

Late Jurassic Plants from the Oginohama Formation, Oshika Group in the Outer Zone of Northeast Japan (I)

By

Tatsuaki KIMURA* and **Tamiko OHANA***

Department of Astronomy and Earth Sciences,
Tokyo Gakugei University, Koganei, Tokyo

(Communicated by Ikuwo OBATA)

Abstract In this paper we describe the fossil plants belonging to 16 genera and 30 species (or forms) newly collected from the Oginohama Formation (Oxfordian-Tithonian) of the Oshika Group, Northeast Japan, together with our revision of the previous works. Among these, three bennettitalean species are new to science.

The fossil plant assemblage of the Oginohama Formation is obviously of the Ryoseki-type as well as those from the Tochikubo Formation (Oxfordian) of the Somanakamura Group, the Moné (Oxfordian) and Kogoshio (Kimmeridgian-Tithonian) Formations of the Shishiori Group, and the Lower Cretaceous plant-beds in the Outer Zone of Northeast and Southwest Japan.

The present fossil plant assemblage is characterized by the dominance of varied *Zamites* and *Ptilophyllum* (bennettitaleans) and by the absence of ginkgoaleans, czekanoskialean and *Podozamites*.

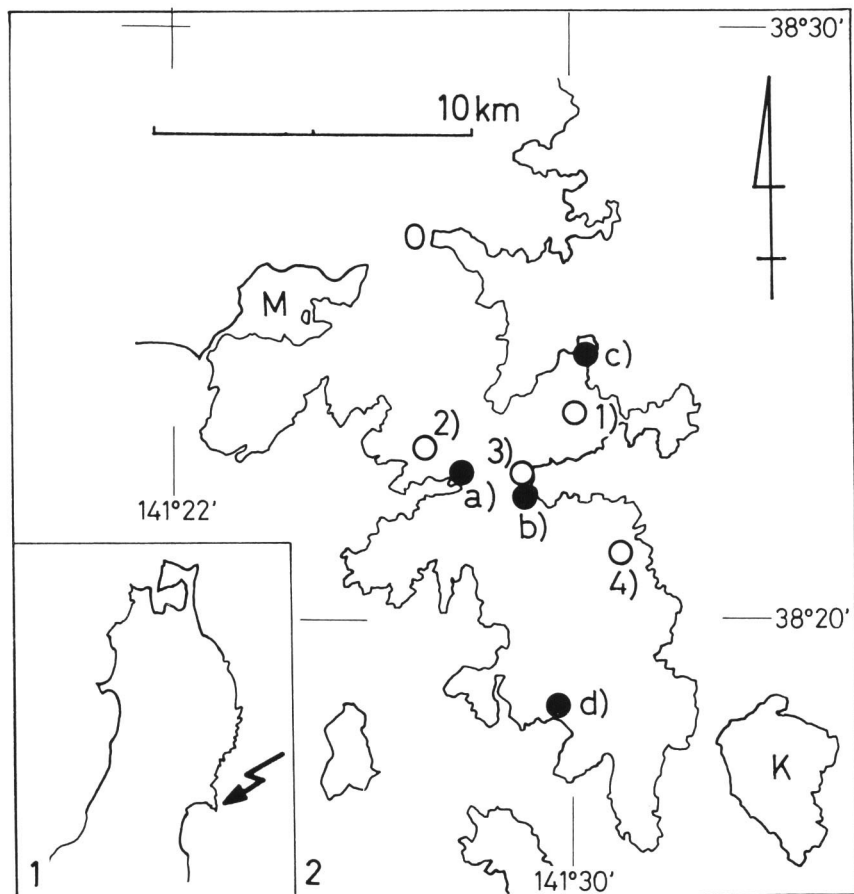
Foreword and Brief geology

This is the second of our serial papers on the Late Jurassic plants in the Outer Zone of Northeast Japan. The Oginohama Formation of the Oshika Group is mostly of marine origin and yields varied ammonites and abundant fossil plants. This formation is exposed in the Oshika Peninsula, Miyagi Prefecture (Fig. 1). Figure 2 shows the main fossil plant-sites in the peninsula.

In recent years, over 3,000 specimens of fossil plants were collected by H. FURUOYA, a graduate student of our university. This paper deals with the description of these fossil plants newly obtained from the Oginohama Formation, together with the revision of the previous works.

Generally the Oshika Group (as Ojika Group in old references) is divided into Tsukinoura, Oginohama and Ayukawa Formations in upward sequence (TAKIZAWA, 1974; ONUKI, 1981). Their geological ages were dated as Bajocian-Callovian, Oxfordian-Tithonian and Berriasian-Valanginian respectively on the basis of rich ammonites. In the Oginohama Formation (ca. 1,600 m thick), the main plant-beds are known to be three in number: The first bed corresponds to the upper part of the lower division

* Present address: Institute of Natural History, High-Life Takatanobaba, 24-14-3 Takata, Toshima-ku, Tokyo 171.



