

Mesozoic Plants from the Kwanto Mountainland, Gumma Prefecture, in the Outer Zone of Japan

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Introductory Notes

It has long been known that the Mesozoic plants occur in the so-called Sanchu Graben (HARADA, 1890) in the Kwanto Mountainland, located at about 100 km to the northwest Tokyo (Fig. 1), in the Outer Zone of Japan.

The stratigraphy of this area has since been studied by many geologists (see, OBATA *et al.*, 1976; TAKEI *et al.*, 1977; MATSUKAWA, 1977). According to the studies by OBATA *et al.* and MATSUKAWA, the Mesozoic rocks of this area are the Ishido, the Sebayashi and the San-yama Formations in ascending order (Fig. 2). The Ishido Formation yields ammonites from both its upper and lower parts. The ammonites and other marine shells from the upper part, consisting of 33 genera including 59 species, indicate the late Barremian and those from the lower part the late Hauterivian to early Barremian in age respectively.

According to MATSUKAWA (1977), the Sebayashi Formation is divisible into the lower and the upper members. The lower member which yields abundant brackish shells comprising 12 genera and 17 species and also plants, is dated as the late Barremian to the early Aptian and the upper member is presumed to belong to the Aptian and the Albian.

The fossil plants occur abundantly from the lower member of Sebayashi Formation. They were collected by MATSUKAWA from the localities he designated by the numbers 3, 103, 209, 291 and 302 (MATSUKAWA, 1977, figs. 3, 4). But of these, localities 103 and 209 gave only indeterminable fragments and his locality 291 is the same as the locality of YOKOYAMA (1894). The stratigraphy mentioned above and the fossiliferous horizons are briefly shown in Fig. 2.

The late Jurassic and early Cretaceous plants in the Outer Zone of Japan had been grouped together as the 'Ryoseki Flora', until KIMURA & HIRATA (1975), KIMURA (1976) and KIMURA & KANSHA (1978a) made clear up their stratigraphical distributions in Kochi, Kumamoto and Wakayama Prefectures. But we still need to improve our

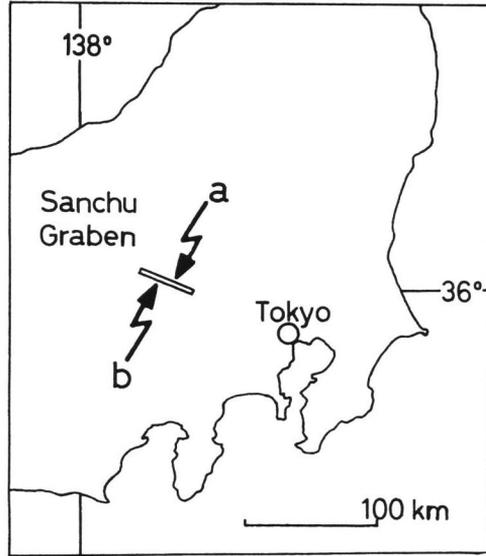


Fig. 1. Location of the studied area. a; Main localities of fossil plants of the Sebayashi Formation. b; Otchisawa locality (presumably of an equivalent of the Ishido Formation).

understanding of the stratigraphy of these plants.

The present work deals with the determinable plants from the lower member of Sebayashi Formation, and with some other plants that we consider to be of the age of the Ishido Formation, but about 7.5 km west, at the Otchisawa, Ueno-mura, Tano-gun, Gumma Prefecture.

Previous Works and General Remarks

YOKOYAMA (1894) first described the following fossil plants from the Hachimanzawa (Kagahara, the present 291 locality), Sebayashi, Nakazato-mura, Tano-gun, Gumma Prefecture, and regarded the age of the flora as Wealden (at the right are the revised names by us);

<i>Pteris</i> ? sp.	= <i>Cladophlebis</i> (<i>Osmunda</i> ?) <i>takezakii</i>
<i>Sphenopteris tenuicula</i>	= <i>S.</i> ex gr. <i>goeppertii</i>
<i>Onychiopsis elongata</i>	
<i>Zamiophyllum buchianum</i>	= <i>Zamites buchianus</i>
<i>Nilssonia schauburgensis</i>	= <i>N.</i> ex gr. <i>schauburgensis</i>
<i>Cyparissidium</i> ? <i>japonicum</i>	= <i>Cupressinocladus japonicus</i>
<i>Podozamites pusillus</i>	= <i>Nageiopsis</i> ? sp. B

In 1940, OISHI gave the following list of fossil plants from the Hachimanzawa;

<i>Cladophlebis takezakii</i> ?	= <i>C.</i> (<i>Osmunda</i> ?) <i>takezakii</i>
<i>Sphenopteris</i> (<i>Ruffordia</i>) <i>goepperti</i>	= <i>S.</i> ex gr. <i>goeppertii</i>

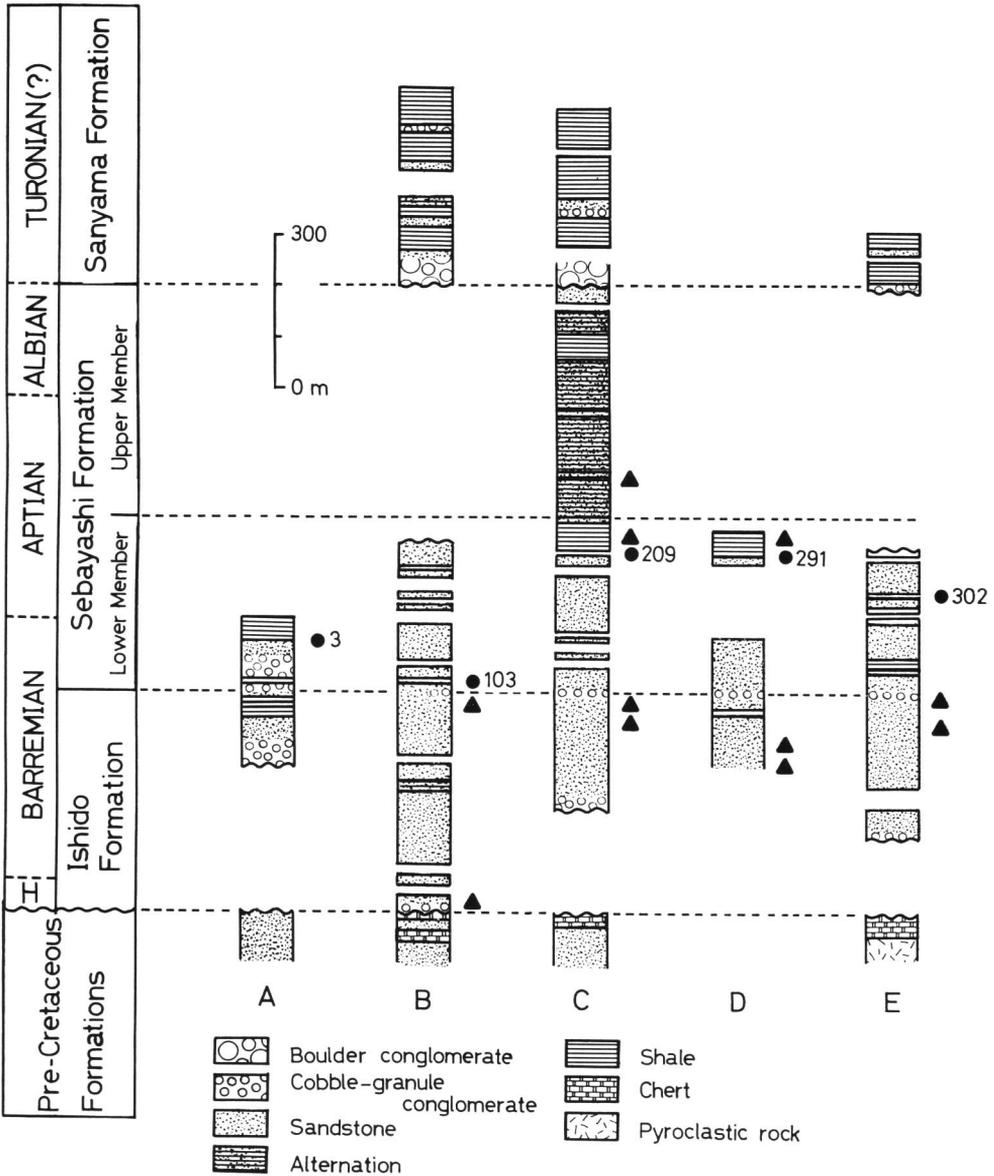


Fig. 2. Brief columnar sections in the eastern part of Sanchu Graben (OBATA *et al.*, 1976; MATSUKAWA, 1977).

