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Some Early Cretaceous Plants from the Outer Zone of Japan

By

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Abstract This paper deals with the description of *Eboracia microlobifolia* sp. nov., *Adiantopteris sawamurae* sp. nov., *Acrostichopteris* sp. A, *Cladophlebis* sp., *Zamites tosanus* OISHI, *Cupressinocladus mimotoi* sp. nov., and *C.* sp. C based on the material newly obtained from the Lower Cretaceous plant-beds in the Outer Zone of Japan. These taxa are characteristic in the Early Cretaceous Ryoseki-type floras in the Outer Zone of Japan and have not been found from the coeval Tetori-type floras in the Inner Zone of Japan.

Introduction

We describe seven miscellaneous species of fossil plants newly obtained from the Lower Cretaceous Ayukawa Formation, NE-Japan, and the Ryoseki and Upper Monobegawa Formations, SW-Japan both in the Outer Zone of Japan. Unfortunately all gymnosperm-specimens here described are represented by leaf-impressions and their cuticles are not preserved.

We are grateful to Mr. Kenji MIMOTO, Mr. Kenji YAMASAKI and Mr. Tadayoshi SAWAMURA who offered their valuable specimens for our study.

Our thanks are extended to Dr. Junji HORIUCHI who cooperated with us in collecting the fossil plants from the Ayukawa Formation.

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Brief geological notes on the localities

The Ayukawa Formation (Figs. 1a–b), the upper formation of the Ojika Group distributed in the Ojika Peninsula, Miyagi Prefecture, is divided into the Kiyosaki Sandstone, Futawatashi Shale and Domeki Sandstone Members in upward sequence (TAKIZAWA, 1970).

From the Kiyosaki Sandstone Member were recorded fossil plants as follows (FUJI, 1956): *Cladophlebis denticulata*, *C.* cf. *lobifolia*, *C.* sp., *Onychiopsis elongata*, *Otozamites sewardi*, *Ptilophyllum pecten*, *Zamiophyllum* sp., *Nilssonia schaumburgensis*, *N. schaumburgensis* var. *parvula*, *N.* cf. *schaumburgensis* var. *parvula*, *N. orientalis*, *N.* cf. *orientalis*, *Czekanowskia rigida*, *Frenelopsis* cf. *hoheneggeri*, *Cupressinocladus*

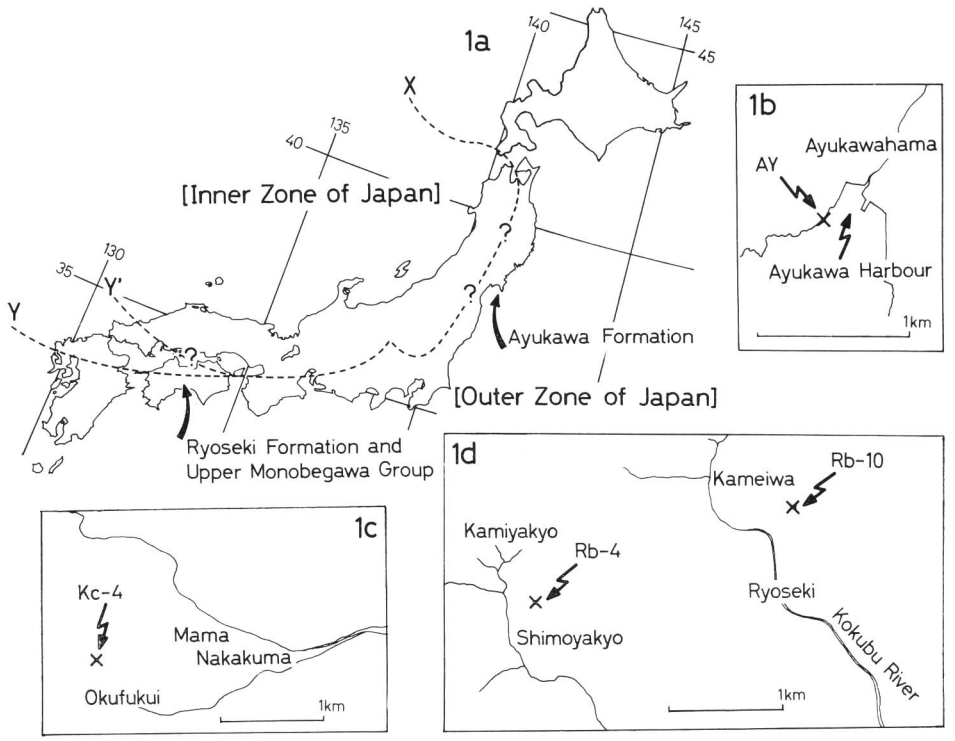


Fig. 1. Maps showing fossil localities.

1a. Locations of the Ayukawa Formation (arrow) and the Ryoseki and Upper Monobegawa Formations (arrow). X–Y; appropriate palaeofloristic boundary between the Ryoseki-type floras (Outer Zone) and the Tetori-type floras (Inner Zone). Floras in the area between X–Y and X–Y′ lines include some elements of the Ryoseki-type flora (For further details, see KIMURA, 1979, '84).

1b. Locality of fossil plants from the Ayukawa Formation; at the cliff along the seashore, east of the Ayukawa Junior High School, Ayukawa, Ojika-cho, Ojika-gun, Miyagi Prefecture (indicated by an arrow AY; roughly 141°30′30″E, 38°17′36″N).

1c. Locality of *Cupressinocladus mimotoi* sp. nov. in the Kochi Basin, near Okufukui, Kochi City; Upper Monobegawa Formation [indicated by an arrow Kc-4 (after HIRATA, 1974); roughly 133°35′E, 33°36′N].