Figs. 1-2. Studied area (Fig. 1) and the localities of fossil plants from the Oginohama Formation in the Oshika Peninsula, Miyagi Prefecture (Fig. 2).

1. Indication of the studied area. 2. Open circles; localities of fossil plants described in this paper. Solid circles; classical localities of fossil plants (where our collection of fossil plants failed).

1) At the pass to the 750 m south of the Onagawa Power Station, Onagawa-cho, Oshika-gun (denoted Onagawa in this paper). 2) Oginohama coast, Ishinomaki City (denoted as Oginohama in this paper). 3) Samenoura coast, Oshika-cho, Oshika-gun (denoted as Samenoura in this paper). 4) Tomari-hama coast, Oshika-cho, Oshika-gun (denoted as Tomari in this paper).

a) Kozumi (Kozumi-hama, Ishinomaki City). b) Oyagawa (Oyagawa-hama, Oshika-cho). c) Koyatori (Onagawa-cho). d) Kukunari (Oshika-cho).

In this brief map, many small islands are neglected.

M; Mangoku-ura (Ishinomaki City). O; the centre of Onagawa-cho. K; Kinkazan Island (Oshika-cho).

of this formation, including such localities as Oyagawa, Samenoura, Kozumi, Arita-hama and Sugekari. The second bed corresponds to the upper part of the middle

division, including Koyatori and Kukunari localities and the third bed to the uppermost part of the formation, including Tomari locality (KIMURA *et al.*, 1988). In this work, fossil plants were collected mainly from Samenoura and Tomari localities.

Previous Works

OISHI (1940) described the following taxa from the Oginohama Formation. The revised name in the present work is shown on the right hand side (*; we could not find in our collection):

Cladophlebis matonioides OISHI*

C. osimaensis OISHI*

Pseudoctenis lanei THOMAS = *Pseudoctenis* sp. cf. *P. lanei* THOMAS

Ptilophyllum pectens (PHILLIPS) MORRIS = *Ptilophyllum oshikaense* KIMURA et OHANA sp. nov.

Cupressinocladus koyatoriensis OISHI

OYAMA (1954) illustrated the following taxa from the Oginohama Formation. The revised name in the present work is shown on the right hand side:

Ptilophyllum pecten (Phillips) MORRIS = *Ptilophyllum oshikaense* KIMURA et OHANA sp. nov.

Pterophyllum n. sp. a = ?

P. n. sp. b = *Ptilophyllum oshikaense* KIMURA et OHANA sp. nov.

Nilssonia cf. *sinensis* YABE et OISHI = *Ptilophyllum oshikaense* KIMURA et OHANA sp. nov.

N. cf. orientalis HEER = *Nilssonia* sp. cf. *N. densinervis* (FONTAINE) BERRY

Cf. *Zamites megaphyllum* (PHILLIPS) = *Zamites* sp. cf. *Z. megaphyllum* (PHILLIPS) SEWARD

Z. yabei OISHI = *Zamites* sp. cf. *Z. choshiensis* KIMURA et OHANA

Glossozamites cf. *hoheneggeri* (SCHENK) = *Zamites nipponicus* KIMURA et OHANA

Ctenis cf. *uwatokoii* TOYAMA et OISHI = ?

Taeniopteris sp. = *Taeniopteris* sp. F ?

List of Fossil Plant-taxa described in This Paper

(*; known from Tomari locality only, **; known from Tomari and Samenoura localities, and ***; known from Samenoura locality only)

Pteridophyta:

Equisetum sp. cf. *E. phillipsi* (DUNKER) BRONGNIART*

Gleichenites ? sp. B**

G. ? sp. C*

Eboracia microlobifolia KIMURA et OHANA*

Sphenopteris sp. B*

Acrostichopteris sp. cf. *A. parvifolia* FONTAINE*

Onychiopsis yokoyamai (YABE) KIMURA et AIBA***

Cladophlebis acutipennis OISHI*

C. sp. cf. C. virginensis FONTAINE*

*C. sp. C****

Bennettitales:

Zamites sp. cf. *Z. choshiensis* KIMURA et OHANA**

Z. densipinnatus KIMURA et OHANA sp. nov.***

Z. sp. cf. Z. megaphyllum (PHILLIPS) SEWARD***

Z. nipponicus KIMURA et OHANA***
Z. sp. cf. Z. tosanus OISHI*
*Z. sp. C****
*Z. sp. D**
Ptilophyllum linearifolium KIMURA et OHANA sp. nov.*
P. oshikaense KIMURA et OHANA sp. nov.**
*Weltrichia sp.****
*Williamsonia sp.****

Cycadales:

Pseudoctenis sp. cf. P. lanei THOMAS***
Nilssonia sp. cf. N. densinervis (FONTAINE) BERRY*
N. sp. cf. N. oblique-truncata KIMURA et OHANA***
N. ex gr. schauburgensis (DUNKER) NATHORST**

Coniferales:

Cupressinocladus koyatoriensis OISHI**
*C. sp. C***
Parasequoia sp. cf. P. cretacea KRASSILOV***
*Elatocladus sp. B**

Unclassified plant:

*Taeniopteris sp. F**

This fossil plant assemblage from the Oginohama Formation is obviously of the Ryoseki-type (e.g. KIMURA, 1984, 1987, 1988). Its floristic significance was already mentioned by KIMURA *et al.* (1988).

Unfortunately details of the reproductive organs and cuticles of gymnosperms are not preserved owing to the subsequent geological disturbances and igneous activities taken place in this region. Therefore, our identification of fossil plants was compelled to depend only on their external morphology.

The specimens described in this paper are kept in the Department of Geology of the National Science Museum, Tokyo except for several ones.

Acknowledgements

We express our sincere gratitude to Dr. Ikuwo OBATA of the National Science Museum, Tokyo for giving us the facilities to publish this paper. The present work was supported by the Grant-in-Aids for Scientific Research from the Ministry of Education, Science and Culture, Japan (no. 59540499).

Systematic Description

Equisetales

Genus *Equisetum* LINNAEUS

Equisetum sp. cf. E. phillipsi (DUNKER) BRONGNIART

(Pl. 1, figs. 1–2; Pl. 6, fig. 1; Figs. 3 a–e)

Material: Specimens examined; NSM PP-8424~8432. *Occurrence and locality:*

Locally common at Tomari.

Description: Several imprints of broken aerial stems and detached diaphragms were obtained. Pl. 1, fig. 1A shows the imprint of a broken aerial stem with three preserved nodal regions; its internode is 2.3 cm long and up to 2.4 cm wide measured on the impression. The free teeth are lancet-shaped, gradually narrowed from their bases to the acutely pointed apices, and are typically 6 mm long and about 1 mm wide at the base; they are about 30 in number in a larger stem. The parts below the free teeth are closely coherent with the stem at their bases on the nodes, and each one is separated from its neighbours by a sharply defined furrow which is widest at the base of a free tooth and narrows down the stem to a mere line. Therefore, a portion of the stem beneath each node is striate to form a sheath. Free teeth are often broken off, leaving the truncate tops at the corresponding position to their bases (Figs. 3 b–c).

Pl. 1, fig. 1B (Fig. 3b) shows a stem compressed vertically at a node, resulting its coherent teeth are splited, radiated and carried its diaphragm away; it is 1.8 cm in diameter and about 30 originally coherent teeth are preserved.

Detached diaphragms are varied in size; 1.4 to 0.75 cm in diameter. They are wheel-shaped with a round hole in the centre around which radiate club-shaped convexities, 24–30 in number at the periphery of the circle (Figs. 3d–e).

Reproductive and subterranean organs are not known.

Remarks: The present aerial stems and detached diaphragms resemble closely in form and size those described by FONTAINE (in WARD, 1905) from the Kootanie Formation of Montana as *Equisetum phillipsi* (DUNKER). It is difficult to make the precise distinction between the present and FONTAINE's specimens in their external form. However, the original specimen of this species (DUNKER, 1846; *Equisetites phillipsi*) and subsequent ones (SCHENK, 1871) from the Wealden of Germany, were only represented by the intact aerial stem internodes lacking their free teeth and diaphragms. Therefore it is difficult to make close comparison of the present specimens with the German ones. Accordingly we at present describe our horsetail remains as *Equisetum* sp. cf. *E. phillipsi*.

Equisetum sp. cf. *E. phillipsi* resembles in form and size such Early Jurassic species as *Equisetites iwamuroensis* KIMURA (KIMURA and TSUJII, 1980), but is distinguished by the form of diaphragm.

Equisetum sp. cf. *E. phillipsi* is unique for its larger size, because other horsetails known from the Upper Jurassic-Lower Cretaceous plant-beds in Japan are represented unexceptionally by the slender stems with small number of tooth (leaf).

Filicales

Gleicheniaceae

Genus *Gleichenites* GOEPPERT, 1836: 172

Gleichenites ? sp. B

(Pl. 1, fig. 3; Pl. 4, fig. 1; Pl. 5, fig. 1; Figs. 4a–c)

Material: Specimens examined; NSM PP-8433~8445. *Occurrence and locality:* Locally common at Tomari.