A; Nogurizawa section, B; Myokezawa section, C; Mamonozawa section, D; Hachimanzawa section E; Niheizawa section, H; Hauterivian (in age).

Solid circles; plant beds with locality numbers Solid triangles; shell beds.

For further details, see MATSUKAWA, 1977.

Onychiopsis elongata
Zamiophyllum buchianum = *Zamites buchianus*
Brachyphyllum japonicum = *Cupressinocladus japonicus*

As known at present, the Sebayashi and the Ishido Formations provide the species listed below. Unfortunately determinations are based on general form alone as no cuticles are preserved.

Sebayashi Formation;

Lycopodiales; *Lycopodites* ? sp.

Ferns; *Cladophlebis acutipennis* OISHI, *C. nathorstii* YOKOYAMA, *C. (Osmunda) takezakii* OISHI, *C. sp. A*, *C. sp. B*, *C. sp. C*, *C. sp. D*, *Acrostichopteris longipennis* FONTAINE, *Sphenopteris* ex gr. *goeppertii* DUNKER, *Onychiopsis elongata* (GEYLER) YOKOYAMA.

Bennettitales; *Zamites buchianus* (ETTINGSHAUSEN) SEWARD, *Ptilophyllum* ex gr. *pecten* (PHILLIPS) MORRIS, *Taeniopteris (Nilssoniopteris)* ? ex gr. *vittata* BRONGNIART.

Cycadales; *Nilssonia* ex gr. *schaumburgensis* (DUNKER) NATHORST.

Conifers; *Cupressinocladus japonicus* (YOKOYAMA) KIMURA & MATSUKAWA, *Nageiopsis* ? sp. A, *N.* ? sp. B.

Ishido Formation;

Bennettitales; *Otozamites* sp., *Zamites buchianus* (ETTINGSHAUSEN) SEWARD, *Taeniopteris (Nilssoniopteris)* ? ex gr. *vittata* BRONGNIART.

Not only of the ferns which we describe under generic and specific names can be placed securely in its family, but very similar specimens are widely distributed in the Outer Zone of Japan. A good many have been included in '*Cladophlebis denticulata*' taking that species in a broad sense, but we note that the specimens of different localities are distinctly different from one another. So we here retain *Cladophlebis nathorstii* which once included in *C. denticulata* by OISHI (1940). Forms of this aspect have not yet been found in the coeval floras of the Inner Zone of Japan. Our *Cladophlebis* leaves including those we designate as A-D often have small pinnules with reflexed margins just as in the Outer Zone floras. *Cladophlebis (Osmunda) takezakii* with large-sized pinnules, is an exceptional case.

Acrostichopteris longipennis previously known from North America is recorded from Japan for the first time. It also resembles *A. pluripartita* already known from Japan (KIMURA & KANSHA, 1978a) as well as from North America and Southern Primorye. *Sphenopteris* ex gr. *goeppertii* taken in a broad sense is common, though fragmentarily. Sterile *Onychiopsis elongata* leaves are also common.

Leaves of *Zamites buchianus* are abundant here as in other Outer Zone floras but the species has not been found in the Inner Zone of Japan. *Ptilophyllum* ex gr. *pecten* is rather rare as it is also elsewhere in the Aptian-Albian floras in the Outer Zone of

Japan. *Taeniopteris* (*Nilssoniopteris* ?) ex gr. *vittata* is a common element not only of the Ishido and the Sebayashi Formations, but also of the Lower Cretaceous plantbeds in the Outer Zone of Japan. *Otozamites* sp. is known only from the Ishido Formation.

Nilssonia leaves are also rather rare and *N.* ex gr. *schaumburgensis* alone is represented.

It is interesting that we have no specimens that we would place in the Ginkgoales, in the Czekanowskiales or in *Podozamites*, and in this our flora agrees with other Outer Zone floras. But these groups are abundant in the coeval Inner Zone floras.

Conifers are rather rare. *Cupressinocladus japonicus* is represented by leafy shoots which reminded us of some conifers belonging to Cupressaceae and we now have the cones which are terminal. Two types of broad-leaved conifers were recognized, among which *Nageiopsis* ? sp. B represented by small-sized leaves was formerly regarded by YOKOYAMA as *Podozamites pusillus*.

Our flora, in its general characters, is a typical early Cretaceous flora and such floras have been called 'Wealden', a term without precise stratigraphical meaning.

Acknowledgements

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Systematic Description

Lycopodiales

Genus *Lycopodites* LINDLEY & HUTTON, 1833: 170

Lycopodites ? sp.

Pl. 1, fig. 1

Comparable specimens:

Lycopodites sp.; KIMURA, 1976, p. 186, pl. 1, fig. 7; pl. 3, figs. 6, 7; pl. 4, fig. 6 (Yatsushiro Formation, Kumamoto Prefecture).

Remarks: A single fragment of sterile foliage as shown in Pl. 1, fig. 1 was obtained. This specimen may belong to *Lycopodites* and is possibly identical with *L.*

sp. formerly described by KIMURA (1976).

Horizon and locality: Sebayashi Formation, Loc. no. 291.

Occurrence: Rare.

Specimen: PP-7477 (one fragment only).

Unclassified ferns

Form-genus *Cladophlebis* BRONGNIART, 1849: 105

Cladophlebis acutipennis OISHI

Pl. 1, fig. 3; Fig. 3

Thyrsopteris sp.; YOKOYAMA, 1894, p. 213, pl. 23, fig. 3 (Fujikawa, Tokushima Prefecture, an equivalent of the Upper Monobegawa Group).

Pecopteris cfr. *virginiensis* FONTAINE; YOKOYAMA, 1894, p. 220, pl. 24, fig. 1 (Ditto).

Cladophlebis acutipennis OISHI; OISHI, 1940, p. 249, pl. 9, figs. 4-6 (Ditto, and Yuasa Formation); KIMURA, 1976, p. 190, fig. 3 (Yatsushiro Formation); KIMURA & KANSHA, 1978a, p. 110, pl. 2, fig. 2; pl. 3, fig. 6; fig. 3 (Yuasa Formation).

Description: Frond probably tripinnate and large in size. Ultimate pinnae elongate-oval in form, more than 8 cm long and 3 cm wide, set closely, overlapping each other laterally, about 2 cm distant, attached suboppositely to the penultimate pinna axis first at an angle of about 55 degrees, then bending outwards. Pinnules variable, elongate-oval or linear in form, bluntly pointed at apex, divided into 9-10 pairs of deeply pinnatifid lobes, each lobe directed forwards, rounded or bluntly pointed at apex. Pinnules gradually contracted at base, then the basiscopic base often decurrent, attached to the slender pinna axis at an angle of 25-55 degrees. Mid-nerve distinct, persisting to the tip, secondaries not clearly visible like those of the type specimen.

Fig. 3 drawn from Pl. 1, fig. 3 shows two types of pinnules; the acroscopic ones are elongate-oval in form and attached to the axis at an angle of 55 degrees, typically 1.8 cm long and 0.6 cm wide at the widest portion, while the basiscopic ones are linear, long and very narrow, nearly parallel-sided and attached to the axis at an angle of 25 degrees, typically 3 cm long and 2 mm wide. The fructification has not been found.

Remarks: Apart from several minor points, the present specimens agree well with *Cladophlebis acutipennis* OISHI recorded from the Lower Cretaceous plant beds in the Outer Zone of Japan.