1d. In the Ryoseki Basin, locality of *Zamites tosanus* OISHI, Togodani, Shimoyakyo, Nangoku City [indicated by an arrow Rb-4 (after HIRATA, 1972)] and that of *Adiantopteris sawamurae* sp. nov., Ryoseki, Tosa-Yamada City [indicated by an arrow Rb-10 (after HIRATA, 1972; roughly 133°40′E, 33°36′N], both belonging to the Ryoseki Formation.

koyatoriensis, *C.* cf. *koyatoriensis* and *Podozamites* sp.

FUJI (1956) mentioned that this florula was rather of the Tetori-type. However, we are of the opinion that these 17 taxa especially for his *Czekanowskia rigida* and *Podozamites* sp. require palaeobotanical reexamination. This florula is of the Ryoseki-type because such genera as *Ptilophyllum*, *Zamiophyllum* (=*Zamites* in our opinion,

KIMURA and OHANA, 1985), *Nilssonia* with *N. schaumburgensis*-type leaves, *Frenelopsis* and *Cupressinocladus* are characteristic of the Ryoseki-type floras and have not been found in the Tetori-type floras.

According to TAKIZAWA (1970, '78), the geological age of the Ayukawa Formation is Late Tithonian-Valanginian based on the marine-fossils obtained from the Futawatashi Shale Member, and that of the Kiyosaki Sandstone Member bearing abundant fossil plants is Late Tithonian-Early Berriasian (?).

In the Kochi and Ryoseki Basins, Kochi Prefecture (Figs. 1a, c–d), Lower Cretaceous deposits are divided into the Lower Neocomian Ryoseki, Upper Neocomian Lower Monobegawa (or Nagashiba) and Aptian-Albian Upper Monobegawa (or Wada) Formations in upward sequence. The latter two are mainly of marine origin and fossil plants have been known from every formation (KIMURA and ASAMA, 1975).

Brief notes on the fossil plants

Fossil plants here described are: *Eboracia microlobifolia* sp. nov.,* *Adiantopteris sawamurae* sp. nov., *Acrostichopteris* sp. A*, *Cladophlebis* sp.*, *Zamites tosanus* OISHI, *Cupressinocladus mimotoi* sp. nov. and *C.* sp. C* (*; from the Ayukawa Formation).

1) *Eboracia microlobifolia* sp. nov.: Of the fossil ferns hitherto known from the Upper Jurassic-Lower Cretaceous plant-beds in the Outer Zone of Japan, their reproductive organs are mostly superficial in position and ferns with marginal reproductive organs are very rare in occurrence. *Eboracia microlobifolia* is one of a few representatives of the marginal-type. It is worth mentioning that these ferns of marginal-type have not been found from the coeval plant-beds in the Outer Zone of Southwest Japan, and they are varied and very abundant in the ceoval Tetori-type floras in the Inner Zone of Japan.

2) *Adiantopteris sawamurae* sp. nov.: *Adiantopteris* is a form-genus of ferns with uncertain affinity and its leaves are with pinnules like those of recent *Adiantum*. *Adiantopteris* is commonly known both from the Tetori-type and Ryoseki-type floras, but *A. sawamurae* seems to be a characteristic species in the Ryoseki-type floras in the Outer Zone of Southwest Japan.

3) *Acrostichopteris* sp. A: *Acrostichopteris* is also a form-genus of ferns with uncertain affinity. So far as our recent knowledge is concerned, *Acrostichopteris* is restricted in distribution to the Late Mesozoic plant-beds in the Outer Zone of Japan.

4) *Zamites tosanus* OISHI: *Zamites* is one of the bennettitalean genus and is varied and abundant in the Ryoseki-type floras but has not been found in the Tetori-type floras.

Zamites tosanus is characterized by its small-sized leaf. Its cuticular characters will be mentioned by us, because in our collection from the Lower Cretaceous Choshi Group in the Outer Zone of Japan, many leaf-fragments with preserved cuticle referable to those of this species are found.

5) *Cupressinocladus mimotoi* sp. nov. and *C.* sp. C: Both are characterized by

twigs with decussate leaves. As far as the Japanese *Cupressinocladus* species are concerned, we cannot mention their attribution to the Cheirolepidiaceae or to the Cupressaceae or its allies because they are all represented by sterile leafy-twigs and their reproductive organs and leaf-cuticles are not preserved.

It is worth mentioning that *Cupressinocladus* and such Cheirolepidiaceous conifers as *Brachyphyllum*, *Frenelopsis* and *Pseudofrenelopsis* are important elements of the Ryoseki-type floras in the Late Jurassic-Early Cretaceous time, but have not been found in the coeval Tetori-type floras.

Systematic description

Filicales

Dicksoniaceae

Genus *Eboracia* THOMAS, 1911: 387

Eboracia microlobifolia KIMURA et OHANA sp. nov.

(Pl. 1, figs. 1–4; Figs. 2a–h)

Material: Holotype; NSM PP-7885. Paratypes; NSM PP-7880, 7882, 7883. Other specimens; NSM PP-7876～7879, 7881, 7884, 7886～7897.

Stratum typicum: Kiyosaki Sandstone Member (Late Tithonian-Berriasian?), Ayukawa Formation, Ojika Group. *Locus typicus*: Cliff along the sea-shore, east of the Ayukawa Junior High School, Ayukawa, Ojika-cho, Ojika (or Oshika)-gun, Miyagi Prefecture. *Derivatio nominis*: According to the small-sized pinnules resembling in form and venation *Eboracia lobifolia*. Occurrence: Locally common, sometimes thickly massed.

