Cupressinocladus sp., Newly Found from the Lower Cretaceous Wakino Formation, West Japan

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Abstract The typical Ryoseki-type plant, Cupressinocladus sp. was found from the equivalent of the Wakino Formation, Yamaguchi Prefecture. This paper deals with its description and its significance for the Early Cretaceous phytogeography in Japan.

Introduction

The Lower Cretaceous Wakino Formation (formerly called Wakino Subgroup), lower half of the Kwanmon Group of non-marine origin, yields various fossil animals. But no identifiable fossil plant had been known from the Wakino Formation and its equivalents (Murakami, 1960) distributed on the west of Ogori-cho, Yamaguchi City. The present Cupressinocladus sp. is the only identifiable plant hitherto known. The specimen is poorly preserved and seems to be botanically worthless, but is palaeophytogeographically significant as mentioned below.

We thank Mr. Naoe Ishikawa who collected the present specimen and offered it for our study. Our thanks are extended to Dr. Shya Chitaley of the Cleveland Museum of Natural History for her linguistic check on the manuscript of this paper.

Palaeophytogeographical significance

The Wakino Formation is considered by most geologists and palaeontologists in Japan to be of late Neocomian age [e.g. Matsumoto, 1954 (editor), 1978] on the basis of its non-marine fauna and its stratigraphical position. Equivalent sediments are widely distributed in Japan. They are Itohiro Group (including the Akaiwa Subgroup) in the Inner Zone of Central Japan and the Ryoseki and Arida Formations and their equivalents in the Outer Zone. Besides the Wakino Formation, these strata yield abundant fossil plants and they are divisible into the Teteri-type flora in the Inner Zone and the Ryoseki-type flora in the Outer Zone. As repeatedly mentioned by Kimura (e.g. 1987a, b), both floras are characterized in floristic composition by the fact briefly shown in Table 1. Table 1 shows that both floras are different in floristic composition from one another and no common species is
Fig. 1. Fossil locality.
1A. Geographical position of Yamaguchi Prefecture.
1B. An arrow shows the fossil locality. The distribution of the Wakino Formation is briefly drawn after Murakami (1960).

Table 1. Main difference of the floristic composition between the Tetori-type and Ryoseki-type floras

<table>
<thead>
<tr>
<th>Fossil plant taxa</th>
<th>Tetori-type</th>
<th>Ryoseki-type</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Ferns</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td><em>Raphaelea</em> (Osmundaceae)</td>
<td>Varied and abundant</td>
<td>None</td>
</tr>
<tr>
<td>Dicksoniaceous ferns</td>
<td>None</td>
<td>Abundant</td>
</tr>
<tr>
<td>Matoniaceous ferns (including Weichselia)</td>
<td>None</td>
<td>Varied and abundant</td>
</tr>
<tr>
<td><em>Zamites</em></td>
<td>None</td>
<td>Abundant</td>
</tr>
<tr>
<td><em>Pilophyllum</em></td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td><em>Neozamites</em></td>
<td>Abundant</td>
<td>None</td>
</tr>
<tr>
<td><em>Dictyozaizites</em></td>
<td>Varied and abundant</td>
<td>None</td>
</tr>
<tr>
<td><em>Ctenis</em></td>
<td>Abundant</td>
<td>None</td>
</tr>
<tr>
<td><em>N. shaumburgensis</em>-type</td>
<td>Present</td>
<td>None</td>
</tr>
<tr>
<td><em>N. densinervis</em>-type</td>
<td>None</td>
<td>Abundant</td>
</tr>
<tr>
<td><em>Ginkgo</em> (or Ginkgoites)</td>
<td>Varied and abundant</td>
<td>None</td>
</tr>
<tr>
<td><em>Ginkgoidium</em> (or Pseudotorelia)</td>
<td>Abundant</td>
<td>Varied and abundant</td>
</tr>
<tr>
<td><em>Czekanowskia</em> (or its allies)</td>
<td>Abundant</td>
<td>Varied and abundant</td>
</tr>
<tr>
<td><em>Phoenicopsis</em></td>
<td>Abundant</td>
<td>Abundant</td>
</tr>
<tr>
<td><em>Podozaizites</em></td>
<td>Abundant</td>
<td>Abundant</td>
</tr>
<tr>
<td>With scale leaves (or Cheirolepideciadeous conifers) including <em>Cupressnocoelus, Brachyphyllum</em> and <em>Frenetopsis</em> (or <em>Pseudofrenetopsis</em>)</td>
<td>Abundant</td>
<td>Abundant</td>
</tr>
<tr>
<td>With needle leaves</td>
<td>Varied and abundant</td>
<td>Very rare or none</td>
</tr>
</tbody>
</table>