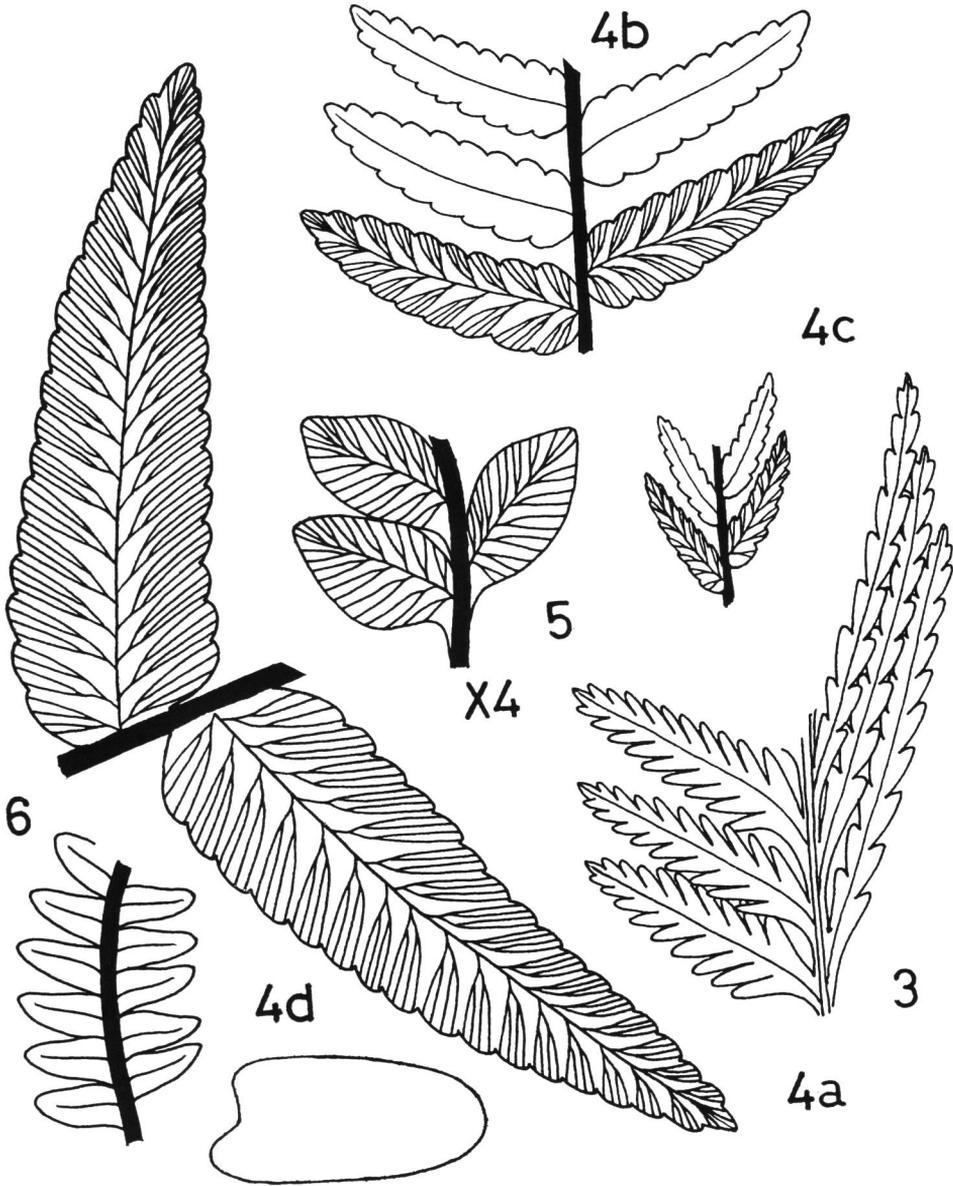
Similar ferns to this species have widely known in the 'Wealden' floras as was mentioned by OISHI (1940, p. 220). But we do not here intend to discuss the specific relation among these sterile specific types.

Horizon and locality: Sebayashi Formation, Loc. no. 291.

Occurrence: Common.

Specimens: PP-7355~PP-7366.

Distribution: Lower Cretaceous plant beds in the Outer Zone of Japan.



Figs. 3-6. (All enlarged twice, unless otherwise stated). 3. *Cladophlebis acutipennis* OISHI; two types of pinnules (PP-7359). 4a-d. *Cladophlebis (Osmunda?) takezakii* OISHI; varied pinnules and venation (a; PP-7383, b; PP-7399, c; PP-7401, d; PP-7404). 5. *Cladophlebis* sp. B; outline of pinnules and detailed venation (PP-7409). 6. *Cladophlebis* sp. C; outline of pinnules (PP-7414).

Cladophlebis nathorstii YOKOYAMA

Pl. 2, fig. 2; Fig. 10

Cladophlebis nathorstii YOKOYAMA; YOKOYAMA, 1894, p. 220, pl. 28, figs. 3, 4, 10, 11 (Kaisekiyama, Kataji and Ishiseki, Kochi Prefecture, Ryoseki Group).

Cladophlebis sp.; NATHORST, 1890, pp. 4, 8, 13, pl. 1, figs. 1–3 (Ueno, Togodani and Hiura, Kochi Prefecture, Ryoseki Group).

Cladophlebis denticulata (BRONGNIART); OISHI, 1940, p. 256 (pars) (NATHORST's and YOKOYAMA's specimens).

Cladophlebis ex gr. *denticulata* (BRONGNIART) NATHORST; KIMURA & KANSHA, 1978a, p. 111, pl. 4, fig. 2; fig. 4 (Yuasa Formation).

Description: Pl. 2, fig. 2 shows a bipinnate sterile frond in part, with a slender rachis, 1 mm thick, in which pinnae are long and narrow, nearly parallel-sided, more than 4 cm long and 1 cm wide, set rather remotely, 1.7 cm distant, and attached alternately to the rachis at an angle of about 40 degrees. Pinnules are katadromic in order, triangular in form, falcate, acutely pointed at apex, and attached by whole base to the axis at an angle of 45 degrees; upper half of margins is finely dentate and lower half entire; midnerve is distinct arising near the basiscopic base, persisting to the tip and sending off 6–7 pairs of once forking secondaries; each secondary nerve is directed forwards and its basal pair is often twice forking; the first basiscopic pinnule is often specialized in form, shorter in length than others, its midnerve arising at the base of pinna axis. Fig. 10 shows the outline of pinnules and the venation in detail.

Remarks: As was previously mentioned by us in the present paper, the present specimens are quite similar in general form and venation to *Cladophlebis nathorstii* originally described by YOKOYAMA (1894) from the Ryoseki Group and its equivalents and less similar to those described as *C. denticulata* from the Lower Cretaceous plant beds in the Inner Zone of Japan.

In this paper, we retain YOKOYAMA's *C. nathorstii* characterized by the first basiscopic pinnules arising at the joint of pinna axis, because such basiscopic pinnules have not been found in Yorkshire's *C. denticulata*. As a matter of course, *Cladophlebis* ex gr. *denticulata* described by KIMURA & KANSHA (1978a) from the Yuasa Formation belongs to this species.

Horizon and locality: Sebayashi Formation, Loc. no. 291.

Occurrence: Common.

Specimens: PP-7367~PP-7378.

Distribution: Lower Cretaceous plant beds in the Outer Zone of Japan.

Cladophlebis (*Osmunda* ?) *takezakii* OISHI

Pl. 2, figs. 3–5; Pl. 5, fig. 1; Figs. 4a–d

Pteris? sp.; YOKOYAMA, 1894, p. 216, pl. 20, fig. 9; pl. 21, figs. 6–7 (Hachimanzawa, Loc. no 291 of ours; Yuasa Formation).

Cladophlebis takezakii OISHI; OISHI 1940, p. 288, pl. 21, figs. 4, 4a (Nishinotani, Kochi Prefecture, Lower Monobegawa Group).

Cladophlebis takezakii OISHI?; OISHI, 1940, p. 290 (YOKOYAMA's specimens).

Cladophlebis (Osmunda?) takezakii OISHI; KIMURA & KANSHA, 1978a, p. 114, pl. 3, fig. 9; fig. 7a-b (Yuasa Formation).

Emended diagnosis: Frond probably bipinnate, large in size. Pinnae elongate-triangular in form, more than 18 cm long and 8 cm wide at base, apex unknown. Pinnules set closely or sometimes remotely, variable in size and form owing to their position on a frond or a pinna, elongate-oval to triangular in form, acuminate to obtuse at apex, constricted at base; margins crenate or serrate throughout; midnerve distinct, persisting to near tip, sending off mostly twice forking secondaries; each crenation receiving a set of secondary nerve; the first pair of secondaries sometimes forking thrice. Posterior pinnules large, elongate-triangular in form, attached to the slender pinna axis at a wide angle; middle pinnules oval in form; apical pinnules rather narrow in form, small in size, directed forwards and their secondaries usually forking once. (Fructification not known).

