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Early Cretaceous Plants from the Yuasa District and the Aridagawa Valley, Wakayama Prefecture, in the Outer Zone of Japan Part 2

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Foreword

This paper (Part 2) deals with the systematic description continued from the last issue, Part 1 (vol. 4, no. 3). All plates and Figs. 8, 9 concerning our descriptions in this paper, were already inserted in Part 1.

Systematic Description

(Continued from the last issue-Part 1)

Form-genus *Sphenopteris* STERNBERG, 1825: 15

Sphenopteris elegans (YOKOYAMA) OISHI

Pl. 2, fig. 5; Fig. 8

Onychiopsis elegans YOKOYAMA; 1894, p. 215, pl. 28, figs. 7, 7a (Kaisekiyama, Ryoseki Group).
Sphenopteris elegans (YOKOYAMA) OISHI; 1940, p. 236, pl. 8, figs. 1–3 (Upper Jurassic Soma Group, Fukushima Prefecture; Otani, Ryoseki Group).

Description: Two pinna fragments referable to this species were obtained, one of which was shown in Pl. 2, fig. 5. The figured specimen shows a basal pinna fragment bearing elongate-oval or lanceolate pinnules in which lamina is decurrent and deeply divided into 5–8 pairs of lobes, but each incision never reaching the midnerve; each lobe is directed forwards and with acutely or rarely bluntly pointed apex; midnerve is thin, nearly straight and persisting to the tip; the secondaries are invisible.

Remarks: OISHI (1940) reexamined YOKOYAMA's *Onychiopsis elegans* to revise it as *Sphenopteris elegans*, together with his new material.

The present specimens agree with those described by OISHI from the Ryoseki and the Soma Groups in the Outer Zone of Japan, but are somewhat different from the YOKOYAMA's specimens in which margins of pinnule are entire in its lower half and

serrate in its upper half.

The present pinnules remind us of some pinnules of *Cladophlebis acutipennis* here described together, but in *C. acutipennis*, pinnules are not decurrent as in the present ones.

Horizon: Yuasa Formation (Lower bed).

Occurrence: Rather rare.

Distribution: Upper Jurassic-Lower Cretaceous, sporadically in the Outer Zone of Japan.

Specimens: NSM–PP–7232, 7319.

Sphenopteris ex gr. *goeppertii* DUNKER

Sphenopteris tenuicula YOKOYAMA; 1894, p. 217, pl. 20, fig. 11; pl. 21, figs. 2, 2a; pl. 28, fig. 6 (Yuasa, Yuasa Formation; Kaisekiyama, Ryoseki Group; Kagahara, Sebayashi Formation).

Remarks: We provisionally define this comprehensive species in the sterile leaves as follows; Frond delicate, at least tripinnate with very slender axes. Pinnules oblong or linear. In oblong pinnules, laminae shallowly dissected into segments or with serrate margins. Nerves *Sphenopteris*-type.

Many specimens referable to the above definition have been described under the name of *Sphenopteris goepperti* or *S.* (*Ruffordia*) *goepperti* from the various localities, especially from the Upper Jurassic to the Lower Cretaceous plant beds in Japan.

Judging from their varied forms, it is possible that this comprehensive species includes several species or even different genera.

YOKOYAMA's specimens regarded by him as *Sphenopteris tenuicula* are such incomplete pinna fragments that we prefer to name them as *Sphenopteris* ex gr. *goeppertii*.

Horizon: Yuasa Formation (Lower bed).

Occurrence: Rather rare.

Distribution in Japan: Upper Triassic to the Lower Cretaceous plant beds.

Form-genus *Acrostichopteris* (FONTAINE) BERRY, 1911: 270

Acrostichopteris pluripartita (FONTAINE) BERRY

Pl. 1, fig. 3; Fig. 9

Baieropsis pluripartita FONTAINE; 1889, p. 208, pl. 89, fig. 4; pl. 90, figs. 2–5; pl. 91, figs. 1, 3, 4, 7; pl. 92, figs. 1, 2, 6; 1905 in WARD, p. 505, pl. 107, fig. 1 (Lower Cretaceous of Potomac).

Baieropsis pluripartita FONTAINE var. *minor* FONTAINE; 1889, p. 208, pl. 91, fig. 5; pl. 92, figs. 3, 4 (Ditto).

Baieropsis longifolia FONTAINE; 1889, p. 210, pl. 91, fig. 6; 1905 in WARD, p. 505, pl. 111, fig. 3 (Ditto).

Acrostichopteris pluripartita (FONTAINE) BERRY; 1911, p. 227, pl. 24, fig. 6 (Ditto); KRASSILOV, 1967, p. 136, pl. 29, fig. 5 (Lower Cretaceous of Southern Primorye).

Acrostichopteris longipennis FONTAINE; NAGAO, 1926, p. 380; YABE, 1927, p. 41 (Yuasa Formation).

Sphenopteris goepperti DUNKER; OISHI, 1931 (pars), p. 112; 1940 (pars), p. 238 (Yuasa Formation).

Description: Three incompletely preserved detached leaves (or pinnae) were obtained. Leaves (or pinnae) are fan-shaped, with short pedicels and usually divided down to near the base into three or four principal segments which by repeated dichotomous sub-

division give rise finally to long and narrow ultimate segments. They are strap-shaped and about 1.2 mm wide, their length not being made out, as their tips are not in any case seen, but probably attaining the length of 3 cm and more from the last point of subdivision; nerves slender, forking at the base to enter the principal segments, and then forking repeatedly at long intervals, one or two in the ultimate segment.

Pl. 1, fig. 3 shows a detached leaf (or pinna) on which the above description is mainly based. Judging from the occurrence of the specimens, it is highly probable that such leaves might have been pinnately disposed. Fig. 9 shows the mode of subdivision of a leaf (or pinna).

Remarks: For numerous leafy stems with fan-shaped leaves from the Potomac Group, FONTAINE (1889) instituted both *Acrostichopteris* and *Baieropsis* of uncertain affinity and described five *Acrostichopteris* species and seven *Baieropsis* species with its three varieties. Later BERRY (1911) included *Baieropsis* into *Acrostichopteris* and unified FONTAINE's thirteen species and three varieties into six *Acrostichopteris* species.