: Distribution of the Wakino Formation equivalent.
Cupressinocladus sp., newly found from the Lower Cretaceous

Seward (1919) proposed a non-committal genus Cupressinocladus for coniferous leafy-shoots having external resemblance to those of extant conifers belonging to

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![Stratigraphical sequence and distribution of fossil plants and other fossils in western part of Yamaguchi Prefecture.](image-url)

**Fig. 2.** Stratigraphical sequence and distribution of fossil plants and other fossils in western part of Yamaguchi Prefecture. Cross mark; horizon of land-plants, open circle; horizon of invertebrates and calcareous algae, solid circle; horizon of guide ammonites, F; Formation, G; Group.
Cupressaceae. Later additional diagnostic features were proposed by Chaloner and Lorch (1960), Harris (1969) and Barnard and Miller (1976). Anyway, the present specimen can be included in Seward’s form-genus.

The western part of Yamaguchi Prefecture and northeastern part of Fukuoka Prefecture (Kwanmon District and its surrounding areas) have geotectonically been included in the Inner Zone of Japan, but this region is unique from palaeophytogeographical point of view.

The stratigraphical sequence in this region is briefly shown in Fig. 2. Fossil plants have been known from the Higashinagano, Nishinakayama, Utano and Kiyosú Formations. The latter is a lower half of the Toyonishi Group.

Only two taxa have been known from the Higashinagano Formation (Oishi, 1940) and one of them is Brachyphyllum. Fossil plants of the Nishinakayama Formation were described by Kimura et al. (1986) and Kimura and Ohana (1987b, c). They are Gleichenites (?), Phlebopteris, Sphenopteris, Ctenozamites (?), Otozamites, Zamites, Pseudocenitis, Araucarites, Brachyphyllum, Cupressinocladus, Elatides and Geinitzia. In spite of our untiring collection for over 30 years, we could not find dicksoniaceous and dipteridaceous ferns, ginkgoaleans, czekanowskialeans and Podozamites leafy-shoots from the Nishinakayama Formation. They are common elements in the nearly contemporary Kuruma-type flora in Japan. This plant-assemblage from the Nishinakayama Formation (Nishinakayama flora) is, although the number of taxa is not so many, typically of the Ryoseki-type, and no common species are known between the Nishinakayama-type flora and Kuruma-type flora in the Inner Zone of Central Japan.

Fossil plants of the Utano Formation (Utano flora) were described by Kimura and Ohana (1987b, c). This plant-assemblage (Utano flora) consists of more than 50 species. The Utano flora is fundamentally of the Ryoseki-type, but includes a few Tetori-type taxa, such as Onychiopsis elongata (Geyler) Yokoyama, Ginkgoites and Czekanowskia. Accordingly, the Utano flora is of the mixed-type. The plant-assemblage of the Kiyosú Formation (Kiyosú flora) is also of the mixed-type, although stratigraphical and taxonomical reexaminations of the flora are needed.

Similar mixed-type floras have been known from the non-marine Upper Jurassic-Lower Cretaceous deposits in Eastern Eurasia, such as the Naktong (or Nagdong) flora in South Korea, Laiyang flora in Shandong Province and its equivalents distributed along the Huanghe River (Yellow River) in Xinjiang, Qinghai, Gansu, Shaanxi, Shanxi and Neimeng Provinces, Northwestern and North China, and in southeastern part of Heilongjiang, Northeast China and southern Primorye, USSR (see, fig. 7 of Kimura, 1987a and fig. 2 of Kimura, 1987b).

These mixed-type floras include conifers with scale-leaves, such as Cupressinocladus, Brachyphyllum and Frenelopsis (or Pseudofrenelopsis) which are characteristic elements of the Ryoseki-type flora. No such mixed-type flora has been found in Japan except for the Kwanmon District and its surrounding areas. Accordingly, as men-
Cupressinocladus sp., newly found from the Lower Cretaceous region is unique in palaeophytogeographical point of view.

The occurrence of Cupressinocladus sp. from the equivalent of the Wakino Formation located in the Inner Zone of Japan, may indicate that the supposed vegetative (or floristic) character of the Wakino Formation is of the Ryoseki- or possibly of mixed-type and is entirely different in vegetative character of the nearly contemporary Tetori-type flora in the Inner Zone of Japan, in which no conifers with scale-leaves have been found so far.

The uniqueness of the Jurassic-Early Cretaceous floras in this region should be examined geotectonically.

**Description of specimen**

Coniferales
Form-genus *Cupressinocladus* SEWARD, 1919
*Cupressinocladus* sp.
Figs. 3a-b

**Specimen:** KMNH GP 100,001 (kept in the Kitakyushu Museum of Natural History).

**Locality and horizon:** Higashi-Hongo (formerly Higashi-Bata) (Fig. 1B), Kagawa, Yamaguchi City (roughly 131°21'20"E, 34°05'40"N): Upper part of the Wakino Formation equivalent (possible late Neocomian in age).