Description: Many varied pinna fragments were obtained. Pl. 2, fig. 3 shows a part of pinna bearing elongate-triangular pinnules nearly perpendicularly to the pinna axis as shown in detail in Fig. 4a. Pl. 5, fig. 1 shows the middle portion of a pinna bearing oval-shaped pinnules in which basal constriction is clearly seen as

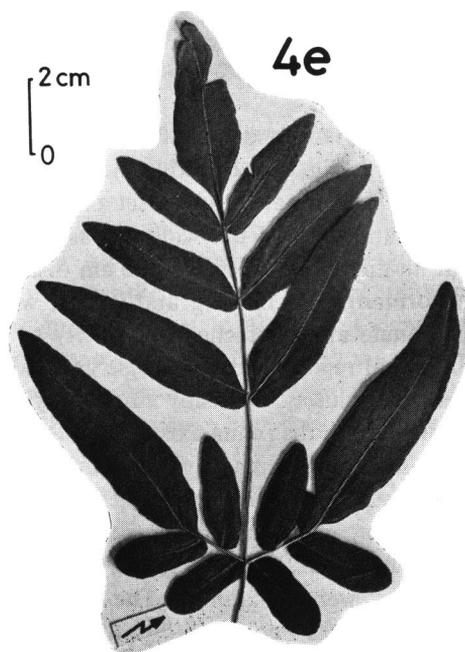


Fig. 4e. *Osmunda japonica* THUNBERG (extant); showing an apical portion of pinna with two types of pinnules to compare with varied pinnules of *Cladophlebis (Osmunda?) takezakii* OISHI (collected at the southern slope of Mt. Oeyama, Kyoto Prefecture, Japan).

shown in detail in Fig. 4b. Pl. 2, fig. 5 shows an apical part of a pinna bearing small-sized pinnules strongly directed forwards as shown in detail in Fig. 4c. In addition, several detached small rectangular pinnules as shown in Fig. 4d were obtained in association with other pinna fragments mentioned above. They strongly remind us of the small-sized pinnules often appearing on the fronds of some recent *Osmunda* as shown in Fig. 4e (by arrow).

Remarks: In his diagnosis of this species, OISHI (1940) stated that the pinnules were attached to the pinna axis by their whole base, but our new material including various parts of the frond showed their basal constriction clearly.

Because its fructification remains unknown we can not be sure of the affinity of this species. But the general shape, especially its larger pinnules and their constricted base reminds us of certain recent species of *Osmunda* and for this reason we add (*Osmunda* ?) to its name.

Horizon and localities: Sebayashi Formation, Loc. no. 3 (Nogurizawa) and 291 (YOKOYAMA's specimens).

Occurrence: Common in Loc. no. 3 and rare in Loc. no. 291.

Specimens: PP-7379~PP-7405, PP-7476.

Distribution: Lower Cretaceous plant beds sporadically in the Outer Zone of Japan.

Cladophlebis sp. A

Pl. 1, fig. 4; Fig. 7a, b

Description: The following is the diagnostic character based mainly on the specimen shown partly in Pl. 1, fig. 4. Frond at least tripinnate, size unknown. Rachis thick, 3 mm across. Penultimate pinnae set closely, elongate-triangular in form, more than 13 cm long and about 6 cm wide at base, apex unknown, attached alternately to the rachis at an angle of 45 degrees, 5.5 cm distant on each side. Ultimate pinnae set closely, normally 3-4 cm long and 0.8 cm wide at base, narrowing gradually towards the acuminate apex, attached alternately to the penultimate pinna axis at a wide angle on the basal region, then the angle gradually reducing. Pinnules katadromic in order, small, set closely, typically finger-shaped, obtusely pointed at apex, attached by their whole base to the pinna axis at a wide angle on the basal region, then the angle reducing, basisopic lamina slightly constricted near the base, then slightly decurrent; margins entire throughout; midnerve arising slightly below the middle point of base of pinnule, persisting to the near tip, sending off typically 6 pairs of secondaries directed forwards, mostly forking once, but apical ones simple.

Remarks: Two specimens were obtained. The present specimens somewhat resemble in general form YOKOYAMA's *Pecopteris browniana* described from the Lower Cretaceous of Kochi and Tokushima Prefectures in the Outer Zone of Japan (YOKOYAMA, 1894, p. 218, pl. 24, figs. 2, 3; pl. 27, figs. 1-4. 5c-d).

Horizon and locality: Sebayashi Formation, Loc. no. 291.

Occurrence: Rare.

Specimens: PP-7406, PP-7407.

Cladophlebis sp. B

Pl. 6, fig. 2; Fig. 5

Description: Several incomplete specimens were obtained. The following is the diagnostic character. Pinnules set closely, rhomboidal in form, with obtusely pointed apex, acroscopic margin constricted at base and basisopic margin constricted near the base, then decurrent, attached to the pinna axis at an angle of 40–50 degrees, typically 0.6 cm long and 0.33 cm wide at the widest portion; margins entire throughout; midnerve distinct in the lower two-thirds and forking distally, sending off 5–6 pairs of once forking secondaries obliquely, as shown in Fig. 5.

Remarks: The present specimens, though incomplete, somewhat resemble *Cladophlebis heterophylla* FONTAINE described by BELL (1956, p. 58, pl. 14, fig. 1; pl. 15, fig. 4; pl. 16, fig. 1; pl. 17, figs. 3, 4) from the early Lower Cretaceous Kootenay Formation, Western Canada, and *C. holttumi* originally described by SEWARD (1926, p. 88, pl. 8, figs. 57, 57A) from the Cretaceous of Western Greenland. But the present specimens differ from the above two in having more coarser nerves.

Horizon and locality: Sebayashi Formation, Loc. no. 291.

Occurrence: Rather rare.

Specimens: PP-7408~PP-7410 and tiny fragments of pinnae.

Cladophlebis sp. C

Pl. 6, fig. 1; Fig. 6

Description: Several incomplete pinna fragments were obtained, one of which was shown in Pl. 6, fig. 1. The following is the diagnostic character. Pinnules set closely, attached nearly perpendicularly to the thick pinna axis by their whole base. Midnerve distinct but not reaching to the tip. (Secondaries not visible). Upper surface of pinnules strongly convex and their both margins reflexed.

Remarks: The present specimens resemble *Cladophlebis* sp. A here described together in general form of pinnules. But they are somewhat different from *C. sp. A* in that the pinnules are attached perpendicularly to the thick pinna axis, the laminae are not contiguous basally and the midnerves originate at the middle point of base of pinnule.

