



Yanliaoa, an extinct genus of Cupressaceae *s. l.* from the Middle Jurassic, northeastern China

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Abstract

Yanliaoa is a common fossil in the Middle Jurassic of western Liaoning, eastern Inner Mongolia and northern Hebei Province, China. It is an important element of the Yanliao biota. The genus was established by Pan in 1977 for fossil plants from the Middle Jurassic Haifanggou Formation in Xiasanjiaochengzi, western Liaoning Province, and in present paper, the genus *Yanliaoa* is studied based on new material. Pan never designated a type specimen and his fossil material cannot be located. We designate a type specimen here for *Yanliaoa*, so that the genus name *Yanliaoa* remains valid. *Yanliaoa sinensis* Pan emend. Tan et al., is found in the same locality and formation as the lost specimens, *Y. sinensis* of Pan, 1977. *Yanliaoa daohugouensis* n. sp., a new species with epidermal anatomy, is from the Middle Jurassic Daohugou, Inner Mongolia. A holotype is also selected from the new material for this new species. Characters of the leafy shoots and ovulate cones of *Yanliaoa* are emended. The epidermal anatomy of this genus is described for the first time. Compared with other extant and extinct species of Cupressaceae *s. l.*, the current species can be distinguished from any known species both by the leafy shoot characters and its epidermal anatomy. It further indicates that *Yanliaoa* is an extinct and endemic conifer found in the Middle Jurassic of northeastern China.

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Keywords: *Yanliaoa*; Cupressaceae; Epidermal structure; Middle Jurassic; Daohugou biota

1. Introduction

The fossil genus *Yanliaoa* (Cupressaceae *sensu lato*) is a well-known element in the Middle Jurassic Yanliao Flora, which is distributed in western Liaoning Province, eastern Inner Mongolia Autonomous Region, and Hebei Province, China. It was established by Pan (1977) based on impression specimens from the Middle Jurassic Haifanggou Formation of the eastern margin of the Jinlingsi-Yangshan Basin, western Liaoning. Only

one species, *Yanliaoa sinensis*, was described. Since then, the generic name “*Yanliaoa*” has been widely used, and its stratigraphic occurrences, classification and its associated plants in the Yanliao Flora have been reported many times (Wang, 1984; Yang and Huang, 1985; Zhang and Zheng, 1987; Pan, 1993; Sun et al., 2011).

As a result of recent fieldwork on the Jurassic outcrops from Sanjiaochengzi Village, western Liaoning and Daohugou Village, Inner Mongolia, numerous well-preserved leafy shoots of *Yanliaoa* with cuticle and associated cones have been discovered. On the basis of their cone morphology, we assign these specimens from the two locations to two different species of *Yanliaoa*. We emend generic and specific diagnosis of *Yanliaoa sinensis* Pan, the type species, from Sanjiaochengzi Village,

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Liaoning Province, the same locality and horizon where Pan's (1977) samples were collected, and establish a new species, *Yanliaoa daohugouensis* n. sp., for the specimens with epidermal anatomy and distinct cone morphology from the Daohugou Village, Inner Mongolia, China.

2. Material and methods

More than fifty compression specimens of leafy shoots and ovulate cones of *Yanliaoa sinensis* were collected from the Haifanggou Formation (which is now correlated to the Jiulongshan Formation) at Sanjiaochengzi Village (type locality of *Y. sinensis*), Huludao City, western Liaoning (40°57'52.15"N, 120°21'39.52"E, Fig. 1). The fossiliferous strata are assigned to Middle Jurassic, between Callovian and Oxfordian according to previous survey (RGSL No. 1, 1967; Liu and Wang, 2016). Thirty-seven leafy shoots with well-preserved cuticle and ovulate cones assigned to the new species *Yanliaoa daohugouensis* were collected from the Daohugou Village, Ningcheng County, Inner Mongolia, China (41°18'33.45"N, 119°13'10.17"E, Fig. 1). These fossil-bearing deposits were also attributed to the Middle Jurassic Jiulongshan Formation, and their geological ages were limited in Bathonian–Callovian based on radiometric dating (Chen et al., 2004; Liu et al., 2004; Yang and Li, 2008; Sullivan et al., 2014). The two fossil sites are about 120 km away from each other, and they are generally considered as the Yanliao biota (Huang, 2015). The specimens of extant *Sequoia sempervirens* were collected from Yunnan Province, China.