Description: Many sterile and fertile leaf-fragments were obtained. The leaf is probably tripinnate but whole leaf is unknown and only penultimate pinna fragments are known. The penultimate pinna is rather small-sized, up to 8 cm wide; the axis sends off ultimate pinnae oppositely or suboppositely, at an angle of 50 degrees, but often flexuous. The ultimate pinnae are more than 5 cm long, nearly parallel-sided for the most part, 0.75 cm wide, gradually narrowed towards the acute apex, and send off more than 24 alternate pairs of pinnules katadromically at a wide angle. The pinnules are shortly subulate or finger-shaped, with obtusely pointed or rounded apex, typically 4 mm long and 1.5 mm wide; midnerve is rather distinct in its basal half but its apical half and lateral veins are indistinct or invisible. Eight~nine alternate pairs of sori (?) are arranged closely on both sides of midnerve side by side, then their outline becoming rectangular. Apart from the central point (placenta ?), details of the reproductive organ are unknown.

Remarks: The present pinnule appears to be leathery, bulging between veins which stand out on the lower and as grooves on the upper surfaces. Because of indistinct nature of the reproductive organ, it is difficult to know the precise botanical affinity of our leaves. Therefore, we describe our leaves as *Gleichenites* ? sp. B.

Our leaves resemble in form those of *Cladophlebis* sp. A described by us (Kimura and Ohana, 1988) from the coeval Tochikubo Formation.

Gleichenites ? sp. C

(Pl. 2, fig. 1; Figs. 5 a-b)

Material: Specimens examined; NSM PP-8446~8449 and many other leaf-fragments. *Occurrence and locality:* Locally common at Tomari.

Description: Obtained specimens are all detached fertile leaf-fragments. In Pl. 2, fig. 1, pinnules are long and narrow, attached obliquely to the axis, 2.8 cm long, nearly parallel-sided for the most part, 2.5 mm wide near the base and 1.5 mm wide at the middle, gradually narrowed towards the acuminate apex; the margins are shallowly lobed; lobes are more than 15 alternate pairs in number, directed forwards and with obtusely pointed or rounded apex. Each lobe bears two rows of sori (?) and each row consists of 2-4 sori (?). In some pinnae, lobes grow into deltoid pinnules with entire margins; each pinnule bears two rows of sori (?) as shown in Fig. 5b; each sorus (?) is up to 1 mm in diameter. Unfortunately details of sori (?) are invisible.

Remarks: Although we have no positive evidence that our leaves belong to a certain fern with precise botanical affinity, they strongly remind us of the gleicheniaceous affinity. Therefore, we at present describe our leaves as *Gleichenites* ? sp. C.

The pinnae of *Gleichenites* ? sp. described by us (KIMURA and OHANA 1987b) from the upper Liassic Nishinakayama Formation equivalent, Yamaguchi Prefecture resemble in form and habit our present pinnae, but both unsatisfactorily preserved

leaves prevent to make precise comparison between them.

Dicksoniaceae

Genus *Eboracia* THOMAS, 1911: 387

Eboracia microlobifolia KIMURA et OHANA

(Fig. 6)

Eboracia microlobifolia KIMURA et OHANA: KIMURA and OHANA, 1987a, p. 16, pl. 1, figs. 1–4; text-figs. 2 a–h (Ayukawa Formation).

Material: Specimens examined; NSM PP-8450, 8451 and many other minor fragments of fertile pinnae. *Occurrence and locality*: Locally common at Tomari.

Remarks: This species was established and described in detail by us on the basis of the leaves collected from the Lowermost Cretaceous Ayukawa Formation (the uppermost unit of the Oshika Group) and Upper Jurassic Tochikubo Formation. The present pinnae agree well with those of the original leaves in all respect.

No dicksoniaceous fern has been found in the Ryoseki-type floras in the Outer Zone of Southwest Japan, but this species and a single *Coniopteris* species are known to occur in the Ryoseki-type floras in the Outer Zone of Northeast Japan.

Genus *Onychiopsis* YOKOYAMA, 1889: 27

Onychiopsis yokoyamai (YABE) KIMURA et AIBA

(Pl. 2, fig. 1 A; Fig. 7)

Sphenopteris yokoyamai YABE: YABE, 1927, p. 223, pl. 23, figs. 1–2. For further synonyms, see KIMURA and AIBA, 1986, p. 44.

Material: Specimens examined: NSM PP-8452, 8453 and many other pinna fragments. *Occurrence and locality*: Locally common at Samenoura.

Remarks: Obtained specimens are all sterile and wrongly preserved pinna fragments. However, as we are very familiar with the leaves of *Onychiopsis yokoyamai* established by KIMURA and AIBA (1986) on the basis of a number of leaves with the fertile part, it is certifiable that the present pinna fragments belong to those of *Onychiopsis yokoyamai*.