**Occurrence:** Very rare (occasional).

**Description:** A single fragment of coniferous leafy-shoot was obtained. Preserved main axis is more than 5.5 cm long, 3 mm wide below and sends pinnately disposed penultimate leafy-branches at an angle of 60–70 degrees and at intervals of 1.5 cm. Penultimate leafy-branch is lanceolate in form, up to 2 cm wide and 6 cm long as seen. Ultimate leafy-branches are closely set, alternate or subopposite, up to 2 cm long and 1 mm wide, nearly parallel-sided for the most part, straight or sometimes falcate, and originated at an angle of 45 degrees to the penultimate axis and at intervals of 3 mm. Ultimate and penultimate axes are entirely covered by scale leaves. Leaves are rhomboidal in form, with acutely pointed apex and decurrent base, decussate, entirely appressed to the axis and 1.5 mm long and 0.75 mm wide. No interstitial appendages originated from the main axis have been recognized between adjacent penultimate branches. Cuticle is not preserved. Reproductive organs are not known.

**Comparison:** In external appearance, the present leafy-shoot resembles those of *Cupressinocladus mimotoi* KIMURA et OHANA (KIMURA and OHANA, 1987a; OHANA and KIMURA, 1989) known from the Lower Cretaceous plant-bed in the Outer Zone of Southwest Japan, but is distinguishable from the latter by its shorter ultimate...
branches.

Affinity and discussion: In fact, the present leafy-shoot resembles those of some extant conifers belonging to Cupressaceae in external appearance.

According to Alvin et al. (1967), the oldest record of fossil cupressaceous conifers are said to be Cupressinocladus ramonensis Chaloner et Lorch (Chaloner and Lorch,

Fig. 3. *Cupressinocladus* sp.:  
3a. A broken leafy-shoot (KMNH GP 100,001).  
3b. A part of ultimate leafy-branch enlarged, drawn partly from Fig. 3a.
Cupressinocladus sp., newly found from the Lower Cretaceous 1960) collected from the Early or Middle Jurassic of Israel [According to LORCH (1969), its age is said to be Late Triassic or Early Jurassic], and C. (Thuites ?) walker Sahni and C. burmensis Sahni (Sahni, 1928) from the Late Triassic or Early Jurassic of Burma. Sahni's specimens, however, are all represented by sterile leafy-shoots without preserved cuticle.

On the other hand, WATSON (1982) inclined to regard Cupressinocladus ramonensis as cheirolepidiaceous on the basis of the presence of internal papillae inside the stomatal pit (CHALONER and LORCH, 1960, pl. 36, fig. 7) and the presence of associated male cone, Masculostrobus harrisianus LORCH (LORCH, 1968).

Kon'no (1968) originally described Cupressinocladus acuminifolia and Frenelopsis malaiana from the Gagau Formation (Malaya) of non-marine origin. We feel that the geological age of the Gagau Formation is Early Cretaceous as was suggested by Kon'no (1967). The latter taxon was transferred by BARNARD and MILLER (1976) to Cupressinocladus, because of leaves having decurrent bases separated by distinct sutures. According to WATSON (1982), they are also cheirolepidiaceous.

So the presence of cupressaceous conifers based on reliable evidence before Early Tertiary becomes dubious.

In Japan, several Cupressinocladus species (or forms) have been described from the Lower Jurassic Nishinakayama Formation (KIMURA et al., 1986) and from the Upper Jurassic-Lower Cretaceous plant-beds from the Outer Zone of Japan (OISHI, 1940; KIMURA and MATSUKAWA, 1979; KIMURA and OHANA, 1987a, 1989, 1990; OHANA and KIMURA, 1989; KIMURA et al., 1991). Unfortunately they are all represented by sterile leafy-shoots without preserved cuticle.

Recently, OKUBO and KIMURA (1991) succeeded to prepare cuticules of Cupressinocladus leafy-shoots collected from the Lower Cretaceous Choshi Group in the Outer Zone of Japan, and concluded that they are not cupressaceous but cheirolepidiaceous. They also discussed the microscopical difference between both families in detail.

In addition, Horiuchi and Yagioka (1991 MS) studied the palyno-flora of the Choshi Group. According to them, Classopolis grains are predominant, but they have not recognized cupressaceous pollen grains.

Under the circumstances, it is highly probable that the present leafy-shoot belongs to Cheirolepidiaceae and not to Cupressaceae.

In this paper we can not give the present leafy-shoot a specific name because of its poor preservation.

References