Depending on OISHI's identification, both NAGAO (1926) and YABE (1927) cited *Acrostichopteris longipennis* and *A.* cfr. *longipennis* respectively from Takata of the Yuasa Formation, but later OISHI (1931, 1940) referred both to *Sphenopteris goepperti*. Though NAGAO and YABE gave no descriptions or figures of their specimens, we suppose that their specimens are referable to *A. pluripartita* rather than *Sphenopteris goepperti*.

Our specimens, though broken, agree well with those described by FONTAINE originally as *Baieropsis pluripartita* and that by KRASSILOV from the Lower Cretaceous of Southern Primorye as *Acrostichopteris pluripartita* with the only exception that our specimens have rather narrower ultimate segments than those of Southern Primorye.

Acrostichopteris nervosa described by TEIXEIRA (1948, p. 74, pl. 19, figs. 1–5; pp. 55, 57, pl. 19, fig. 6) which had once been referred to *Czekanowskia nervosa* by HEER (1881, p. 18, pl. 17, figs. 5–7a, 5b, 8–11, 10b), appears to be very close to the present species in general outline.

Horizons: Arida Formation (Middle bed), and probably from the Yuasa Formation (after NAGAO and YABE).

Occurrence: Rather rare.

Distribution: Lower Cretaceous of Southern Primorye and Potomac; Lower Cretaceous, sporadically in the Outer Zone of Japan.

Specimens: NSM–PP–7307, 7311, 7352.

Genus *Adiantopteris* VASSILEVSKAJA, 1968: 49

Adiantopteris yuasensis (YOKOYAMA) KRASSILOV

Adiantites yuasensis YOKOYAMA; 1894, p. 216, pl. 21, fig. 15; OISHI, 1940, p. 235, pl. 47, figs. 6–8; pl. 48, fig. 5 (Yuasa Formation); JÄHNICHEN & KAHLERT, 1972, p. 967, pl. 2, figs. 1–2 (Jurasso-Cretaceous? of Mongolia).

Adiantopteris yuasensis (YOKOYAMA) KRASSILOV, 1967, p. 123, pl. 20, figs. 3–6 (Lower Cretaceous of Southern Primorye).

Remarks: We found no fresh specimen of *Adiantopteris yuasensis*, but YOKOYAMA

and OISHI described several detached pinnules. They scarcely give a satisfactory basis for a species. However better specimens described by KRASSILOV and JÄHNICHEN & KAHLERT have been identified with *A. yuasensis*.

Horizons: Yuasa Formation (Lower and Upper beds).

Occurrence: Probably rare.

Distribution: Lower Cretaceous of Southern Primorye; Jurasso-Cretaceous? of Mongolia; Yuasa Formation.

Genus *Onychiopsis* YOKOYAMA, 1889: 27

Onychiopsis elongata (GEYLER) YOKOYAMA

Onychiopsis elongata (GEYLER) YOKOYAMA; 1889, p. 27, pl. 2, figs. 1–3, 4a–c; pl. 3, fig. 6d; pl. 12, figs. 9–10 (Oguchi Formation). For further references, see KIMURA, 1975a, p. 77.

Remarks: Though many small pinna fragments were found, *Onychiopsis elongata* seems much less abundant than it is in the Tetori Supergroup, particularly in the Oguchi Formation.

Recently some Russian palaeobotanists (e.g. SAMYLINA, 1976) regard the attribution of this genus as Pteridaceae, but so far as the Japanese specimens are concerned, no evidence as to its attribution has so far been found.

Horizon: Yuasa Formation (Lower bed).

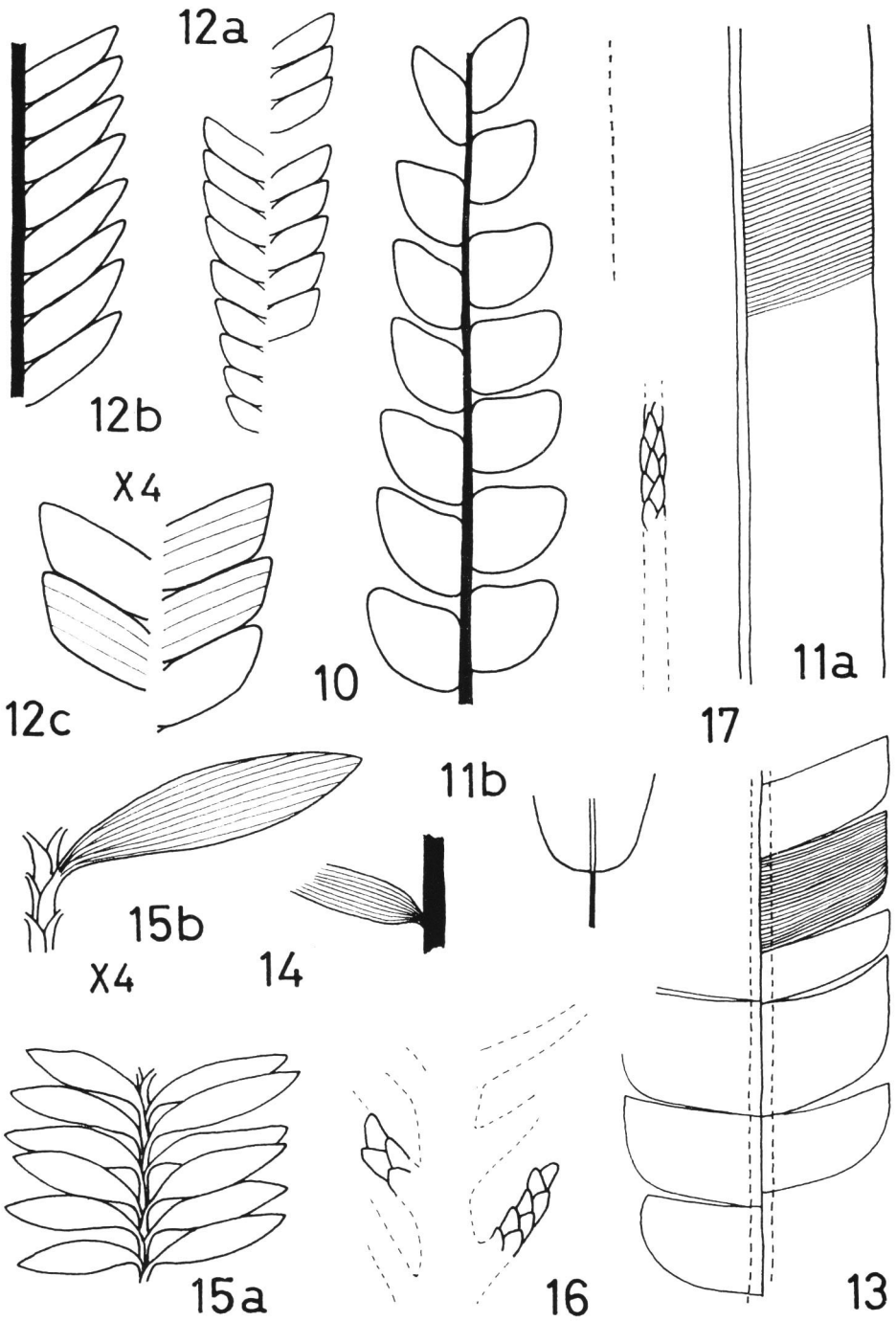
Occurrence: Common, but tiny fragments.