Diagnosis: Leaf small-sized, probably bipinnate. (Whole size unknown.) Pinnae long and narrow, typically 6.5 cm long, gradually narrowing to the acuminate apex, 0.6 cm wide near the base, sending katadromically off 33–34 pairs of closely set pinnules. Pinnules triangular or rhomboidal in form, typically 0.5 cm long and 2 mm wide near the base; acroscopic margin straight or concave, sometimes constricted at the base; basiscopic margin rounded, constricted near the base, then decurrent; laminae sometimes contiguous each other near the base; margins entire, with obtusely pointed apex. Venation of the *Eboracia*-type, sympodially disposed; midnerve not straight but zigzag, sending off 3–4 alternate pairs of lateral veins dichotomously forking twice. Fertile pinnules reduced in size, rather remotely set, markedly decurrent; vein simple at the origin, then dichotomously forking once to twice, terminated by the elliptic reproductive organs, 0.75 mm high and 1.5 mm wide. (Details of the reproductive organ unknown.)

Discussion and *comparison*: The present leaves are characterized by the elongated pinnae with acuminated apex, sending off small-sized *Eboracia*-type pinnules in form and venation. The reason why we regard the present leaves as belonging to *Eboracia* is that the form and venation of sterile pinnules are of the *Eboracia*-type and the marginal habit of the reproductive organs.

Such small-sized *Eboracia*-type leaves as the present ones have not been recorded so far. Accordingly we here propose *Eboracia microlobifolia* as a new species.

The ordinal form of sterile pinnules and venation of *Eboracia lobifolia* (PHILLIPS) THOMAS is similar to those of *E. microlobifolia*, but *E. lobifolia* is easily distinguished by its ordinal sterile pinnules with undulated margins, almost twice as large as those of *E. microlobifolia* and a pair of basal pinnules markedly specialized (HARRIS, 1961).

Cladophlebis novopokrovskii PRYNADA represented by sterile leaves known from the Upper Jurassic-Lower Cretaceous of the Bureja Basin (VAKHRAMEEV and DOLUDENKO, 1961) and the Lower Cretaceous of Southern Primorye (KRASSILOV, 1967) is similar in form to *Eboracia microlobifolia*, but *C. novopokrovskii* is distinguished by its pinnules twice as large as those of *E. microlobifolia*.

Cladophlebis cf. *lobifolia* listed by FUJI (1956) is most probably synonymous with *Eboracia microlobifolia*. Additional description of *Eboracia microlobifolia* will be made by us in the near future based on well preserved material collected from the Upper Jurassic Tochikubo Formation, Soma-Nakamura Group, Fukushima Prefecture, in the Outer Zone of Japan.

Unclassified ferns

Form-Genus *Adiantopteris* VASSILEVSKAJA, 1968: 49

Adiantopteris sawamurae KIMURA et OHANA sp. nov.

(Pl. 2, fig. 1; Figs. 4a–b)

Adiantites toyoraensis OISHI: OISHI, 1940, p. 235 (pars), pl. 7, fig. 4, 4a (Kobodani) (non figs. 2, 2a, 3).

Material: Holotype; OISHI's 8589 (kept in the Hokkaido University) shown in OISHI, 1940, pl. 7, fig. 4, 4a. Paratype; Pl. 2, fig. 1 in this paper, kept by T. SAWAMURA. *Stratum typicum*: Ryoseki Formation (s. str.). *Locus typicus*: Kobodani (Rb-10 in Fig. 1d), Tosa-Yamada City, Kochi Prefecture. *Derivatio nominis*: Dedicated to Mr. T. SAWAMURA, a good collector. *Occurrence*: Rare.

Diagnosis: Leaf small-sized with slender rachis, 0.5–0.6 mm wide, sending alternately off shortly petioled semicircular pinnules, 1.8 cm high with irregularly rugged or irredularly emarginate outer margin and with entire and straight basal margins. First vein forking dichotomously at the top of short petiole, each running along the basal margin forming 'marginal vein', sending proximally off 4–6 radiate veins forking 3–4 times dichotomously; marginal vein itself also forking once or twice distally; vein-dichotomy rather regular. (Fructification unknown.)

Discussion and *comparison*: The diagnosis mentioned above is based on OISHI's specimen (his pl. 7, fig. 4a) and our additional specimen here illustrated (Pl. 2, fig. 1; Fig. 4a), collected by T. SAWAMURA from Ueno, northern part of Ryoseki, Nangoku City [Ryoseki Formation (s. str.)].

In 1940 OISHI instituted *Adiantites toyoraensis* based on incomplete leaves collected from Takaji (Middle Jurassic Utano Formation) and from Kobodani [Ryoseki Forma-

tion (s. str.)]. According to our careful observation on our additional specimens collected from the Utano Formation, they are specifically distinct from those from the Ryoseki Formation, because in the former leaves, all veins are radiated from the top of short petiole but in the latter, the first vein is forking dichotomously and each branch is running along the basal margin, then is forking once or twice distally, sending off 4–6 radiate veins proximally. In addition, in the former pinnules are not semicircular as in *Adiantopteris sawamurae* but mostly wedge-shaped.

Accordingly we here propose *Adiantopteris sawamurae* for the leaves obtained from the Ryoseki Formation, separating from *A. toyoraensis*.

From the Japanese Mesozoic, besides *Adiantopteris sawamurae* the following *Adiantopteris* species have been known:

A. sewardi (YABE) VASSILEVSKAJA: Lower Cretaceous Itoshiro Group (Inner Zone of Japan).

A. yuasensis (YOKOYAMA) VASSILEVSKAJA: Lower Cretaceous Yuasa Formation (Outer Zone of Japan).

A. ginkgoifolia KIMURA et SEKIDO (MS): Lower Cretaceous Itoshiro Group (Inner Zone of Japan).

A. ishidae KON'NO et NAITO: Carnic Momonoki Formation.

Of these *Adiantopteris sewardi*, *A. ginkgoifolia* and *A. ishidae* differ in the form of pinnules from *A. sawamurae*. *Adiantopteris yuasensis* originally described by YOKOYAMA (1894, p. 216, pl. 21, fig. 15) differs from *A. sawamurae* in its venation that a single first vein runs along the basal margin of pinnule, sending off 8–9 once-thrice forked branch veins.