Specimens were observed under a Keyence microscope (VHX-1000) with an attached digital camera. Some photographs were taken with a Canon digital camera (Canon 5D Mark II). Cuticular preparations were made following a standard procedure, including treatment in HF, Schulze's reagent and dilute ammonia solution (Dilcher, 1974; Kerp, 1990; Kerp and Barthel, 1993). Cuticle samples were observed and photographed with a JSM-6700 CF SEM at 8 kV. Some cuticular fragments were observed and photographed under an optical microscope (Olympus CX31) at the Research Center of Paleontology and Stratigraphy, Jilin University, Changchun, China. Samples of extant *Sequoia sempervirens* were obtained by preparing the leaves with a solution of hydrogen peroxide (H₂O₂) and glacial acetic acid (CH₃COOH) at 1:1, or in a chromium trioxide (CrO₃) solution according to Alvin and Boulter (1974) and Ma et al. (2005).

3. Systematics

Class Coniferopsida

Order Coniferales

Family Cupressaceae *sensu lato*

Genus *Yanliaoa* Pan emend. Tan, Dilcher, Wang and Sun

Emended generic diagnosis: Leafy twigs may have up to three orders of branching. Ultimate branches oriented in one plane, alternately (sometimes sub-oppositely) arranged on penultimate

axes. Leaf bases helically arranged on axis but leaves orientated in one plane. Leaf straight or slightly falcate, broadly attached to axis; margin entire, apex rounded. Midrib prominent, sunken on adaxial side and raised on the abaxial side.

Leaf hypostomatic. Lower cuticle containing a stomatal zone on each side of the midvein. Each stomatal zone consisting of three to four rows of stomata; guard cells normally surrounded by four to six subsidiary cells.

Ovulate cone elliptical. Scales of immature ovulate cones inserted at an acute angle to the axis and those of mature ovulate cones inserted at an obtuse angle, both with spine-like distal end; two seed scars present at the proximal portion of the adaxial surface of the scale.

Type species: *Yanliaoa sinensis* Pan emend. Tan, Dilcher, Wang, and Sun.

Yanliaoa sinensis Pan emend. Tan, Dilcher, Wang, and Sun

(Figs. 2a–f, 3a, b)

Lectotype: RCPS-SJS003-1 (Fig. 2a).

Paratype: RCPS-SJS093 (Fig. 2b).

Other specimens: RCPS-SJS042 (Fig. 2c, d), RCPS-SJS117 (Fig. 2e), RCPS-SJS070 (Fig. 2f).

Syntypes: L006A, L0040A, L0027, and L0034A. These are specimens described in Pan (1977).

Type locality: Sanjiaochengzi Village, Huludao City, Liaoning Province, China.

Horizon: Haifanggou Formation, Middle Jurassic.

Deposition: RCPS-SJS003-1, RCPS-SJS093, RCPS-SJS042, RCPS-SJS117, RCPS-SJS070 are stored in the Research Center of Paleontology and Stratigraphy, Jilin University, Changchun, China.

Emended specific diagnosis: Leafy twigs may have up to three orders of branching. Ultimate branches oriented in one plane, alternately (sometimes sub-oppositely) arranged on penultimate axis. Leaf bases appearing to be organized helically but leaves orientated in one plane. Most mature leaves straight or slightly falcate, with entire margin and rounded apex, 6–12 mm long, 1–1.5 mm wide, and the length-width ratio usually higher than 5. Midrib prominent, sunken on adaxial side and raised on the abaxial side. Leaves attached broadly to axis at their bases, each leaf extending outward at angles of 25–40°. Immature leaves and leaves on branches bearing ovulate cones notably smaller and appressed to the axis, with a lower length-width ratio.

Ovulate cones elliptical, 12–15 mm long, 8–12 mm wide. The scales of the immature ovulate cones inserted at an acute angle to the axis and those of the mature ovulate cones inserted at an obtuse angle, both with spine-like distal end; two seed scars present at the proximal portion of the adaxial surface of the scale.

Description:

Leafy twig: An incomplete leafy twig shows three orders of branching (Fig. 2a–c). Ultimate branches are 10–15 mm wide, more than 100 mm long, organized in one plane, alternately (sometimes sub-oppositely) arranged on the penultimate

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