Distribution in Japan: Upper Liassic Nishinakayama and Middle Jurassic Utano Formations (after E. TAKAHASHI, 1957); Upper Jurassic to the Lower Cretaceous plant beds.

Specimens: NSM–PP–7317, 7323, 7329, 7343, 7350, 7353.

Figs. 10–17. (All enlarged twice, unless otherwise stated)

10. *Ptilozamites*? sp.; showing the outline of pinnules (PP–7276).
11. *Nilssoniopteris* cfr. *vittata* (BRONGNIART) FLORIN; 11a. middle part of ribbon-like leaf, showing the venation (PP–7306), 11b. showing the base of lamina (PP–7331).
12. *Ptilophyllum* ex gr. *pecten* (PHILLIPS) MORRIS; 12a. a leaf, both apex and base are missing (PP–7270), 12b. an incomplete fragment of rather larger leaf (PP–7275). 12c. showing the venation, enlarged partly from 12a.
13. *Nilssonia densinervis* (FONTAINE) BERRY; an incomplete leaf, showing the outline of segments and the venation (PP–7280).
14. *Nageiopsis angustifolia* FONTAINE; showing a leaf attached to rather slender axis and the basal part of its nerves, the detailed mode of attachment is not visible (PP–7344).
15. *Nageiopsis* ex gr. *zamioides* (FONTAINE) BERRY; 15a. a part of leafy-shoot (PP–7274), 15b. showing the mode of attachment of leaf to axis, the outline of leaf and the venation, enlarged from 15a.
16. *Brachyphyllum expansum* (STERNBERG) SEWARD; showing a part of pinnate leafy-shoot and the disposition of scale-leaves (PP–7344).
17. *Cyparissidium japonicum* YOKOYAMA; a part of leafy-shoot, showing the disposition of scale-leaves (PP–7304).


12a
12b
X4
12c
10
11a
17
11b
15b
X4
14
15a
16
13

Pteridospermales

Genus *Ptilozamites* NATHORST, 1878: 21

Ptilozamites? sp.

Pl. 1, fig. 4; Fig. 10

Description: We have two similar fragments, the longer being 12.5 cm and part of it is figured (Pl. 1, fig. 4; Fig. 10) where the shape of the pinnules is clear. They are strongly convex, the upper ones 7×3 mm, the lower 8.5×5 mm. We could not see the nerves even in the transfer preparations but these preparations indicated that the lamina was of thick substance.

Remarks: The information available does not enable us to be sure that the specimens belong to *Ptilozamites*. Apart from Pteridosperm genera, a few species included in *Otozamites* are of rather similar form.

Horizon: Arida Formation (Middle bed).

Occurrence: Rare.

Specimens: NSM-PP-7276, 7295 (NSM-PP-7277, 7279, 7281, 7282 are balsam transfer slides from PP-7276).

Caytoniales

Genus *Sagenopteris* PRESL, 1838: 164

Sagenopteris inequilateralis OISHI

Sagenopteris ? *inequilateralis* OISHI; 1940, p. 363, pl. 47, figs. 3–5 (Yuasa Formation).

Sagenopteris inequilateralis OISHI; KIMURA, 1976, p. 196, pl. 2, fig. 4; pl. 4, fig. 4; text-fig. 10a, b (Yatsushiro Formation).

Remarks: This species was first described by OISHI (1940) from the Yuasa Formation with his hesitation in referring this species fully to *Sagenopteris*.

In 1976, KIMURA discriminated this species from the Albian Yatsushiro Formation and assigned this species to *Sagenopteris*. As was stated by OISHI, this species is characterized by the leaflets divided by the midnerve into two unequal halves as shown in its specific name. We could not find any additional specimen from the Yuasa Formation.

Horizon: Yuasa Formation (Upper bed).

Occurrence: Probably rare.

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

Bennettitales

Genus *Otozamites* BRAUN, 1842

Otozamites klipsteinii (DUNKER) SEWARD

Otozamites klipsteini (DUNKER) SEWARD; OISHI, 1940, p. 332 (Yuasa Formation, without illustration).

Remarks: This Wealden-type species is characterized by its medium to large-sized pinnae, elongate-oval in form, with indistinct auricles at base and with very crowded nerves.

Unfortunately we could not collect this species in the present area, but recently MATSUKAWA collected several similar specimens to this species from the Upper Neocomian Ishido Formation, Gumma Prefecture in the Outer Zone of Japan.

Horizon: Yuasa Formation (Upper bed, after OISHI, 1940).

Occurrence: Probably rare.

Distribution in Japan: Upper Jurassic Kiyosue Formation, Yamaguchi Prefecture (after OISHI, 1940); Lower Cretaceous, sporadically in the Outer Zone of Japan.

Genus *Nilssoniopteris* NATHORST, 1909: 29

Nilssoniopteris cfr. *vittata* (BRONGNIART) FLORIN

Pl. 1, figs. 5–7; Pl. 4, fig. 5; Fig. 11a, b

Comparable specimens:

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).

Description: Ribbon-like leaves of varied dimension were obtained. Judging from their homogeneity, it is clear that they belong to one species. Leaves are long and narrow and short petioled. Laminae are attached to the sides of slender rachis, entire, varied in size, nearly parallel-sided and narrowing gradually towards the rounded base as shown in Pl. 1, fig. 7 (Fig. 11b), and abruptly narrowing to the bluntly pointed apex as shown in Pl. 1, fig. 5. Their maximum width varies from 16 to 22 mm (average, 18.7 mm), but their length is unknown, in the preserved specimens, more than 9 cm. Nerves are simple, fine and delicate, often invisible, and making an angle of 70–90 degrees to the rachis, the density of which is 26 per cm as shown in Fig. 11a.

