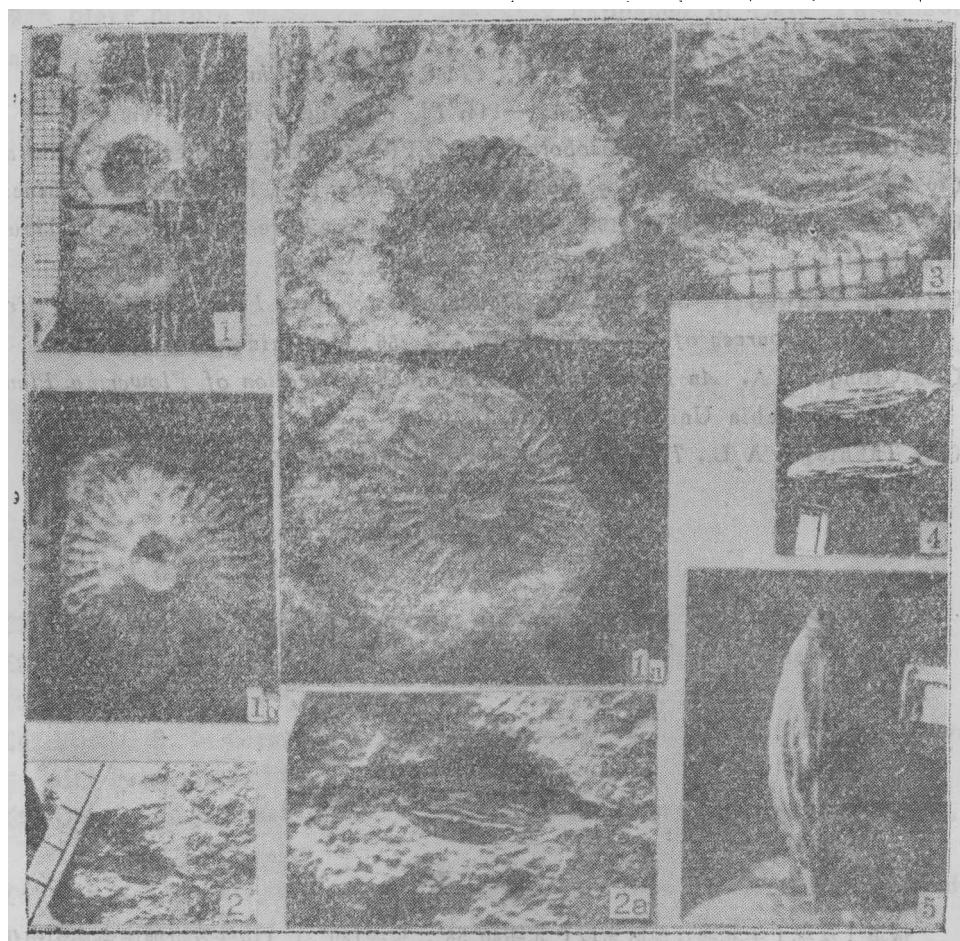


Plate I

- 1, 1a, 1b. *Paliurus jurassinicus* sp. nov. 1, Impression of the flat disc like top of the fruit (the lower, LSJ 0743A) and the cup-shaped mould of the fruit body (the upper, LSJ 0743B), $\times 1$; 1a, fig. 1 $\times 3$. Exactly corresponding of the counterparts of the specimen is shown by the matchable curved streaks on their surface; 1b, Photograph of the same fruit top taken from a different view to show the impression of the 4-lobed style on its centre, $\times 3$
- 2, 2a, 3. *Zizyphus liaoxijujuba* sp. nov. Impressions of two fruit stones. 2. LSJ0531, $\times 1$; 2a, fig. 2, $\times 3$; 3. LSJ 0744 A, $\times 3$
- 4, 5. Fruit stones of the extant *Zizyphus jujuba* Mill. in Liaoning province, 4. $\times 1$; 5. $\times 2$. Comparison made between the fruit stones of the fossil *Zizyphus liaoxijujuba* sp. nov. and the extant species *Zizyphus jujuba* Mill. shows they are similar in morphology, structure and surface ornament