In the case of leaves represented by incomplete pinnules it is difficult to distinguish *Adiantopteris sawamurae*, *A. toyoraensis* and *A. yuasensis* specifically.

From the Upper Jurassic-Lower Cretaceous plant-beds in Siberia and NE-China, a few *Adiantopteris* species have been known, but they differ from *A. sawamurae* in the form of pinnules and venation.

Form-Genus *Acrostichopteris* FONTAINE, 1890: 106

Acrostichopteris sp. A

(Pl. 2, fig. 2; Fig. 3)

Material: NSM PP-7878. *Locality* and *Horizon*: The same as *Eboracia microlobifolia*. *Occurrence*: Rare.

Description: Obtained is a single fragment of penultimate pinna, more than 2.1 cm long. Ultimate pinnae are attached suboppositely to the slender penultimate pinna-axis at an angle of 35 degrees, sending katadromically off closely set pinnules at a narrow angle. Pinnules are wedge-shaped deeply divided typically into four divisions directed forwards; each division is further shallowly divided apically into two lobes with obtusely pointed or rounded apex. A single vein is originated from the very slender pinna axis, repeatedly forking dichotomously; each lobe receives a single vein. Reproductive organ is not known.

Remarks: We accommodate the present leaf-fragment in the Form-Genus *Acrostichopteris* based upon its habit of ultimate pinnae and venation of pinnules. But it is difficult to make its specific identity to the *Acrostichopteris* species hitherto known from the Lower Cretaceous plant-beds in United States, Southern Primorye, Southern Europe and also in the Outer Zone of Japan.

Form-Genus *Cladophlebis* BRONGNIART, 1849: 105

Cladophlebis sp.

(Fig. 5)

Material: NSM PP-7876. *Locality* and *Horizon*: The same as *Eboracia microlobifolia*. *Occurrence*: Rare.

Description: Obtained is an incompletely preserved pinna fragment with 8 small-sized and closely set pinnules. The pinnules are elongate-deltoid in outline, about 0.75 cm long attached alternately to the pinna axis at an angle of 45–50 degrees by the whole base; margins are entire but apices are all missing. Venation is of *Cladophlebis*-type; midnerve is distinct, sending katadromically off 5–6 pairs of once forked laterals at a narrow angle. Fructification is not known.

Remarks: Because of insufficiency of our specimen, we could not make any precise specific identity of it. Our pinnules, however, are close in form and venation to those described by OISHI (1940) as *Cladophlebis concinna* (HEER). But it is doubtful whether OISHI's *Cladophlebis concinna* is truely identical with HEER's *Dicksonia concinna* or not.

Cladophlebis denticulata listed by FUJI (1956) is most probably synonymous with the present *C.* sp. Many sterile fern leaves have been recorded from the Mesozoic plant-beds in Japan under the name of *Cladophlebis denticulata*, but most of them are different in form and size of pinnules from the original leaves of *C. denticulata* or *Todites denticulatus* known from the Jurassic of Yorkshire.

Bennettitales

Genus *Zamites* BRONGNIART, 1828 em. HARRIS, 1969: 3

Zamites tosanus OISHI

(Pl. 2, fig. 3; Fig. 6)

Zamites tosanus OISHI: OISHI, 1940, p. 357, pl. 35, fig. 4, 4a (8596 kept in Hokkaido University: Kobodani, Ryoseki Formation: Holotype).

Material: Shown in Pl. 2, fig. 3 (Paratype, kept by Kenji YAMASAKI).

Locality and *Horizon*: Togodani, Rb-4 in Fig. 1d, Ryoseki Formation (s. str.). *Occurrence*: Rare.

Description: Obtained is a single additional leaf-fragment referable to OISHI's *Zamites tosanus*. The leaf is rather small-sized with thick rachis, 3 mm wide, sending alternately off pinnae at a wide angle from the upper edge of rachis. Pinnae are closely set, long and narrow, more than 4.5 cm long, gradually and symmetrically

constricted towards the base, but nearly parallel-sided for the most part, up to 5 mm wide; apex is unknown. Upper surface of pinnae is markedly convex. Veins are originated from the base, 5–6 in number, forking dichotomously near the base, then parallel to each other, 13–14 in number at the middle of pinna. A successive and delicate stripe is observed between veins. Reproductive organs are not known.

Remarks: OISHI (1940) instituted this species based on a single leaf-fragment obtained from Kobodani, the Ryoseki Formation (s. str.). In OISHI's holotype, the pinnae are alternate, set closely, at a wide angle to the rachis, linear, straight, 2.5 cm long and 2.5 mm wide, obtusely pointed at apex, rounded at base, and attached to the upper face of the rachis; nerves are forking at their origin or rarely near the apex, parallel to each other except at the base where they are somewhat divergent to the lateral margin of the pinnae, and the number is 5–6 at the middle of pinna.

The present leaf agrees well with the holotype in outline of pinnae but is twice as large as the holotype. We think the holotype and the present leaf (paratype) represent apical and middle parts of the same leaf respectively.

As mentioned by OISHI (1940), the leaves described as *Podozamites hoheneggeri* by SCHENK (1869), *Glossozamites hoheneggeri* (SCHENK) by YOKOYAMA (1906) and *Zamites hoheneggeri* (SCHENK) by LEE (LI, X. X.) (in SZE *et al.*, 1963) are close in external form to those of *Zamites tosanus*, but are distinguished by their rather remotely set pinnae and small number of veins (7 in number in the same sized pinna as the present paratype).