Remarks: Unfortunately no cuticle is preserved in the present material, but judging from the outline of leaves, it would be presumed that the present material belongs to a bennettitalean *Nilssoniopteris*.

The present material is characterized by its narrow and ribbon-like leaves and delicate nerves, and it is presumed that its elongate laminae did reach a considerable length.

Taeniopteris sp. cfr. *Nilssoniopteris vittata* described by KIMURA & HIRATA from the Lower Monobegawa Group, Kochi Prefecture might be synonymous to the present material. Similar specimens to the present ones were recently collected by MATSUKAWA from the Sebayashi Formation, Gumma Prefecture, in the Outer Zone of Japan. To the present material, *Nilssoniopteris rhitidorachis* (KRYSHTOFOVICH) KRASSILOV is an allied form, together with *Taeniopteris* sp. cfr. *Nilssoniopteris rhitidorachis* described by KIMURA & HIRATA from the Upper Monobegawa Group, Kochi Prefecture. But they differ from the present material in having stout and less crowded nerves.

The specimens are clearly distinguished from *Nilssonia*, e.g. *Nilssonia orientalis* by the fact that part of the rachis is visible on the upper side of the leaf.

Horizons: Yuasa Formation (Upper bed, after OISHI, the specimens regarded by him as *Nilssonia orientalis*); Arida Formation (Middle bed).
Occurrence: Common.
Distribution in Japan: Lower Cretaceous in the Outer Zone of Japan.
Specimens: NSM-PP-7305, 7306, 7313, 7318, 7331, 7337, 7340, 7351.

Genus *Ptilophyllum* MORRIS, 1840: 327
Ptilophyllum ex gr. *pecten* (PHILLIPS) MORRIS

Pl. 4, figs. 3, 4; Fig. 12a, b

Japanese specimens:
Ptilophyllum cfr. *cutchense* Morris; NATHORST, 1890, p. 12, pl. 4, fig. 8 (Shiroishigawa, now corresponding to the Upper Jurassic Torinosu Group, Kochi Prefecture); YOKOYAMA, 1894, p. 229 (after NATHORST).
An indeterminable fragment; NATHORST, 1890, p. 10, pl. 2, fig. 4 (Ueno, Ryoseki Group).
Ptilophyllum cutchense MORRIS; YABE, 1927, pl. 1, fig. 3 (Yuasa, Yuasa Formation).
Nilssonia pterophylloides YOKOYAMA (non NATHORST); 1894, p. 228, pl. 22, figs. 8–10; pl. 25, fig. 7 (Yuasa, Yuasa Formation; Ryoseki, Ryoseki Group).
Ptilophyllum pecten (PHILLIPS) MORRIS; OISHI, 1940, p. 348, pl. 32, figs. 1–6; pl. 35, figs. 1, 3 (Upper Jurassic Kiyosue Formation; Upper Jurassic Ogihama and Soma Groups; Lower Cretaceous in the Outer Zone of Japan, see OISHI, 1940, p. 349).
Ptilophyllum sp.; KIMURA, 1976, p. 198, text-fig. 11 (Yatsushiro Formation).
Remarks: Several leaf-fragments were obtained. They are varied in size, form and density of nerves. They seem to be an aggregation of two or three species, but it is difficult to separate them on their external appearance.

The illustrated specimens resemble in general form those once described by YOKOYAMA as *Nilssonia pterophylloides* (non NATHORST) from Yuasa and Ryoseki, but differ in having 3–4 nerves in each pinna from YOKOYAMA's specimens with numerous nerves.

In his description of the Lower Cretaceous material derived from Malaya, KON'NO revised YOKOYAMA's species as *Ptilophyllum pterophylloides* (YOKOYAMA) and regarded it as being distinct from other *Ptilophyllum* species hitherto known. We, however, think that it is at present appropriate to treat the discussed *Ptilophyllum*-leaves of Japan into a comprehensive *Ptilophyllum* ex gr. *pecten*. Similar forms to ours are widely distributed in the Upper Jurassic to the Lower Cretaceous plant beds in VAKHRAMEEV's Indo-European Palaeofloristic Area.
Horizons: Yuasa Formation (Lower and Upper beds); Arida Formation (Middle bed).
Occurrence: Common.
Distribution in Japan: Upper Jurassic Kiyosue Formation; Upper Jurassic to Lower Cretaceous in the Outer Zone of Japan.
Specimens: NSM-PP-7270, 7275.

Genus *Zamites* BRONGNIART, 1828

Zamites buchianus (ETTINGSHAUSEN) SEWARD

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

Zamiophyllum buchianum (ETTINGSHAUSEN) NATHORST; 1890, p. 6, pl, 2. figs. 1, 2; pl. 3; pl. 5, fig. 2; p. 9 (Ryoseki Group); YOKOYAMA, 1894, p. 223, pl. 20, fig. 1; pl. 22, figs. 1, 2; pl. 23, fig. 6; pl. 28, figs. 1, 2 (non pl. 27, figs. 5a, b) (Lower Cretaceous in the Outer Zone of Japan); OISHI, 1939, p. 213, pls. 12–13 (Middle Jurassic Utano Formation; Upper Jurassic Kiyosue Formation; Lower Cretaceous in the Outer Zone of Japan); 1940, p. 353 (Ditto); KRASSILOV, 1967, p. 143, pl. 36, figs. 1–3; pl. 38, fig. 5; pl. 39, figs. 4–5 (Lower Cretaceous of Southern Primorye).

Zamites buchianus (ETTINGSHAUSEN) SEWARD; 1917, p. 531 (nomenclature and history); KIMURA, 1976, p. 199, pl. 4, fig. 5; pl. 5, fig. 5; pl. 6, fig. 7 (Yatsushiro Formation).

For further references, see KIMURA, 1976, p. 199.

Remarks: This plant, formerly assigned to *Zamiophyllum buchianum*, is quite abundant in the Lower Cretaceous plant beds in the Outer Zone of Japan, often very crowded in occurrence, and is one of the characteristic elements of the late Jurassic to the early Cretaceous floras in the Outer Zone of Japan. It has not been found both in the Tetori Supergroup in the Inner Zone of Japan and in the coeval plant beds in Siberia except Primorye (Maritime District).