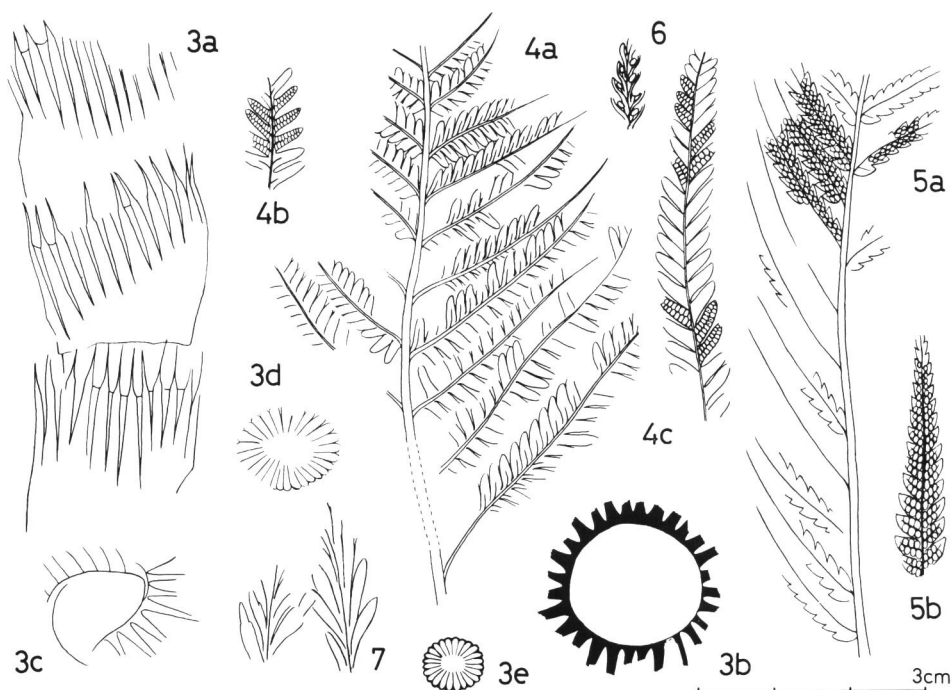
Onychiopsis yokoyamai is one of the common elements of the Late Jurassic-Early Cretaceous Ryoseki-type floras restricted in distribution in the Outer Zone of Japan.

Typical types of the leaves of *Onychiopsis yokoyamai* were shown in detail by KIMURA and AIBA (1986) together with the detailed comparison of this species with other *Onychiopsis* species. The present pinna fragments agree well in form with those of *Onychiopsis yokoyamai* as shown in their text-figs. 4–7.

Form-genus *Sphenopteris* STERNBERG, 1825: 15

Sphenopteris sp. B

(Figs. 8 a–b)



Figs. 3–7 (All natural size, unless otherwise indicated).

3. *Equisetum* sp. cf. *E. phillipsi* (DUNKER) BRONGNIART: 3 a. A broken aerial stem drawn from Pl. 1, fig. 1 A (NSM PP-8424; Tomari). 3 b. A vertically preserved nodal region drawn from Pl. 1, fig. 1 B (ditto). 3 c. A vertically and laterally compressed nodal region, drawn from Pl. 6, fig. 1 (NSM PP-8427; Tomari). 3 d–e. Nodal diaphragms. 3 d. (NSM PP-8428; Tomari). 3 e. Drawn from Pl. 1, fig. 2 A (NSM PP-8430; Tomari).
4. *Gleichenites* ? sp. B; 4a. A sterile leaf-fragment, drawn from Pl. 1, fig. 3 (NSM PP-8433; Tomari). 4 b–c. Fertile pinna fragments, drawn from NSM PP-8435 (Samenoura) and NSM PP-8434 (Pl. 4, fig. 1; Tomari) respectively.
5. *Gleichenites* ? sp. C: 5 a. A fertile pinna fragment, drawn partly from Pl. 2, fig. 1 (NSM PP-8446; Tomari). 5 b. Ditto, drawn from NSM PP-8447 (Tomari).
6. *Eboracia microlobifolia* KIMURA et OHANA: A fertile pinna fragment, drawn from NSM PP-8450 (Tomari).
7. *Onychiopsis yokoyamai* (YABE) KIMURA et AIBA: Sterile pinna fragment, drawn partly from NSM PP-8452 (Samenoura).

Material: Specimens examined; NSM PP-8454~8466 and many other leaf or pinna fragments. **Occurrence and locality:** Locally common at Tomari.

Description: The whole leaf is unknown. Obtained specimens are all sterile leaf- or pinna fragments. Fig. 8a shows possibly a part of the penultimate pinna with rather slender axis sending off elongate-triangular ultimate pinnae alternately at an angle of 30–40 degrees. The ultimate pinnae are typically 5 cm long and up to 7 mm

wide near the base and send off 9–10 alternate pairs of pinnules katadromically at an acute angle. The pinnules are elongate-rhomboidal in form, typically 0.6 cm long and up to 2 mm wide and with obtusely pointed apex; margins are often very shallowly lobed in their apical half and mostly entire in their proximal half. Venation is of the *Sphenopteris*-type and faintly preserved; midnerve is indistinct and send off typically 5 pairs of once forked lateral veins directed forwards. Each lobe receives a set of lateral veins.