Unclassified conifers

Form-Genus *Cupressinocladus* SEWARD, 1919: 307

Key to *Cupressinocladus* species in Japan

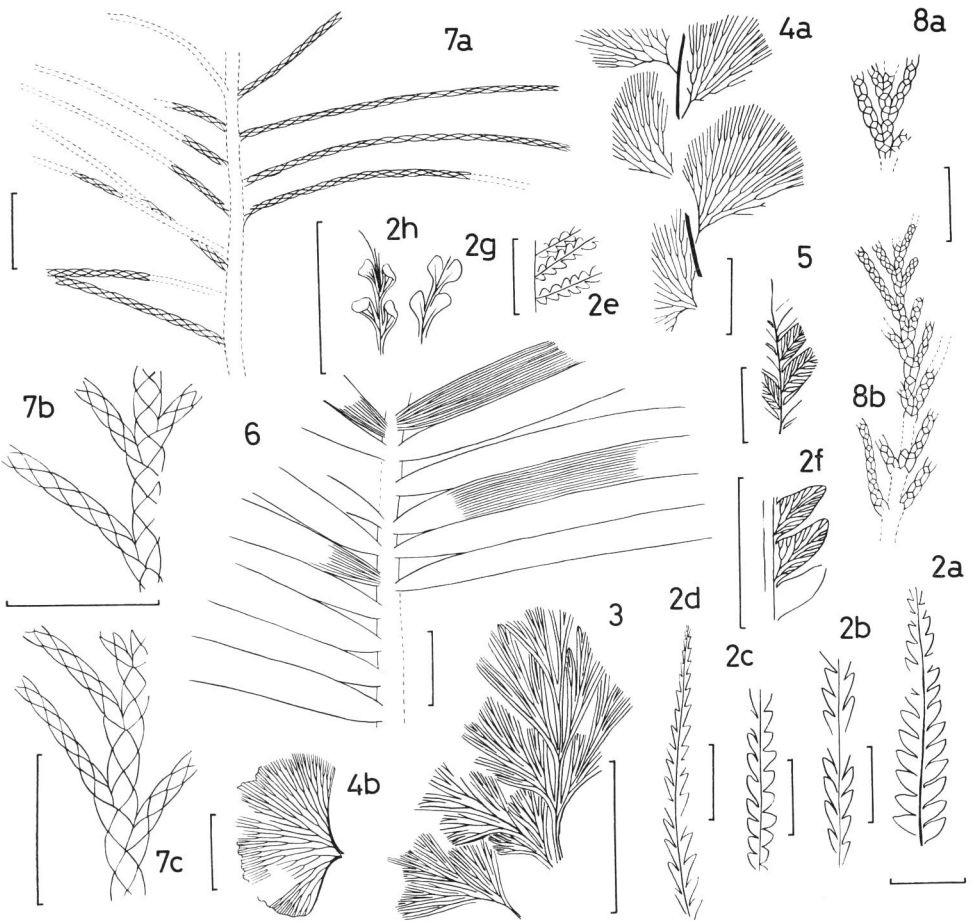
1. Leaves appressed 2
1′. Leaves not appressed 3
2. All leaves nearly the same size and form 4
2′. Lateral leaves larger 5
3. Lateral leaves free ..... *C. koyatoriensis*
3′. All leaves free ..... *C.* sp. B
4. Ultimate branches at a wide angle ..... *C. mimotoi*
4′. Ultimate branches at a narrow angle ..... *C. japonicus*
5. Ultimate branches at a rather wide angle ..... *C.* sp. A
5′. Ultimate branches at a narrow angle ..... *C.* sp. C

[*C. koyatoriensis* (see OISHI, 1940), *C. japonicus* (see KIMURA and MATSUKAWA, 1979, *C.* sp. A and *C.* sp. B (see KIMURA, NAITO and OHANA, 1986)].

Cupressinocladus mimotoi KIMURA et OHANA sp. nov.

(Pl. 2, fig. 4; Fig. 7a–c)

Material: Holotype; NSM PP-7875. *Stratum typicum*: Upper Monobegawa



Figs. 2–8. (Each bar indicates the length of 1 cm).

2a–h. *Eboracia microlobifolia* KIMURA et OHANA sp. nov.: 2a–e; sterile pinna fragments [2a–c; NSM PP-7885 (Holotype), 2d–e; NSM PP-7880 (Paratype)], 2f; drawn partly from 2a to show the venation, 2g–h; fertile pinna fragments [NSM PP-7882, 7883 (Paratypes)].

3. *Acrostichopteris* sp. A; a sterile penultimate pinna (NSM PP-7878), drawn from Pl. 2, fig. 2.

4. *Adiantopteris sawamurae* KIMURA et OHANA sp. nov.: 4a; sterile leaf-fragment (Paratype, kept by T. SAWAMURA), 4b; a pinna redrawn from OISHI's pl. 7, fig. 4a, 1940 [8589 (Holotype), kept in the Hokkaido University].

5. *Cladophlebis* sp. (NSM PP-7877). 6. *Zamites tosanus* OISHI; middle part of a leaf (Paratype, kept by K. YAMASAKI), drawn from Pl. 2, fig. 3.

7. *Cupressinocladus mimotoi* KIMURA et OHANA sp. nov.: 7a; drawn partly from the holotype (NSM PP-7876), 7b–c; drawn partly from the holotype to show the leaf-arrangement and branching at the distal portion of twigs where ultimate branches are at a narrow angle.

8. *Cupressinocladus* sp. C: 8a–b; showing the leaf-arrangement and branching (NSM PP-7885) drawn from Pl. 1, fig. 6.

(or Wada) Formation (Aptian-Albian). *Locus typicus*: Okufukui (Kc-4 in Fig. 1c), Kochi City. *Derivatio nominis*: Dedicated to Mr. K. MIMOTO, serving the holotype for our study. *Occurrence*: Rare.