KIMURA (1976, p. 198) explained why he adopted *Zamites* BRONGNIART instead of *Zamiophyllum* NATHORST, 1890 for this plant.

In this area, this species is quite abundant, though fragmental, in the Yuasa Formation, but has not been found in its overlying formations. Its reproductive organs have not so far been found, in spite of the abundant occurrence of its leaves.

The oldest record of this species was made by TAKAHASHI (1957) from the Middle Jurassic Utano Formation, Yamaguchi Prefecture, but with neither description nor illustration. The late Cretaceous records including OYAMA's Cfr. *Zamiophyllum buchianum* (1960, p. 68, pl. 2, fig. 13) from Oarai, Ibaraki Prefecture, are generically doubtful not only in their identification, but also partly in their age.

Horizons: Yuasa Formation (Lower and Upper beds).

Occurrence: Very abundant.

Distribution: Middle Jurassic Utano Formation and Upper Jurassic Kiyosue Formation; Upper Jurassic to Lower Cretaceous plant beds in the Outer Zone of Japan; Lower Cretaceous of Southern Primorye (Thaukhin, Sibaigin and Lypovetz Formations); Wealden of Germany and other parts of Europe.

Specimens: NSM–PP–7221, 7253, 7296, 7308, 7309, 7312, 7314, 7324, 7326, 7328, 7330, 7333.

Genus *Cycadolepis* SAPORTA, 1874: 201

Cycadolepis kiiensis OISHI

Cycadolepis kiiensis OISHI; 1940, p. 367, pl. 37, figs. 4, 5 (Yuasa Formation).

Remarks: OISHI based this species on two incomplete scale-leaves with faint indication of nerves or striations running parallel to each other and to their lateral margins on the strongly convex upper surface. There is, however, no evidence regarding its attribution to Bennettitales.

Horizons: Yuasa Formation (Lower and Upper beds).
Occurrence: Probably rare.
Distribution: Known only from the Yuasa Formation.

Cycadolepis? sp.

Pl. 4, fig. 6

Description: Two incomplete specimens referable to scale-leaf as shown in Pl. 4, fig. 6, were obtained, in association with *Zamites buchianus* leaves.

Scale-leaf elongate triangular in outline, more than 1.65 cm long and 5.5 mm wide below and 2.5 mm above, both apex and base are missing and covered with numerous and densely crowded thick hairs on both margins.

Remarks: The thick hairs strongly suggest a Bennettitalean scale, as more than half the species are more or less hairy. This seems like a typical Bennettitalean floral scale, particularly in its hairs, which are unusually broad. Its association with *Zamites buchianus* is interesting.

Somewhat similar scale-leaves (*Deltolepis*) belong to *Nilssonia* (HARRIS, 1942, 1953), but they are glabrous.

Horizon: Yuasa Formation (Upper bed).
Occurrence: Rare.
Specimen: NSM-PP-7303 (one slab only).

Cycadales

Genus *Nilssonia* BRONGNIART, 1825: 200

Nilssonia densinervis (FONTAINE) BERRY

Pl. 2, fig. 6; Fig. 13

Platypteridium densinerve FONTAINE; 1889, p. 169, pl. 30, fig. 8; pl. 31, figs. 1–4; pl. 32, figs. 1–2; pl. 33, fig. 1; pl. 34, fig. 1; pl. 35, figs. 1, 2; FONTAINE in WARD, 1905, p. 521, pl. 112, fig. 8 (Lower Cretaceous of Potomac).

Nilssonia densinerve (FONTAINE) BERRY; 1911, p. 362, pls. 57, 58 (Ditto); OISHI, 1940, p. 300, pl. 24, figs. 2–4 (Upper Jurassic Kiyosue Formation; Yuasa Formation).

Nilssonia densinervis (FONTAINE) BERRY; KRASSILOV, 1967, p. 171, pl. 56, figs. 4, 5 (Lower Cretaceous of Southern Primorye).

Description: A single incomplete specimen was obtained. Leaf is fairly small-sized, segmented, 1.8 cm wide and each segment is quadrilateral in form, and wholly covers the upper surface of the rather thick rachis. The upper margin of segments is mostly straight or concave and the lower margin usually rounded to meet nearly truncated lateral margin. Nerves are delicate, unbranched and numerous, 23 in number in the segment shown in Fig. 13.

Remarks: The present specimen is like the original ones in general form and in its numerous nerves, but smaller in size.

OISHI's specimens (1940, pl. 24, figs. 3, 4) from Tanzaki are rather narrower leaf fragments than those described from the Lower Cretaceous of Potomac.

The present specimen is rather like *Nilssonia* ex gr. *schaumburgensis* (DUNKER) NATHORST, a common leaf in the Outer Zone of Japan, but differs in its rounded lateral margin and less numerous nerves.

Horizons: Yuasa Formation (Lower bed; Upper bed after OISHI).

Occurrence: Rare.

Distribution: Upper Jurassic Kiyosue Formation; Yuasa Formation; Lower Cretaceous of Southern Primorye and Potomac.

Specimen: NSM-PP-7280.

Nilssonia ex gr. *schaumburgensis* (DUNKER) NATHORST

Nilssonia cfr. *schaumburgensis* (DUNKER) NATHORST; 1890, p. 5, pl. 1, figs. 6–9a (Lower Cretaceous of Kochi Prefecture).

Nilssonia schaumburgensis (DUNKER) NATHORST; YOKOYAMA, 1894, p. 227, pl. 20, figs. 12, 14; pl. 21, fig. 14; pl. 22, figs. 5–7 (Lower Cretaceous in the Outer Zone of Japan).
For further references, see KIMURA, 1976, p. 202.

Horizon: Yuasa Formation (Lower bed).

Occurrence: Probably rare.

Distribution: Lower Cretaceous in the Outer Zone of Japan (see KIMURA, 1976, pp. 202–204).

Unclassified Conifers

Genus *Nageiopsis* FONTAINE, 1889: 194

Nageiopsis angustifolia FONTAINE

Pl. 4, fig. 7B; Fig. 14

Nageiopsis angustifolia FONTAINE; 1889, p. 202, pl. 86, figs. 8, 9; pl. 87, figs. 2–6; pl. 88, figs. 1, 3, 4, 6–8; pl. 89, fig. 2 (Lower Cretaceous of Potomac); 1905 in WARD, pp. 219, 491, 516, 528, 560, pl. 117, figs. 4, 5 (Ditto); BERRY, 1911, p. 389, pl. 63, figs. 3, 4 (Ditto).