Remarks: It is difficult for us to make the specific determination of such featureless sterile leaves.

The present leaves resemble those of *Sphenopteris elegans* (YOKOYAMA) OISHI known from the coeval Tochikubo Formation and *S. sp. (B)* from the Middle Jurassic Utano Formation (KIMURA and OHANA, 1987b), but are distinguished from the former by its pinnules with more markedly lobed margins and from the latter by its pinnules with wholly entire margins respectively.

Form-genus *Acrostichopteris* FONTAINE em. BERRY, 1911: 220

Acrostichopteris sp. cf. *A. parvifolia* FONTAINE

(Pl. 1, fig. 4; Fig. 9)

Material: Specimen examined; NSM PP-8467, 8468 (counterpart). *Occurrence and locality:* Only a single pinna fragment at Tomari.

Description: A single ultimate pinna fragment was obtained as shown in Pl. 1, fig. 4. The axis is comparatively thick, 0.6 mm wide and sends off pinnate pinnules suboppositely at an angle of 50 degrees. The pinnules are rhomboidal in form, shortly stalked, small-sized, 3.6 mm long and up to 2.6 mm wide, divided rather deeply into 3 pairs of lateral lobes directed forwards and each with obtusely pointed or rounded apex; veins are invisible.

Remarks: The present pinnules resemble in form those of *Acrostichopteris parvifolia* and *A. densifolia* originally described by FONTAINE (1889) from the Lower Cretaceous Potomac Group. The latter species was included by BERRY (1911) in the former species as being synonymous. However, FONTAINE's pinnules illustrated differ from the present pinnules in their lobes each with shallowly notched apex.

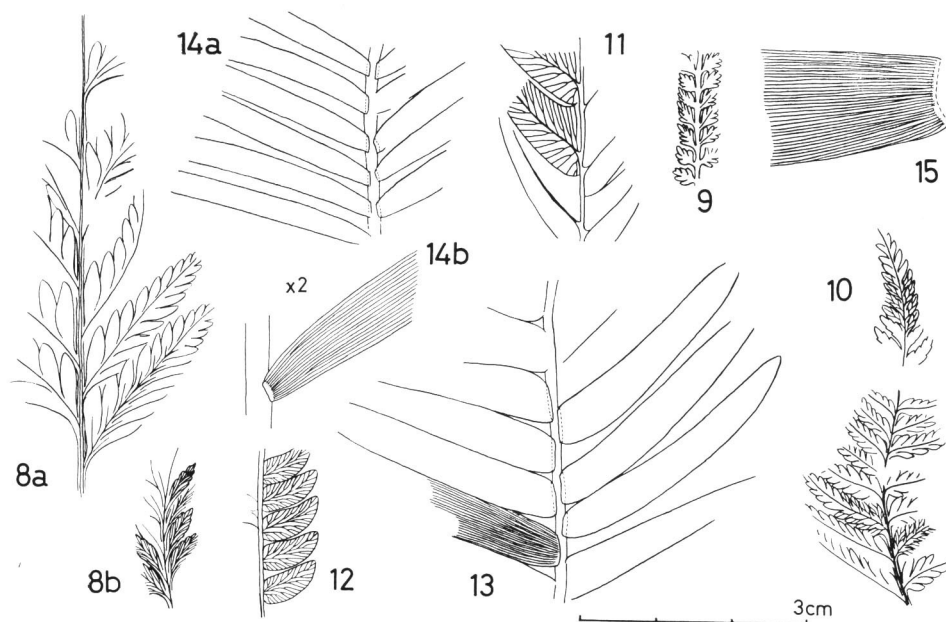
The pinnules of *Onychiopsis brevifolia* (FONTAINE) illustrated by BERRY (1911, pl. 34, figs. 1–2) also resemble in form the present pinnules, but differ from the latter in their more elongated form each divided typically into two pairs of lateral lobes.

Under the circumstances, at present we provisionally describe our pinna as non-committal *Acrostichopteris* sp. cf. *A. parvifolia* FONTAINE.

Form-genus *Cladophlebis* BRONGNIART, 1849: 105

Cladophlebis acutipennis OISHI

(Fig. 10)



Figs. 8–15 (All natural size, unless otherwise indicated).