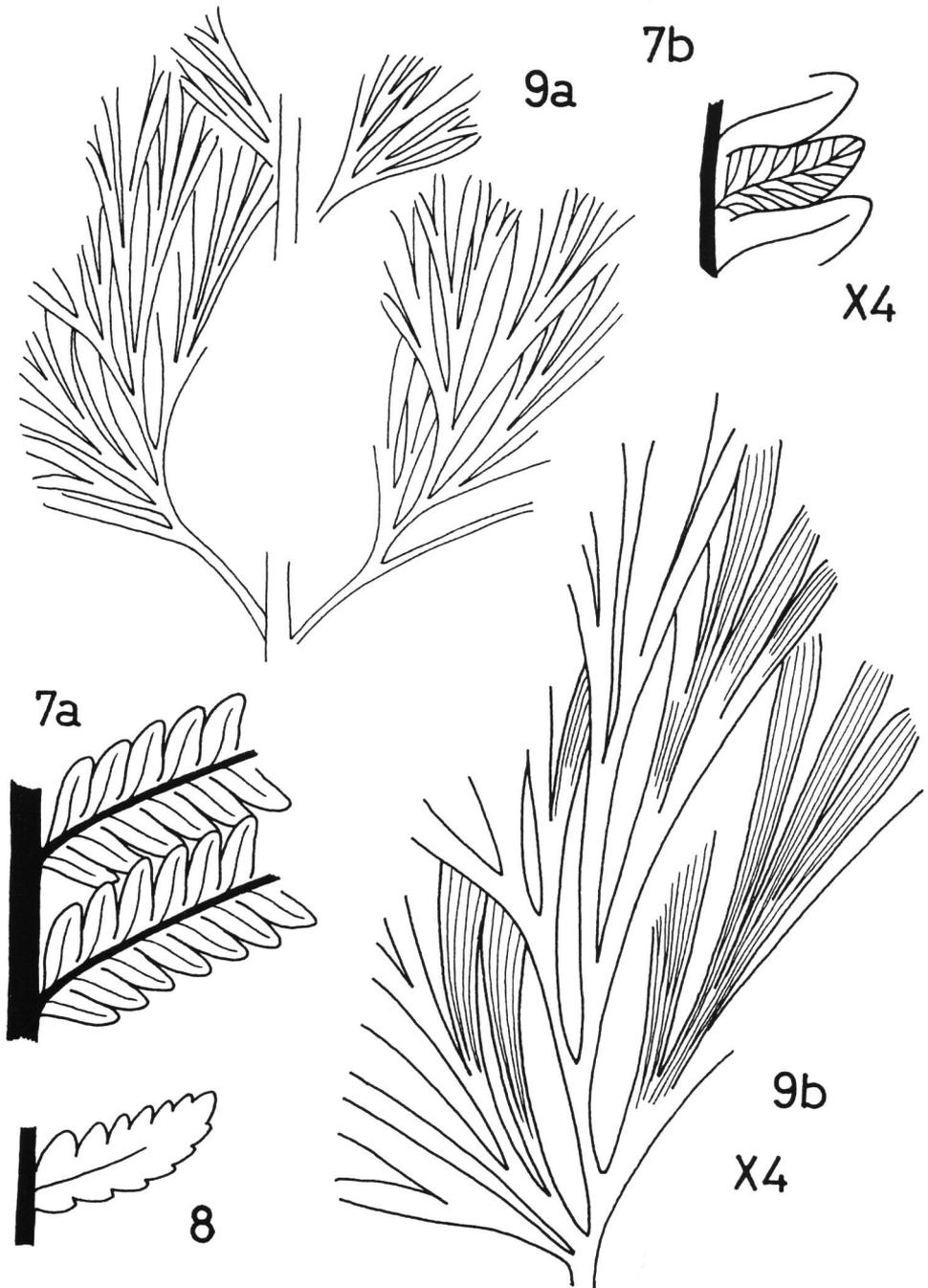
Horizon and locality: Sebayashi Formation, Loc. no. 291.

Occurrence: Rare.

Specimens: PP-7411~PP-7415.

Cladophlebis sp. D

Pl. 4, fig. 1; Fig. 8



Description: Several incomplete pinna fragments were obtained, two of which were shown in Pl. 4, fig. 1. The following is the diagnostic character. Pinnules set rather remotely, elongate-oval, apex bluntly pointed, base constricted, straight or slightly falcate; lamina divided into 5–6 pairs of lobes, each lobe directed forwards and attached to the pinna axis at a wide angle, typically 1.4 cm long and 0.5 cm wide at middle; midnerve distinct in its basal half. (Secondaries not clear).

Remarks: The present specimens remind us of '*Polypodites*' *polysorus* PRYNADA described by KRASSILOV (1967, p. 129, pl. 24, figs. 1–8; pl. 25, figs. 1–3; text-fig. 16), especially his pl. 25, fig. 1 from the Aptian beds of Southern Primorye in general appearance.

Horizon and locality: Sebayashi Formation, Loc. no. 291.

Occurrence: Rare.

Specimens: PP-7416, PP-7417.

Genus *Acrostichopteris* FONTAINE em. BERRY, 1911: 220

Acrostichopteris longipennis FONTAINE

Pl. 2, fig. 6; Pl. 3, fig. 2; Figs. 9a, b

Acrostichopteris longipennis FONTAINE; BERRY, 1911, p. 223, pl. 23, figs. 1, 2 (FONTAINE'S specimens); pl. 24, fig. 7 (Lower Cretaceous Potomac Group).

For further references, see BERRY, 1911, p. 223.

Description: Two incomplete specimens were obtained. They are shown in Pl. 2, fig. 6 and Pl. 3, fig. 2. Ultimate pinnae subopposite, at an angle of 60 degrees to the slender axis. Pinnules katadromic in order, elongate-oval in form, deeply divided into several pairs of segments. Segments elongate-oblanclate in form, 0.8–1.0 cm long and 1 mm wide, often forking distally, apex rounded; midnerve distinct only at the basal part, then forking to form fine nerves at all levels, each segment receiving a set of fine nerves, typically 4 in number in the distal part.

Remarks: The present specimens are referable to *Acrostichopteris longipennis* FONTAINE redescribed by BERRY (1911) from the Lower Cretaceous of Virginia, but slightly different from the North American specimens in having mostly four nerves on the ultimate segments instead of two.

This species also resembles *Acrostichopteris pluripartita* (FONTAINE) redescribed by BERRY (1911, p. 229, pl. 24, fig. 6) from the Lower Cretaceous of Virginia, Columbia and Maryland, and later described by KRASSILOV (1967, p. 136, pl. 29, fig. 5) from the Albian bed of Southern Primorye, and *A. nervosa* (HEER) described by TEIXEIRA (1948, p. 74, pl. 19, figs. 1–6) from the Lower Cretaceous of Portugal. But the present species differs from the above two in its more delicate habit.

Figs. 7–9. (All enlarged twice, unless otherwise stated). 7a, b. *Cladophlebis* sp. A; outline of pinnules and venation (PP-7407). 8. *Cladophlebis* sp. D; outline of a pinnule (PP-7416) 9a, b. *Acrostichopteris longipennis* FONTAINE; a part of frond (9a) and detailed venation (9b) (PP-7418).

OISHI (1931, p. 112) included *Acrostichopteris longipennis* recorded by NAGAO (1926, p. 380) and *A. cfr. longipennis* by YABE (1927, p. 41) which were said to be from the Yuasa Formation, in *Sphenopteris goeppertii*. But we regard *Sphenopteris goeppertii* as distinct. Their *A. longipennis* or *A. cfr. longipennis* is now referable to *A. pluripartita*.

Very recently KIMURA & KANSHA (1978a) described *Acrostichopteris pluripartita* from the Arida Formation overlying the Yuasa Formation, in the Outer Zone of Japan.

FONTAINE (1889) described many types of ferns as *Acrostichopteris* and *Baieropsis*, and regarded them as creeping ferns. But so far as the present specimens are concerned, whether they are creeping or not is unknown.

This is the first record of the occurrence of *Acrostichopteris longipennis* in Japan.

Horizon and locality: Sebayashi Formation, Loc. no. 291.

Occurrence: Rather Rare.

Specimens: PP-7418, PP-7419.

Distribution: Lower Cretaceous of North America and the Kwanto Mountainland.

Form-genus *Sphenopteris* (BRONGNIART) STERNBERG, 1825: 15

Sphenopteris ex gr. goeppertii DUNKER

Sphenopteris goeppertii DUNKER; KIMURA & SEKIDO, 1976, p. 355, pl. 37, fig. 4, text-fig. 3 (Akaiwa Formation).

For further references, see OISHI, 1940, p. 238 and KIMURA & SEKIDO, 1976, p. 355.

Remarks: Several pinna fragments agree with *Sphenopteris goeppertii*, taken in a broad sense. They are just like the figures of Japanese specimens cited above. No Japanese specimen has yet been found with the *Ruffordia*-type of fructification.

Horizon and locality: Sebayashi Formation, Loc. no. 291.

Occurrence: Common.

Specimens: PP-7420~PP-7422.

Distribution in Japan: Cretaceous plant beds.

Genus *Onychiopsis* YOKOYAMA, 1889: 26

Onychiopsis elongata (GEYLER) YOKOYAMA

Pl. 1, fig. 2; Pl. 2, fig. 1; Pl. 3, fig. 1

Thyrsopteris elongata GEYLER; GEYLER, 1877, p. 224, pl. 30, fig. 5; pl. 31, figs. 4-5 (Kuwashima, Oguchi Formation).

For further references, see KIMURA, 1975, p. 77.

Remarks: Many sterile pinna fragments referable to this well known species were obtained. In Japan, this species has been known from the Upper Liassic Nishi-Nakayama Formation (E. TAKAHASHI, 1959, p. 200) to the late Lower Cretaceous plant beds successively.