Description: A single incomplete shoot and many detached leaves referable to this species were obtained. Leaves are long and narrow, more than 5.8 cm long and 3 mm wide at base, narrowing gradually towards the apex which is missing, abruptly constricted at base with short petiole and attached to the slender axis at wide angle as shown in Fig. 14. Nerves are mostly simple, 8–12 in number in each leaf, and probably not converging at apex.

Remarks: The present specimens are indistinguishable from those originally described by FONTAINE and later by him again and BERRY from the Potomac Group in North America. *Nageiopsis longifolia* FONTAINE described by OISHI (1940) from the Kiyosue Formation differs from the present species in having more longer and broader leaves than those of the present species.

This is the first record of *Nageiopsis angustifolia* in Japan.

Horizons: Yuasa Formation (Upper bed) and Arida Formation (Middle bed).

Occurrence: Leaf-fragments are common.

Specimens: NSM-PP-7344, 7349.

Nageiopsis ex gr. *zamioides* (FONTAINE) BERRY

Pl. 2, fig. 7; Pl. 4, fig. 8; Fig. 15a, b

Comparable specimens:

Nageiopsis decrescens FONTAINE; 1889, p. 199, pl. 77, figs. 3, 3a (Lower Cretaceous of Potomac).

Nageiopsis microphylla FONTAINE; Ibid., p. 201, pl. 84, fig. 6; pl. 86, figs. 3, 6 (non pl. 85, fig. 14; pl. 86, fig. 1) (Ditto).

Podozamites sp.; YOKOYAMA, 1894, p. 223, pl. 25, figs. 8–12 (Ryoseki Group in Kochi Prefecture).

Description: Several incomplete fragments of small-sized twigs were obtained, two of which were illustrated here. Leaves are small but variable in form and size, elongate-ovate to lanceolate, generally elongate-ovate in outline with acutely pointed apex, and attached to the slender axis oppositely by very short and twisted petiole. Nerves are parallel and simple except near their origin, 6–8, mostly 8 in number and not convergent at apex as shown in Fig. 15b. The leaf-size (length and maximum width) are as follows; 2.4 cm×0.6 cm, 2.3×0.45, 2.1×(0.5–0.4), 2.0×(0.6–0.4), 1.8×0.5 and 1.7×0.6.

Remarks: In 1889, FONTAINE instituted the genus *Nageiopsis* under which he described 14 new species from the Lower Cretaceous of Potomac. Afterwards, BERRY (1911) revised FONTAINE's work to unite his 14 species into 3, *Nageiopsis angustifolia, N. longifolia* and *N. zamioides*, and FONTAINE's *Nageiopsis decrescens, N. heterophylla, N. microphylla, N. ovata* and *N. recurvata* were included into BERRY's *N. zamioides*. In other words, BERRY broadened the range in variation of *Nageiopsis zamioides* in size of leaves. Because BERRY's *Nageiopsis zamioides* includes not only such small-sized leaves as FONTAINE's *N. decrescens* and *N. microphylla*, but also such large-sized leaves as FONTAINE's *N. recurvata* having longer leaves attaining 8 cm long.

The present specimens are all small-sized and are most close to FONTAINE's *Nageiopsis decrescens* and next to his *N. microphylla* in leaf form and venation.

Without OISHI's specimen regarded by him as *Nageiopsis zamioides* (1940, p. 402, pl. 43, figs. 3, 3a) from Tanzaki of the Yuasa Formation, BERRY's *Nageiopsis zamioides* including such small-sized forms as FONTAINE's *N. decrescens* and *N. microphylla*, would have been reconsidered by us. For OISHI's *N. zamioides* is intermediate in leaf-size between FONTAINE's *N. zamioides* and *N. decrescens* or *N. microphylla*, and these are generally indistinguishable each other in leaf-form and venation.

In these circumstances, we prefer to name the present material as *Nagiopsis* ex gr. *zamioides*.

KRYSHTOFOVICH & PRYNADA recorded the occurrence of *Nageiopsis zamioides* from the Lower Cretaceous of Southern Primorye (1932, p. 372), but they gave neither description nor illustration on it.

Nageiopsis striata originally described by BELL (1956) from the Lower Cretaceous Blaimore Group and Luscar Formation in Western Canada, is similar in leaf-form, leaf-size and venation to the present material, especially so in his pl. 69, fig. 2, but in BELL's species, leaf-apices are mostly obtuse or bluntly pointed instead of acutely pointed in our material.

Horizons: Yuasa Formation (Upper bed); Arida Formation (Middle bed).
Occurrence: Rather common.
Distribution: Yuasa and Arida Formations; Upper Jurassic Soma Group (after OISHI); Lower Cretaceous of Southern Primorye? and Potomac.
Specimens: NSM-PP-7274, 7294, 7300, 7301, 7302, 7304.

Genus *Brachyphyllum* BRONGNIART, 1828: 109
Brachyphyllum expansum (STERNBERG) SEWARD

Pl. 4, fig. 7A; Fig. 16

Comparable specimens:
Echinostrobus (*Thuites*) *expansus* FEISTMANTEL; 1876, p. 60, pl. 9, figs. 6–9; pl. 10, figs. 3–4 (Jurassic of Kach); 1877, p. 17, pl. 11, figs. 4, 5, 5a (Lower Cretaceous of Jabalpur).
Brachyphyllum expansum (STERNBERG) SEWARD; 1919, p. 317, figs. 754, 755, 756 (nomenclature and discussion); KENDALL, 1949, p. 308, fig. 1A, D (Middle Jurassic of Stonesfield); OISHI, 1940, p. 391, pl. 39, figs. 10, 11; pl. 40, fig. 9 (Upper Jurassic Kiyosue Formation); SITHOLEY, 1963, p. 51, pl. 15, figs. 107, 108 (FEISTMANTEL's specimen).
Description: A single fragment of pinnate vegetative shoot was obtained, as shown in Pl. 4, fig. 7A. The primary branch is 4.5 mm thick, and the secondaries are more thinner than it, about 1–1.3 cm long, nearly straight and making an angle of approximately 45 degrees with the primary branch. The surface of these branches is covered with the impression of appressed and spirally arranged triangular leaves with subacute apices, as shown in Fig. 16, but unfortunately we could not make their phyllotaxis clear.
Remarks: Many *Brachyphyllum* or *Brachyphyllum*-like shoots including the cones have been recorded from the various localities in the world, and they have been classified into various species. Without cones and cuticles, it would be difficult to identify such vegetative shoot as the present one, depending only on the published characters.