Diagnosis: Branched shoot with leaves in decussate pair; main branch preserved 3 mm wide sending pinnately off penultimate branches at a wide angle. Penultimate branch more than 8 cm long, set closely at an interval of 2.5 cm, sending subopposite ly and pinnately off ultimate branches at a wide angle proximally and at a rather narrow angle distally. Penultimate branch 1.7 mm wide proximally but narrowing distally. Ultimate branch set closely, long and narrow, overlapping each other laterally, at an interval of about 0.5 cm, typically 4.5 cm long, nearly parallel-sided for the most part, 1 mm wide, bending outwards distally; distal ones shorter in length. Leaves small-sized, varied in form according to the position; elongate-rhomboidal on the axis of penultimate branch, rhomboidal on the ultimate branch; all appressed to the axis. (No keel visible on the abaxial surface of a leaf: Reproductive organs not known.)

Discussion and *comparison*: Although obtained is a single branched shoot, the present specimen is characterized by having unbranched, long and narrow ultimate branches with appressed decussate leaves. However, we unavoidably accommodate the present specimen in a noncommittal genus *Cupressinocladus* because its reproductive organs have not been known and its leaf cuticle is not preserved.

KIMURA and MATSUKAWA (1979) revised YOKOYAMA's *Cyparissidium* (?) *japonicum* and OISHI's *Brachyphyllum japonicum* (pars) described from the Lower Cretaceous plant-beds in the Outer Zone of Japan as *Cupressinocladus japonicus* (YOKOYAMA), because in these branched shoots leaves are not spiral but decussate in arrangement.

The present specimen differs from those of *Cupressinocladus japonicus* in its slender axis giving off long and narrow and unbranched ultimate branches at a wide angle except their distal portion, instead of thick main axes giving off repeatedly branching twigs usually at a narrow angle in the latter. *Cupressinocladus* species with such long, narrow and unbranched ultimate branches as the present shoot has not been recorded. Accordingly we here propose *Cupressinocladus mimotoi* as a new species.

Cupressinocladus sp. C

(Pl. 1, figs. 5–7; Fig. 8a–b)

Material: NSM PP-7884, 7886. *Locality* and *Horizon*: The same as *Eboracia microlobifolia*. *Occurrence*: Rather rare.

Description: Obtained are closely set penultimate leafy branches, sending subopposite ly or alternately off ultimate branches at an angle of 25 degrees. The ultimate branches are shorter, more than 1.3 cm long; these branches are pinnate in one plane. The leaves are decussate in arrangement, all appressed but leaves of lateral pairs are twice as long (or high) as those of longitudinal pairs. The lateral leaf on the ultimate branch is typically 1.5 mm high and 0.75 mm wide measured on the preserved plane, often bulging laterally. The longitudinal leaf is rhombic or rhomboidal in outline;

on the ultimate branches they are typically 0.75 mm high and 1 mm wide. Reproductive organs have not been known.

Remarks: The present specimens are characterized by closely set penultimate leafy branches and ultimate leafy branches markedly directed forwards both with longer (or higher) lateral pairs of leaves and smaller longitudinal pairs of leaves.

However, we at present regard our specimens as *Cupressinocladus* sp. C because of insufficiency of them. *Cupressinocladus* sp. C is similar in leaf-form to *C.* sp. A known from the Lower Jurassic Nishinakayama Formation (KIMURA, NAITO and OHANA, 1986), but is distinguishable by its ultimate branches markedly directed forwards.

References

FUJI, N., 1956. On the fossil plants from the Cretaceous Ayukawa Formation, Ozika Peninsula, Miyagi Prefecture, Japan. *Earth Science* (*Chikyu Kagaku*), no. **29**: 32–35 (in Japanese with English abstract).

HARRIS, T. M., 1961. *The Yorkshire Jurassic flora. I. Thallophyta-Pteridophyta.* Brit. Mus. (Nat. Hist.): ix+212 pp.

HIRATA, M., 1972. *Illustrated catalogue of fossils.* 1. Ryoseki-type plants from Kochi Prefecture. Hirata Geol. Inst.: 81 pp. (in Japanese).

———, 1974. *Ditto.* 2. Mesozoic fossils (excluding fossil plants) from Kochi Prefecture. Ibid.: 99 pp. (in Japanese.)

KIMURA, T., 1979. Late Mesozoic palaeofloristic provinces in East Asia. *Proc. Japan Acad.*, Ser. B, **55**: 425–430.

———, 1984. Mesozoic floras of East and Southeast Asia, with a short note on the Cenozoic floras of Southeast Asia and China. Geol. Palaeont. SE-Asia, vol. 25: 325–350.

——— & K. ASAMA, 1975. On the Paleozoic and Mesozoic land floras of Japan, with special reference to the stratigraphical distribution of Early Cretaceous plants in Kochi Prefecture, in the Outer Zone of Southwest Japan. *Mem. Natn. Sci. Mus. Tokyo*, no. 8: 91–114 (in Japanese.).

——— & M. MATSUKAWA, 1979. Mesozoic plants from the Kwanto Mountainland, Gumma Prefecture, in the Outer Zone of Japan. *Bull. Natn. Sci. Mus., Tokyo*, Ser. C, **5** (3): 89–112, pls. 1–6.

———, G. NAITO & T. OHANA, 1986. Early Jurassic plants in Japan. Part 7. Fossil plants from the Nishinakayama Formation, Toyora Group, Yamaguchi Prefecture, Southwest Japan. *Trans. Proc. Palaeont. Soc. Japan*, N. S., no. **144**, 528–540, pls. 99–100.

——— & T. OHANA, 1985. *Zamites choshiensis* sp. nov. from the Lower Cretaceous Choshi Group, in the Outer Zone of Japan. *Proc. Japan Acad.*, Ser. B, **61**: 352–355.