It is possible that there is a slight difference between the sterile leaves identified as *Onychiopsis elongata* from the Outer and the Inner Zones. The Outer Zone specimens have pinnules at a rather wider angle. The matter needs further study.

Horizon and locality: Sebayashi Formation, Loc. no. 291.

Occurrence: Common.

Specimens: PP-7423~PP-7425 and many other pinna fragments.

Distribution in Japan: As mentioned above.

Bennettiales

Genus *Otozamites* BRAUN, 1842

Otozamites sp.

Pl. 1, fig. 5; Pl. 4, fig. 2; Fig. 11a, b

Description: Four leaf fragments were obtained, two of them were shown here. The following is the diagnostic character based mainly on the specimens shown in Pl. 1, fig. 5 and Pl. 4, fig. 2. Pinnae variable in size, nearly oval in form, borne at a wide angle, basal auricles asymmetrical, apex rounded, attached to upper surface of rachis, attachment region constricted. Nerves originating from whole region of attachment, first parallel each other, then divergent to the margin, mostly forking once dichotomously at all levels, density 14 per cm at middle portion.

Fig. 11a drawn from Pl. 4, fig. 2, shows an entire pinna outline with asymmetrically auriculated base, attached by its basisopic base to the rachis, 8 cm long and 3.4 cm wide near the base. Fig. 11b drawn from Pl. 1, fig. 5 shows a basal part of a medium-sized pinna.

Remarks: The present specimens resemble *Otozamites klipsteinii*, a well known Wealden species, especially to *O. klipsteinii* var. *superba* defined by SEWARD (1895, p. 65) in general form. But they are somewhat different from *O. klipsteinii* in that our pinnae are attached by their basisopic base or constricted whole base to the rachis, while in those regarded as *O. klipsteinii* recorded from the Wealden and its equivalents, are mostly attached by their middle basal area to the rachis. Under the circumstances, we at present regard the present specimens as *Otozamites* sp.

Horizon and locality: Ishido Formation; at Otchisawa, Ueno-mura, Tano-gun, Gumma Prefecture.

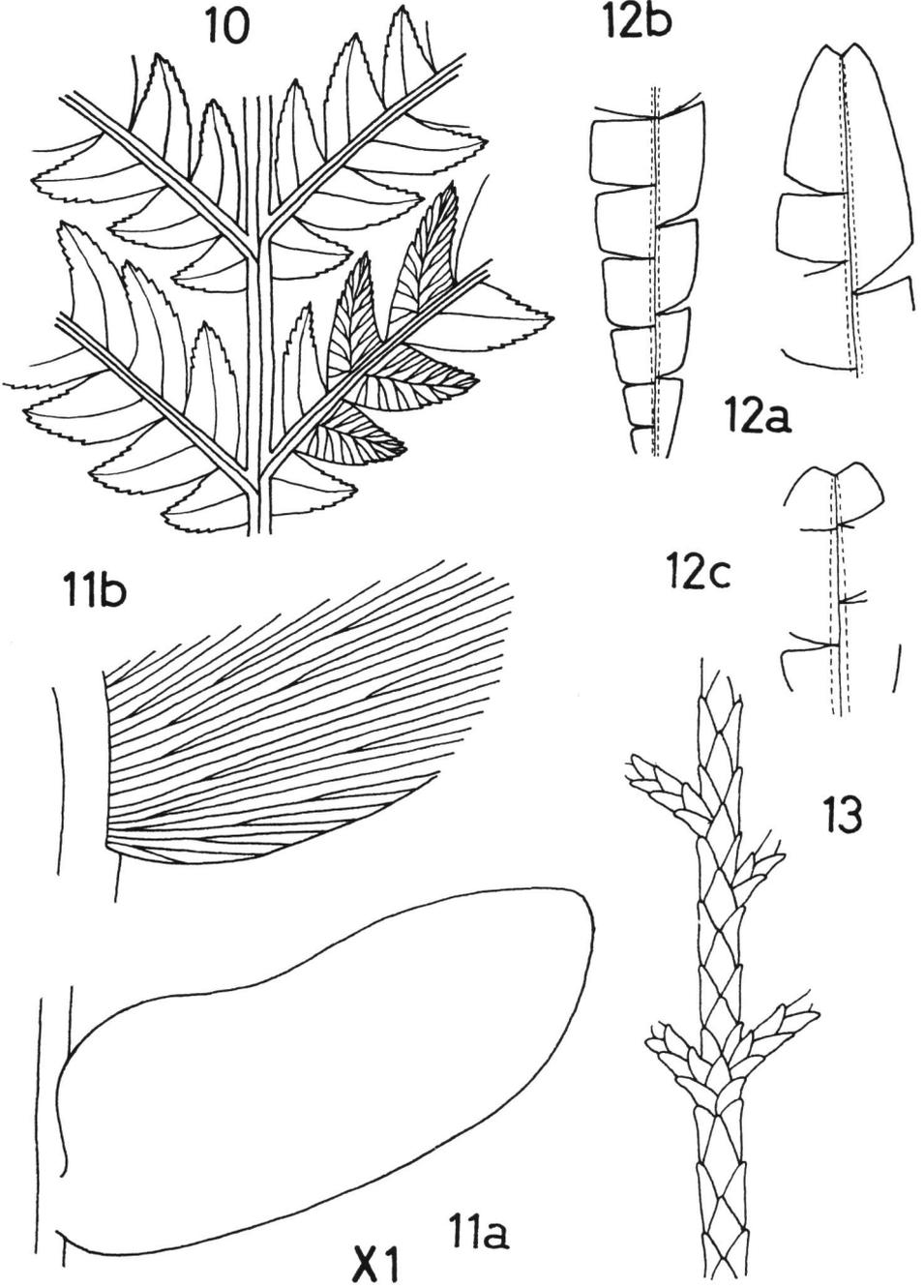
Occurrence: Probably common, judging from the abundant occurrence of minor pinna fragments.

Specimens: PP-7426~PP-7429.

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

Zamites buchianus (ETTINGSHAUSEN) SEWARD

Pl. 5, figs. 2-4



Pterophyllum buchianum ETTINGSHAUSEN; ETTINGSHAUSEN, 1852, p. 21, pl. 1, fig. 1 (Lower Cretaceous of Germany).

Zamites buchianus (ETTINGSHAUSEN) SEWARD; SEWARD, 1917, p. 536, figs. 601A-C, 602.

For further references, see OISHI, 1939, p. 213 and KIMURA, 1976, p. 199.

Remarks: Many leaf-fragments referable to this well-known Wealden species were obtained and three are illustrated here. As was mentioned by KIMURA (1976, p. 200), this species is a common or sometimes very abundant in occurrence in the Upper Jurassic to the Lower Cretaceous plant beds in the Outer Zone of Japan, and has not so far been recorded from the coeval plant beds in the Inner Zone of Japan.

This species is also known from the Middle Jurassic Utano Formation, Yamaguchi Prefecture (E. TAKAHASHI, 1957, p. 81) and possibly from the Upper Cretaceous plant beds in the Outer Zone of Japan (OISHI, 1940, p. 354).

Horizons and localities: Ishido Formation, at Otchisawa and Sebayashi Formation, Loc. no. 291.

Occurrence: Abundant.

Specimens: PP-7430~PP-7447.

Distribution in Japan: As mentioned above.

Genus *Ptilophyllum* MORRIS, 1840: 327

Ptilophyllum ex gr. *pecten* (PHILLIPS) MORRIS

Pl. 3, fig. 3

Ptilophyllum cfr. *cutchense* MORRIS; NATHORST, 1890, p. 12, pl. 4, fig. 8 (Upper Jurassic Torinosu Group, Kochi Prefecture).

For further references of the Japanese specimens, see KIMURA & KANSHA, 1978b, p. 172.

Remarks: This comprehensive species is common to the Upper Jurassic and the Lower Cretaceous plant beds in the Outer Zone of Japan. As mentioned before by KIMURA & KANSHA (1978b), *Ptilophyllum* ex gr. *pecten* seems to be an aggregation of two or three true species, but they can not be satisfactorily distinguished on macroscopic characters alone.

Horizon and locality: Sebayashi Formation, Loc. no. 291.