The present specimen, however, resembles in general features *Brachyphyllum expansum* known from Oxfordshire, India, Japan, etc.
Horizon: Yuasa Formation (Upper bed).
Occurrence: A single specimen only, with its counterpart.
Distribution in Japan: Upper Liassic Nishinakayama Formation and Upper Jurassic Kiyosue Formation (after OISHI); Yuasa Formation.
Specimens: NSM-PP-7344, 7349.

Form-genus *Cyparissidium* HEER, 1875: 74

In 1969, HARRIS redefined this form-genus as follows; Shoot bearing leaves spirally. Free part of leaf contracting gradually from basal cushion, somewhat flattened, appressed to stem, its length exceeding width of its basal cushion.

Cyparissidium japonicum YOKOYAMA

Pl. 4, fig. 9; Fig. 17

Comparable specimens:

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

Brachyphyllum japonicum (YOKOYAMA) OISHI; 1940, p. 391, pl. 42, figs. 2, 3, 3a (Nagdong Group, Korea; Nishinotani, Ryoseki Group); KRASSILOV, 1967, p. 216, pl. 68, figs. 8–9 (Lower Cretaceous of Southern Primorye).

Remarks: Many fragments of leafy-shoots were obtained but without cone, one of which is shown in Pl. 4, fig. 9 and Fig. 17. Judging from their general outline, they do not belong to *Brachyphyllum* but to the form-genus *Cyparissidium* redefined by HARRIS (1969), and are referable to *C. japonicum* which was first described by YOKOYAMA as *C.* (?) *japonicum*.

Horizons: Yuasa Formation (Upper bed); Arida Formation (Middle bed).

Occurrence: Common (fragments of leafy-shoots).

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

Specimens: NSM–PP–7300, 7303, 7304.

References

BELL, W. A., 1956. Lower Cretaceous floras of Western Canada. *Geol. Surv. Canada*, 285, v+331 pp. incl. 85 pls.

BERRY, E. W., 1911. Sections on fossil plants. *In* Maryland Geol. Surv., Lower Cretaceous, 99–172, 213–508, pls. 22–97.

ENDO, S., 1926. On genus *Tempskya* from Yuasa, Prov. Kii. *Chikyu*, **6**: (2), 1–5. (In Japanese.)

ETTINGSHAUSEN, C. von, 1852. Beitrag zur näheren Kenntniss der Flora der Wealdenperiode. *Abhandl. k. k. geol. Reichsanst.*, Wien, I, **3**(2): 1–32, pls. 1–5.

FEISTMANTEL, O., 1876. Jurassic (Oolitic) flora of Kach. *In* Fossil flora of the Gondwana System, vol. 2. *Mem. Geol. Surv. India, Palaeont. Indica*, **11**(1–2): 1–80, pls. 1–12.

——— 1877. Flora of the Jabalpur Group (Upper Gondwanas), in the Son-Narbada region. *Ibid.*, **11**–2: 81–115, pls 1–14.

FONTAINE, W. M., 1889. The Potomac or younger Mesozoic flora. *Mon. U.S Geol. Surv.*, 15, pt. 1; text, xvi+377 pp., pt. 2; plates, 180 pls.

——— 1905 (in WARD, L. F.). Status of the Mesozoic flora of the United States. *Ibid.*, 48, pt. 1; text, 616 pp., pt. 2; atlas, 45 pls.

GEYLER, H. T., 1877. Ueber fossile Pflanzen aus der Juraformation Japans. *Palaeontogr.*, **24**: 221–232, pls. 30–34.

HARRIS, T. M., 1942a. On two species of Hepatics of the Yorkshire Jurassic flora. *Ann. Mag. Nat. Hist.*, London, (11), **9**: 393–401.

——— 1942b. Notes on the Jurassic flora of Yorkshire, 1–3. 1 *Ptilophyllum caytonense* sp. n.; 2 *Deltolepis crepidota* gen. et sp. nov.; 3 On *Nilssonia compta* and its reference to *Beania gracilis*. *Ibid.*, 568–587.

——— 1953. Ditto, 58–60. 58. Bennettitalean scale-leaves; 59. *Williamsonia himas* sp. n.; 60. *Williamsonia setosa* NATHORST. *Ibid.*, (12), **6**: 33–52.

——— 1969. Naming a fossil conifer. *J. SEN Mem. Vol., Bot. Soc. Bengal*, 243–252.

HEER, O. 1881. Contribution à la Flore Fossile du Portugal. xix+51 pp., 28 pls. *Lisbon.*

JÄHNICHEN, H. & KAHLERT, H., 1972. Über eine mesozoische Flora aus der mongolischen Volksrepublik. *Geol.*, **21** (8): 964–1001, incl. pls. 1–6.

KENDALL, M. W., 1949. On *Brachyphyllum expansum* (STERNBERG) SEWARD, and its cone. *Ann. Mag. Nat. Hist.*, London, (12), **2**: 308–320.

KIMURA, T., 1958. On the Tetori flora (part 1). Mesozoic plants from the Kuzuryu Subgroup, Tetori Group, Japan. *Bull. Sen. High Sch., Tokyo Univ. Educ.*, 2–2: 1–47, pls. 1–4.

——— 1961. Mesozoic plants from the Itoshiro Subgroup, the Tetori Group, Central Honshu, Japan, Part 2. *Trans. Proc. Palaeont. Soc. Japan, N. S.*, 41: 21–32, pls. 4–6.

——— 1975a. Middle-late early Cretaceous plants newly found from the upper course of the Kuzuryu River area, Fukui Prefecture, Japan. *Ibid.*, 98: 55–93, pls. 5–8.

——— 1975b. Notes on the early Cretaceous floras of Japan. *Bull. Tokyo Gakugei Univ.*, (4), **27**: 218–257.

——— 1976. Mesozoic plants from the Yatsushiro Formation (Albian), Kumamoto Prefecture, Kyushu, Southwest Japan. *Bull. Natn. Sci. Mus., ser. C (Geol. Palaeont.)*, **2** (4): 179–208, pls. 1–6.

——— & ASAMA, K., 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.*, 8: 91–114. (In Japanese.)