KRASSILOV, V. A., 1967. Early Cretaceous flora from Southern Primorye and its significance for stratigraphy. *Moscow*: 248 pp., 93 pls. (in Russian.).

OISHI, S., 1940. The Mesozoic floras of Japan. *Journ. Fac. Sci., Hokkaido Imp. Univ.*, Ser. 4, **5**: 123–480, pls. 1–48.

SZE, H. C., X. X. LI, P. J. LI, Z. Y. ZHOU, S. Q. WU, M. N. YE & G. L. SHEN, 1963. *Mesozoic plants from China. Fossil plants of China*, 2. Sci. Press, Beijing: 429 pp. 118 pls. (in Chinese).

TAKIZAWA, F., 1970. Ayukawa Formation of the Ojika Peninsula, Miyagi Prefecture, Northeast Japan. *Bull. Geol. Surv. Japan*, **21**: 567–578, pl. 44.

———, 1978. Palaeoenvironment of the Jurassic deposits in the Southern Kitakami Massif. *Chishitsu News*, no. 291: 18–31 (in Japanese.).

VAKHRAMEEV, V. A. & M. P. DOLUDENKO, 1961. Upper Jurassic and Lower Cretaceous floras of the Bureja Basin and their significance for stratigraphy. Trans. USSR Acad. Sci. Geol. Inst., no. 54:

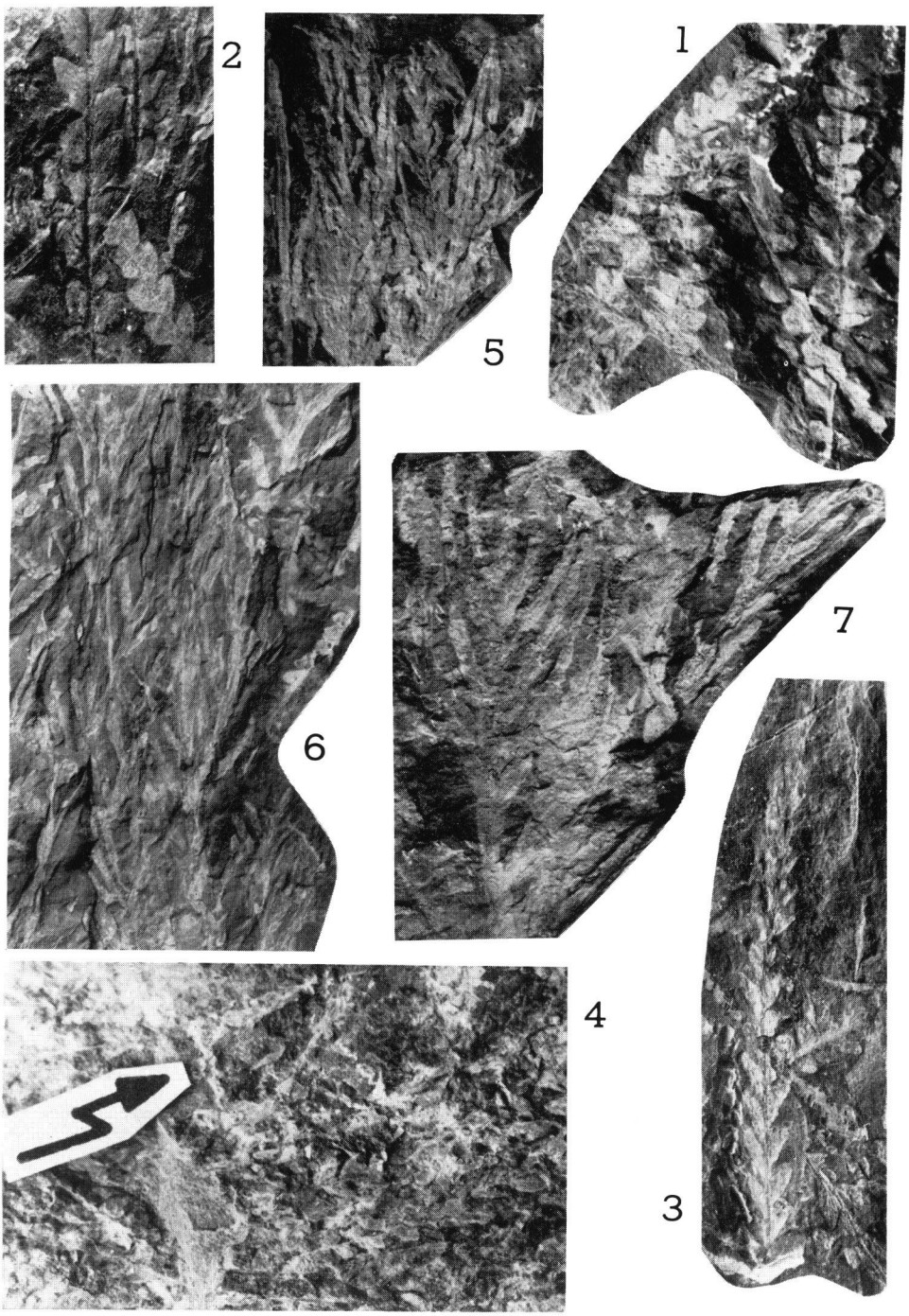
135 pp., 40 pls. (in Russian.).
YOKOYAMA, M., 1984. Mesozoic plants from Kozuke, Kii, Awa, and Tosa. *Journ. Coll. Sci., Imp. Univ. Japan*, **7**: 201–231, pls. 20–28.
———, 1906. Mesozoic plants from China. *Journ. Coll. Sci., Imp. Univ. Tokyo*, **21** (9): 1–39, pls. 1–12.