Occurrence: Rather rare.

Specimens: PP-7456 and the one here illustrated was collected by K. OHARA.

Distribution in Japan: Upper Jurassic Kiyosue Formation; Upper Jurassic to Lower Cretaceous plant beds in the Outer Zone of Japan.

Figs. 10-13. (All enlarged twice, unless otherwise stated). 10. *Cladophlebis nathorstii* YOKOYAMA; outline of pinnules and detailed venation (PP-7367). 11a, b. *Otozamites* sp.; outline of a pinna (11a) and venation observed (11b) (a; PP-7427, b; PP-7428). 12a, b. *Nilssonia* ex gr. *schaumburgensis* (DUNKER) NATHORST; varied leaf-forms (a; PP-7459, b; PP-7460, c; PP-7458). 13. *Cupressinocladus japonicus* (YOKOYAMA) n. comb.; a leafy shoot (PP-7469).

Bennettitales ?

Form-genus *Taeniopteris* BRONGNIART, 1828: 31*Taeniopteris* (*Nilssoniopteris* ?) *vittata* BRONGNIART

Pl. 4, figs. 3–7; Fig. 14a–c

Taeniopteris sp. cfr. *Nilssoniopteris vittata* (BRONGNIART) FLORIN; KIMURA & HIRATA, 1975, p. 85, pl. 13, fig. 1 (A, C, D); text-fig. 2 (Lower Monobegawa Group, Kochi Prefecture).

Nilssoniopteris cfr. *vittata* (BRONGNIART) FLORIN; KIMURA & KANSHA, 1978b, p. 171, pl. 1, figs. 5–7; pl. 4, fig. 5; Fig. 11a, b. (Yuasa and Arida Formations).

Description: Leaves of varied size were obtained both from the Ishido and the Sebayashi Formations. Five of them are shown in Pl. 4, figs. 3–7. We judged that they belong to a single species. Leaves are long and narrow and ribbon-like or oblanceolate in form, and with short petiole. Pl. 4, figs. 3–5 show parts of long and narrow and nearly parallel-sided leaves. Their whole length and form are not known. Pl. 4, fig. 7 shows a small oblanceolate leaf in which its apex is missing. Pl. 4, fig. 6 shows a similar leaf in form to the above, but larger in size.

In all specimens at hand, midnerves are distinct and sending off simple and crowded secondaries laterally at a wide angle, 34–44 per cm in density. Figs. 14a–c show the outline of preserved leaves and venation in detail.

Remarks: The specimens are impressions lacking cuticles and merely show their macroscopic features but these match the Yorkshire Middle Jurassic *Nilssoniopteris vittata*. However, we now think it would be appropriate to regard the present specimens as *Taeniopteris* (*Nilssoniopteris* ?) *vittata*, because it is difficult to identify fully such ribbon-like leaves without cuticles.

The present leaves are referable to those of *Taeniopteris* sp. cfr. *Nilssoniopteris vittata* formerly described by KIMURA & HIRATA and also of *Nilssoniopteris* cfr. *vittata* recently described by KIMURA & KANSHA.

The oblanceolate leaves regarded by OISHI (1940) as *Nilssonia orientalis* from the Upper Jurassic to the Lower Cretaceous plant beds such as in Kochi, Wakayama and Fukushima Prefectures, would belong to the present species.

Horizons and localities: Ishido Formation and Sebayashi Formation, Loc. no. 302.

Occurrence: Common in both formations.

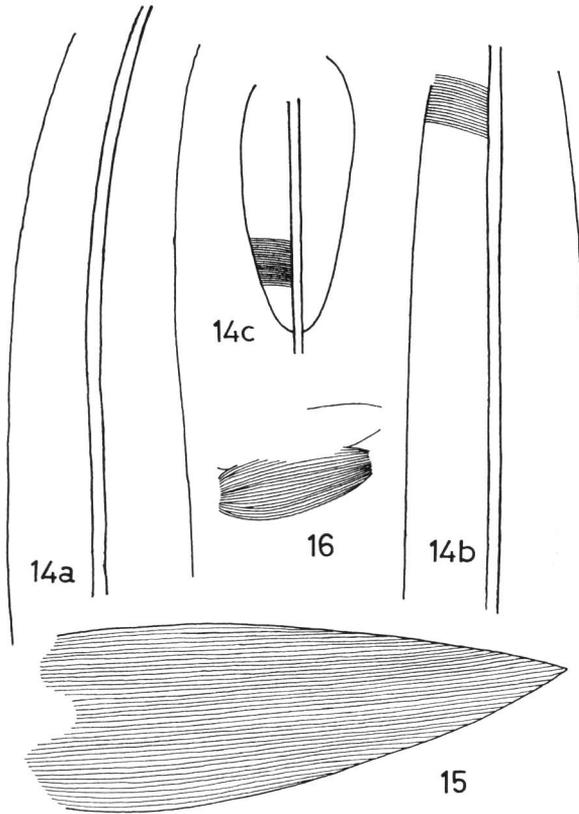
Specimens: PP-7448~PP-7455, PP-7475.

Distribution in Japan: Upper Jurassic (?) and Lower Cretaceous plant beds in the Outer Zone of Japan.

Cycadales

Genus *Nilssonia* BRONGNIART, 1825: 200*Nilssonia* ex gr. *schaumburgensis* (DUNKER) NATHORST

Pl. 4, figs. 8, 9; Fig. 12a–c



Figs. 14–16. (All $\times 1.2$). 14a–c. *Taeniopteris* (*Nilssoniopteris*?) *vittata* BRONGNIART; varied leaf-forms (a; PP-7455, b; PP-7453, c; PP-7452). 15. *Nageiopsis*? sp. A; venation (PP-7471). 16. *Nageiopsis*? sp. B; outline of leaves (both ends missing) and venation (PP-7472).

Nilssonia cfr. *schaumburgensis* (DUNKER) NATHORST; NATHORST, 1890. p. 5, pl. 1, figs. 6–9a (Ryoseki, Lower and Upper Monobegawa Groups, Kochi Prefecture).

For further references, see KIMURA, 1976, p. 202.

Remarks: This comprehensive species is common in the Lower Cretaceous plant beds in the Outer Zone of Japan. We judge from the varied leaf-form of *Nilssonia* ex gr. *schaumburgensis* that our material may be an aggregation of several true species. It is, however, impossible to separate them without cuticles.

The specimens here illustrated agree with NATHORST's specimens. No such leaves have been found in the Upper Jurassic and the Lower Cretaceous plant beds in the Inner Zone of Japan, apart from some doubtful specimens.

Horizon and locality: Sebayashi Formation, Loc. no. 291.

Occurrence: Common.

Specimens: PP-7457~PP-7460.

Distribution in Japan: Common to the Upper Jurassic and the Lower Cretaceous plant beds in the Outer Zone of Japan.

Unclassified conifers

Form-genus *Cupressinocladus* SEWARD, 1919: 307

Cupressinocladus japonicus (YOKOYAMA) n. comb.

Pl. 3, figs. 4-6; Pl. 5, fig. 5; Pl. 6, figs. 3, 4; Fig. 13

Cyparissidium (?) *japonicum* YOKOYAMA; YOKOYAMA, 1894, p. 229, pl. 20, figs. 3a, 6, 6a, 13; pl. 24, fig. 4 (Sebayashi Formation).

Brachyphyllum japonicum (YOKOYAMA) OISHI; OISHI, 1940 (pars), p. 391, pl. 42, fig. 3, 3a (Nishinotani, Lower Monobegawa Group) (non fig. 2).

Emended diagnosis: Thickest stems 1 cm across, with longitudinal striations, and sending off leafy branches. Leafy branches branching several times at a narrow angle, typically 30 degrees; each branch covered with decussately disposed small-sized leaves. Ultimate branches long and narrow, often curved, typically 5-6 cm long and 0.5-0.8 mm wide. Free part of leaf contracting gradually from basal cushion, appressed to stem, its length exceeding width of its basal cushion. Cones spherical, terminal, about 1 cm in diameter, consisting of cone scales about 10 in number.

Description: Many specimens were obtained, but unfortunately we could not make the cone structure clear, owing to the ill-preservation of material.