8. *Sphenopteris* sp. B: 8 a. A sterile leaf-fragment, drawn from NSM PP-8454 (Tomari). 8 b. A pinna fragment, showing the venation of pinnules, drawn from NSM PP-8455 (Tomari).
9. *Acrostichopteris* sp. cf. *A. parvifolia* FONTAINE; drawn partly from Pl. 1, fig. 4 (NSM PP-8467; Tomari).
10. *Cladophlebis acutipennis* OISHI: A sterile leaf-fragment, drawn from NSM PP-8469 (Tomari).
11. *Cladophlebis* sp. cf. *C. virginienensis* FONTAINE: A sterile pinna fragment, drawn partly from NSM PP-8470 (Tomari).
12. *Cladophlebis* sp. C: A pinna fragment, drawn partly from NSM PP-8452 (Samenoura), a counterpart of the specimen shown in Pl. 2, fig. 2 B (NSM PP-8453).
13. *Zamites densipinnatus* KIMURA et OHANA sp. nov.; showing the mode of attachment of pinnae and venation, drawn from NSM PP-8480(B) (paratype; Samenoura).
14. *Zamites* sp. cf. *Z. tosanus* OISHI: 14 a. A leaf-fragment, drawn partly from NSM PP-8515 (Tomari). 14 b. Showing the mode of attachment of pinna and venation (enlarged partly from Fig. 14 a).
15. *Zamites* sp. C; showing the basal part of pinna and venation, drawn partly from Pl. 4, fig. 4 (NSM PP-8500; Samenoura).

Cladophlebis acutipennis OISHI: OISHI, 1940, p. 249, pl. 9, figs. 4–6. For further references, see KIMURA and OHANA, 1988.

Material: Specimens examined; NSM PP-8469 and many other leaf-fragments.

Occurrence and locality: Locally common at Tomari.

Remarks: This species is represented only by sterile leaves and commonly known

from the Upper Jurassic-Lower Cretaceous plant-beds in the Outer Zone of Japan. The present leaves agree well with those of *Cladophlebis acutipennis* OISHI in all respect.

Cladophlebis sp. cf. *C. virginiensis* FONTAINE

(Fig. 11)

Material: Specimens examined; NSM PP-8470 and many other detached pinna fragments. *Occurrence and locality*: Locally common at Tomari.

Remarks: Many pinna fragments with several pinnules were obtained. The pinnules are indistinguishable in form, size and venation from those described by us (KIMURA and OHANA, 1988) as *Cladophlebis* sp. cf. *C. virginiensis* from the Tochikubo Formation. The latter pinnules are with finely serrate margins. It is highly probable that the real margins of the present pinnules are also finely serrate, because in the present pinnules their margins are markedly reflexed and conceal their real margins.

Cladophlebis sp. C

(Pl. 2, fig. 1 B; Fig. 12)

Material: Specimens examined; NSM PP-8452 and many other detached pinna fragments. *Occurrence and locality*: Locally common at Samenoura.

Description: Many detached sterile pinna fragments were obtained, but most of them were so poorly preserved that we could not observe their details. The pinnules are set closely, elongate-deltoid in form, slightly contracted at base, obtusely pointed at apex, slightly falcate and with entire margins; typically 8 mm long and 4 mm wide near the base. The venation looks like sympodial branching; lateral veins are directed forwards, originated katadromically and typically represented by 5 alternate pairs of which basal two or three pairs are twice forked and others are once forked or simple.

Remarks: The present pinnule is characterized by its venation of sympodial branching-type, then is not ordinary *Cladophlebis*-type.

Some pinnules of *Cladophlebis virginiensis* (FONTAINE, 1889, pl. 4, figs. 4, 4a-b) show similar venation. In *Cladophlebis* sp. cf. *C. virginiensis* described by us (KIMURA and OHANA, 1988), its venation of pinnules is ordinary *Cladophlebis*-type and mostly with once forked lateral veins.

Bennettitales

Genus *Zamites* BRONGNIART, 1828

Zamites sp. cf. *Z. choshiensis* KIMURA et OHANA

(Pl. 2, fig. 3; Pl. 3, figs. 1-2; Pl. 4, fig. 2)

Zamiophyllum buchianum (ETTINGSHAUSEN) NATHORST: OISHI, 1939, pp. 210-220, pls. 12-13. For further references, see OISHI, 1940, p. 353; KIMURA, 1976, p. 199; KIMURA and OHANA, 1985, p. 354.

Material: Specimens examined; NSM PP-8472~8479 and many other broken leaves. *Occurrence and localities:* Locally common at Samenoura, but rather rare at Tomari.

Description: Obtained specimens are all leaf-fragments of which pinnae are inserted obliquely to the upper surface of thick rachis by the concave semi-amplexicaul base.

Pl. 2, fig. 3 shows a basal part of leaf of which the rachis is 1.1 cm wide with numerous longitudinal striations on its surface. The pinnae are narrower, 6 mm wide and at angle of 25 degrees to the rachis; their upper surface is convex and margins are reflexed. Similar leaf is shown in Pl. 3, fig. 1.