Explanation of Plate 1

(All from the Ayukawa Formation)

Figs. 1–4. *Eboracia microlobifolia* KIMURA et OHANA sp. nov.: 1. Sterile ultimate pinna fragments. Detached ultimate pinnae are massed and lying one upon another. (NSM PP-7886) ×2. 2. Ditto. [NSM PP-7880 (Paratype)] ×2. 3. Ditto, showing a long and narrow pinna on the left-side. [NSM PP-7880 (Paratype)] ×2. 4. Closely massed sterile and fertile ultimate pinnae; an arrow shows a fertile pinna. [NSM PP-7883 (Paratype)] ×2.

Figs. 5–7. *Cupressinocladus* sp. C: Closely branched shoots (5; NSM PP-7884, ×1, 6; NSM PP-7885, ×1, 7; NSM PP-7886, ×2).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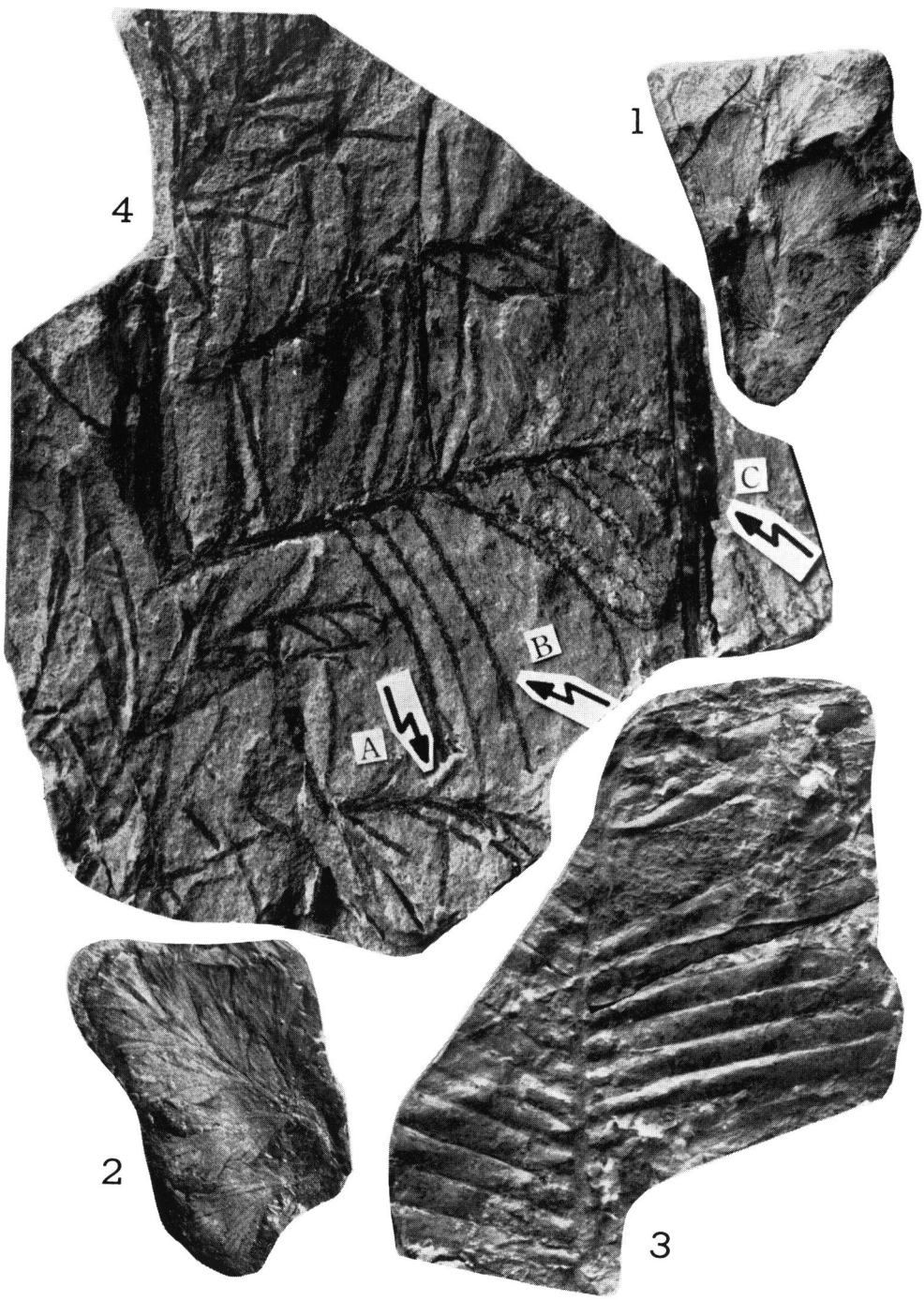
Explanation of Plate 2

Fig. 1. *Adiantopteris sawamurae* KIMURA et OHANA sp. nov.: Paratype. Collected and kept by T. SAWAMURA from the Ryoseki Formation, Kochi Prefecture. ×1.

Fig. 2. *Acrostichopteris* sp. A: A single penultimate pinna fragment. Ayukawa Formation (NSM PP-7878). ×2.

Fig. 3. *Zamites tosanus* OISHI: Paratype. Collected and kept by K. YAMASAKI from the Ryoseki Formation, Kochi Prefecture. ×1.

Fig. 4. *Cupressinocladus mimotoi* KIMURA et OHANA sp. nov.: Holotype (NSM PP-7875). Upper Monobegawa Formation, Kochi Prefecture. ×1. Arrow-A shows an apical penultimate branch bearing short ultimate branches at a narrow angle. Arrow-B shows a developed and elongated ultimate branch attached to the penultimate branch at a wide angle. Although it looks like branching, it does not branch but is accidentally overlapped by an other detached branch. Arrow-C shows a thick detached stem giving most probably off such penultimate branches as shown in this figure.


1
2
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4
A
B
C