——— & HIRATA, M., 1975. Early Cretaceous plants from Kochi Prefecture, Southwest Japan. *Ibid.*: 67–90, pls. 10–13.

——— & SEKIDO, S., 1976. Mesozoic plants from the Akaiwa Formation (Upper Neocomian), the Itoshiro Group, Central Honshu, Japan. *Trans. Proc. Palaeont. Soc. Japan, N. S.*, 103: 343–378, pls. 36–39.

——— & ——— (MS). On the Oguchi flora (Earliest Cretaceous), in the Inner Zone of Japan.

KON'NO, E., 1967. Some younger Mesozoic plants from Malaya. *Geol. Palaeont. SE-Asia*, Tokyo, 3: 135–164, pls. 25–27.

KRASSILOV, V. A., 1967. Early Cretaceous flora of Southern Primorye and its significance for stratigraphy. *Sib. Branch, Far East Geol. Inst., Acad. Sci. USSR*, Moscow, 364 pp., pls. 1–93. (In Russian.)

KRYSHTOFOVICH, A. N., 1929. A liverwort from the Middle Daido Formation and the Nikan Series of the Manchurian border. *Ann. Soc. Palaeont. Russie*, Leningrad, 8: 144–147, pl. 15.

——— & PRYNADA, V., 1932. Contribution to the Mesozoic flora of the Ussuriland. *Bull. Geol. Prosp. Surv. USSR*, Moscow, **51**: 363–373, pls. 1, 2.

LUNDBLAD, B., 1955. Contribution to the geological history of the Hepaticae. II. On a fossil member of the Marchantiinae from the Mesozoic plant-bearing deposits near Lago San Martin, Patagonia (Lower Cretaceous). *Bot. Notis.*, **108** (1): 22–39, pls. 1–3.

MATSUMOTO, T., 1947. Geology of the Aritagawa valley. A contribution to the structural development in the Outer Zone of Southwest Japan. *Sci. Rep. Kyushu Univ. (Geol.)*, **2** (1): 1–12. (In Japanese.)

——— (chairman) et al., 1953. The Cretaceous System in the Japanese Islands. *Jap. Soc. Prom. Sci.*, Tokyo, xiv+324 pp., pls. 1–20.

NAGAO, T., 1926. On some facts concerning the Mesozoic formation in Arita-gun, Prov. Kii. *Journ. Geol. Soc. Tokyo*, **33** (396): 378–384. (In Japanese.)

NATHORST, A. G., 1890. Beiträge zur mesozoischen Flora Japans. *Denks. Math.-Nat. Cl. Kaiser. Akad. Wiss.*, Wien, **57**: 41–60, pls. 1–6.

OGURA, Y., 1927. On the structure and affinities of some fossil tree-ferns from Japan. *Journ. Fac. Sci., Imp. Univ. Tokyo*, (3), **1**: 351–380, pls. 2–8.

OISHI, S., 1931. Fossil plants from Japan and Korea. *Sci. Rep. Tohoku Imp. Univ., sec. ser. (Geol.)*, **14** (2A): 107–118, pl. 36.

——— 1939. On the morphology of the genus *Zamiophyllum* NATHORST. *Jubl. Publ. Comm. Prof. H. YABE 60th Birthday*, 1: 209–220, pls. 12–13.

——— 1940. The Mesozoic floras of Japan. *Journ. Fac. Sci., Hokkaido Imp. Univ.*, (4), **5** (2–4): 123–480, pls. 1–48.

——— 1941. Notes on some Mesozoic plants from Lo-tzu-kou, Province Chientao, Manchuokuo.

Ibid., **6** (2): 167–176, pls. 36–38.

OYAMA, T., 1960. On the conclusion of the Oarai flora from the Oarai Formation in Oarai, Ibaraki Prefecture, Japan (Fossil plants of Ibaraki Prefecture, no. 7). *Bull. Fac. Arts & Sci., Ibaraki Univ., Nat. Sci*, **11**: 75–101, pls. 1–9.

SAMYLINA, V. A., 1976. The Cretaceous flora of Omsukchan (Magadan District). *KOMAROV Bot. Inst., Acad. Sci. USSR*, Leningrad: 1–206, incl. pls. 1–48 (In Russian.)

SEWARD, A. C., 1917. Fossil plants. A text-book for students of botany and geology, Vol. 3. xviii+656 pp. Cambridge.

——— 1919. Ditto, Vol. 4. xvi+543 pp. Cambridge.

SITHOLEY, R. V., 1963. Gymnosperms of India. 1. Fossil forms. *Bull. Natn. Bot. Gard.*, Lucknow, **86**: 1–78, pls. 1–15.

TAKAHASHI, E., 1957. Fossil flora of the Toyora and the Toyonishi Groups, Yamaguchi Prefecture. *Yamaguchi Journ. Sci.*, **8**: 79–82. (In Japanese.)

TEIXEIRA, C., 1948. Flora Mesozóica Portuguesa. 1 Parte. *Serv. Geol. Portugal*, Lisboa, 118 pp., 45 pls.

VAKHRAMEEV, V. A., 1964. Jurassic and early Cretaceous floras of Eurasia and the palaeofloristic provinces of this period. *Trans. Acad. Sci. USSR*, 102: 1–261. (In Russian.)

——— 1966. Jurassic floras of the USSR. *Palaeobotanist*, **14** (1–3): 118–123.

——— 1971. Development of the early Cretaceous flora in Siberia. *Geophyt.*, **1**: 75–83.

YABE, H., 1905. Mesozoic plants from Korea. *Journ. Coll. Sci., Imp. Univ. Tokyo*, **20** (8): 1–59, pls. 1–4.

——— 1922. Notes on some Mesozoic plants from Japan, Korea and China, in the collection of the Institute of Geology and Palaeontology of the Tohoku Imperial University. *Sci. Rep. Tohoku Imp. Univ., sec. ser. (Geol.)*, **7** (1): 1–28, pls. 1–4.

——— 1927. Cretaceous stratigraphy of the Japanese Islands. *Ibid.*, **11** (1): 27–100, pls. 3–9.

YOKOYAMA, M., 1889. Jurassic plants from Kaga, Hida and Echizen. *Journ. Coll. Sci., Imp. Univ. Japan*, **3** (1): 1–66, pls. 1–14.

——— 1894. Mesozoic plants from Kozuke, Kii, Awa, and Tosa. *Ibid.*, **7** (3): 201–231, pls. 20–28.