Pl. 3, fig. 4 and 5 show two thickest stems with longitudinal striations but without leaves. Pl. 3, fig. 6 shows a thinner stem without leaves, sending off leafy branches rather remotely. Pl. 6, fig. 3 shows two leafy branches. In this specimen, the left branch is sending off remotely set thinner leafy branches, and the right one is sending off slender and closely set leafy ultimate branches. According to our detailed observation of these branches, leaves appear to be represented on the stems less than 2 mm across, and the mode of branching appears to be the thinner and curved branches which are abundantly found at the locality (291). Pl. 6, fig. 4 shows three spherical cones terminated on the remotely set short branches with leaves as shown in Fig. 13 removed cones.

Remarks: It is sure that the present specimens with decussately disposed leaves belong to *Cupressinocladus* (SEWARD, 1919; HARRIS, 1969).

YOKOYAMA's original specimens regarded by him as *Cyparissidium* (?) *japonicum* are here revised by us to place them in *Cupressinocladus japonicus*, because in his figures, leaves are drawn decussately.

Many small leafy shoots with spirally disposed leaves regarded by KIMURA & KANSHA (1978b) as *Cyparissidium japonicum* from the Yuasa and the Arida Formations are now distinguishable from the present species and need the revision.

Brachyphyllum japonicum illustrated by OISHI (1940, p. 391, pl. 42, fig. 2) from

the Nagdong Group, Korea, is not identical with ours but is referable to a certain species of *Cupressinocladus*.

Cupressinocladus koyatoriensis originally described by OISHI (1940) from the Upper Jurassic plant beds of Miyagi Prefecture is distinguishable from ours in its perpendicularly attached lateral leaves, instead of our appressed ones.

Horizon and locality: Sebayashi Formation, Loc. no. 291.

Occurrence: Very abundant.

Specimens: PP-7461~PP-7469 and many other small leafy shoots.

Distribution: At present, restricted in the Sebayashi Formation.

Form-genus *Nageiopsis* FONTAINE, 1889: 194

Nageiopsis ? sp. A

Pl. 1, fig. 6; Pl. 3, fig. 7; Fig. 15

Description: Two incomplete specimens were obtained. No complete leaf or leafy shoot was found. Judging from the leaf-fragments as shown in Pl. 1, fig. 6 and Pl. 3, fig. 7, leaves are broadly lanceolate in form, constricted at base and acutely pointed at apex. The length and the maximum width may reach 10 cm and 2 cm respectively. Observable nerves are parallel each other, not radiate at base, simple and not converging at apex, the density of them is 20 per cm at the middle portion of a leaf. The mode of attachment of leaves is uncertain. Fig. 15 shows the detailed venation drawn from Pl. 1, fig. 6.

Remarks: Taking into account of its 'pinnately' arranged leaves, there remains a doubt that this plant may belong to a certain cycadophyte such as *Zamites*. However, we prefer to regard them as a broad-leaved conifer, because the nerves appear parallel at the leaf base, not radiating as in a normal *Zamites*.

The present plant resembles *Nageiopsis zamioides* (FONTAINE) BERRY illustrated by FONTAINE (1889) and BERRY (1911) from the Lower Cretaceous of North America in the shape of its leaves. But its leaves differ in being much longer; the range does not overlap. Its leaf is longer also than in *Nageiopsis zamioides* as described by OISHI (1940) and *N. ex gr. zamioides* of KIMURA & KANSHA (1978b) from the Yuasa and the Arida Formations.

Horizon and locality: Sebayashi Formation, Loc. no. 291.

Occurrence: Rather rare.

Specimens: PP-7470, PP-7471.

Negeiopsis ? sp. B

Pl. 1, fig. 7; Pl. 6, fig. 5; Fig. 16

Description: Several small, oval detached leaves were obtained. Pl. 6, fig. 5 shows one isolated leaf, 1.8 cm long and 1 cm wide, with crowded nerves which are sometimes forked near the base, parallel to each other and not converging at the

rounded apex. Pl. 1, fig. 7 shows a block with parallel and closely set leaves. Neither leaf apices nor bases are seen but its nerves (Fig. 16) are typical. Nerves are 28 in number at the middle portion of a leaf.

Remarks: We believe that the leaves from the locality figured by YOKOYAMA (1894) as *Podozamites pusillus* VELENOVSKY are specifically identical with our *Nageiopsis* ? sp. B. They agree in size, shape and crowded nerves. We have not however seen his specimens because they were destroyed by big earth-quake (1923). A possible difference is that the nerves in his figure converge to the leaf apex but in ours do not. However we are not convinced that the figure was accurate.

As the nerves converge strongly forwards the leaf apex in a true *Podozamites*, we have described our specimens under the non-committal name *Nageiopsis* ? sp. B.

Horizon and locality: Sebayashi Formation, Loc. no. 291.

Occurrence: Rather rare.

Specimens: PP-7472 ~ PP-7474.

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Explanation of plates

Plate 1

- Fig. 1. *Lycopodites?* sp.; (PP-7477), $\times 2$.
 Fig. 2. *Onychiopsis elongata* (GEYLER) YOKOYAMA; (PP-7425), $\times 1$.
 Fig. 3. *Cladophlebis acutipennis* OISHI; (PP-7359), $\times 1$.
 Fig. 4. *Cladophlebis* sp. A; (PP-7407), $\times 2$.
 Fig. 5. *Otozamites* sp.; (PP-7428), $\times 1$.
 Fig. 6. *Nageiopsis?* sp. A; (PP-7471), $\times 1$.
 Fig. 7. *Nageiopsis?* sp. B; (PP-7472), $\times 2$.

Plate 2

- Fig. 1. *Onychiopsis elongata* (GEYLER) YOKOYAMA; (PP-7423), $\times 1$.
 Fig. 2. *Cladophlebis nathorstii* YOKOYAMA; (PP-7367), $\times 2$.
 Figs. 3-5. *Cladophlebis (Osmunda?) takezakii* OISHI; (3; PP-7383, 4; PP-7389, 5; PP-7401), $\times 2$.
 Fig. 6. *Acrostichopteris longipennis* FONTAINE; (PP-7419), $\times 2$.

Plate 3

- Fig. 1. *Onychiopsis elongata* (GEYLER) YOKOYAMA; (PP-7424), $\times 1$.
 Fig. 2. *Acrostichopteris longipennis* FONTAINE; (PP-7418), $\times 2$.
 Fig. 3. *Ptilophyllum* ex gr. *pecten* (PHILLIPS) MORRIS; collected by K. OHARA.
 Figs. 4-6. *Cupressinocladus japonicus* (YOKOYAMA) n. comb.; (4-5; PP-7468, 6; PP-7467), $\times 1$.
 Fig. 7. *Nageiopsis?* sp. A; (PP-7470), $\times 1$.

Plate 4

- Fig. 1. *Cladophlebis* sp. D; (PP-7416), $\times 2$.
 Fig. 2. *Otozamites* sp.; (PP-7427), $\times 1$.
 Figs. 3-7. *Taeniopteris (Nilssoniopteris?) vittata* BRONGNIART; (3. PP-7455, 4; PP-7448, 5; PP-7451, 6; PP-7454, 7. PP-7452), $\times 1$.
 Figs. 8-9. *Nilssonia* ex gr. *schaumburgensis* (DUNKER) NATHORST; (8; PP-7459, 9; PP-7460), $\times 2$.

Plate 5

- Fig. 1. *Cladophlebis (Osmunda?) takezakii* OISHI; (PP-7399), $\times 2$.
 Figs. 2-4. *Zamites buchianus* (ETTINGSHAUSEN) SEWARD; (2; PP-7444, 3; PP-7445, 4; PP-7438), $\times 1$ (2, 4), $\times 2$ (3).
 Fig. 5. *Cupressinocladus japonicus* (YOKOYAMA) n. comb.; (PP-7462), $\times 2$.

Plate 6

- Fig. 1. *Cladophlebis* sp. C; (PP-7414), $\times 2$.
 Fig. 2. *Cladophlebis* sp. B; (PP-7409), $\times 2$.
 Figs. 3-4. *Cupressinocladus japonicus* (YOKOYAMA) n. comb.; (3; PP-7450, 4; PP-7469), $\times 2$.
 Fig. 5. *Nageiopsis?* sp. B; (PP-7405), $\times 2$.