Pl. 4, fig. 2 shows possibly an apical portion of leaf of which closely set pinnae are 6 mm wide and attached to the rachis at an angle of 35 degrees. Pl. 3, fig. 2 shows a basal part of leaf with thick petiole; its base is swollen.

All of the pinnae examined are long and narrow and with acuminate apex; the longest one is more than 13 cm long and 1 cm wide. Veins are simple, parallel and 19 and 13 in number in wider and narrower pinnae respectively; 22 per cm in density.

Remarks: KIMURA and OHANA (1985) originally described *Zamites choshiensis* on the basis of '*Zamites buchianus*' (or '*Zamiophyllum buchianum*')-type leaves and their well-preserved cuticle collected from the Lower Cretaceous Choshi Group in the Outer Zone of Japan, and presumed that the Japanese leaves hitherto described as *Zamites buchianus* or *Zamiophyllum buchianum* might belong to their *Z. choshiensis*.

However, as the present leaves are represented only by impression, we describe our present leaves as *Zamites* sp. cf. *Z. choshiensis*.

Zamites sp. cf. *Z. choshiensis* is quite abundant especially in the Lower Cretaceous plant-beds in the Outer Zone of Japan. Its leaves are large-sized and attainable to 1 m long and often thickly massed and appressed in preservation. While, its reproductive organs have not yet been found. However, the leaves resembling those of *Zamites choshiensis* are not so abundant in the Upper Jurassic plant-beds in the Outer Zone of Japan. In general, the Upper Jurassic leaves are medium-sized.

Zamites densipinnatus KIMURA et OHANA sp. nov.

(Pl. 6, fig. 2; Pl. 7, figs. 1–2; Pl. 8, fig. 1; Fig. 13)

Material: Holotype; NSM PP-8480(A). Paratypes; NSM PP-8480(B), 8481, 8482, 8483, SAM-303. Specimens examined; NSM PP-8484~8499 and many other leaf-fragments. *Stratum typicum:* Oginohama Formation (Oxfordian), Oshika Group. *Locus typicus:* Samenoura Coast (see Fig. 2). *Derivatio nominis:* According to the very closely set pinnae. *Occurrence:* Locally abundant at Samenoura, but rare at Onagawa.

Diagnosis: Leaf medium-sized, elongate-oblongate in outline, more than 35 cm long including thick petiole and up to 12 cm wide. Rachis slender, 2 mm wide at the middle of leaf, sending off closely set and about 70 alternate pairs of pinnae at an

angle of 55 degrees to the upper sides of rachis, but angle reducing apically and proximally. Pinnae long and narrow, linear, nearly parallel-sided for the most part, typically 3.5 cm long and 3 mm wide, suddenly narrowing to the bluntly pointed apex and with the base contracted and symmetrically rounded. Veins 15 in number at the base, dichotomously forking near the base, then running in parallel and ending at the distal margins; 19 in number at the middle; acroscopic 3–4 and basiscopic 2 veins radiated and ending at the basal margins. Petiole 5 cm long, markedly thicker than the rachis, becoming thicker to its expanded base where 9 mm wide. (Reproductive organs not known.)

Discussion and comparison: Our leaves are characterized by their very closely set and long and narrow pinnae attached to the rather thin rachis. We place our leaves in *Zamites*, because our pinna base is symmetrically rounded. In some *Ptilophyllum* species, the pinnae show similarly formed pinna base, but in such *Ptilophyllum* leaves, pinna base is usually asymmetrical.

Pl. 8, fig. 1 shows a wider leaf, but it is referable to this species in all respects.

Zamites nipponicus KIMURA et OHANA known abundantly from the Oginohama and coeval Tochikubo Formations is distinguished from the present species by its remotely set pinnae with asymmetrically narrowed base. So far as we know, no such *Zamites* leaf with closely set pinnae as those of the present species has been found in the Mesozoic of East Asia. Therefore, we here propose *Zamites densipinnatus* sp. nov.

Zamites sp. cf. *Z. megaphyllum* (PHILLIPS) SEWARD

(Pl. 3, fig. 3)

Material: Specimens examined; NSM PP-8500~8507 and many other pinna fragments. *Occurrence and locality:* Locally common at Samenoura.

Description: Obtained specimens are all detached and broken pinnae and their both ends are uncertain. Their width is variable. Pl. 3, fig. 3 shows the widest specimen, more than 6.4 cm wide with parallel veins, 16 per cm in density, but the vein-density is variable according to the pinnae.

Remarks: As the specimens obtained were all broken, we could not make the precise identification of them. OISHI (1940) described a similar pinna as Cf. *Zamites megaphyllum* (PHILLIPS) (his pl. 34, fig. 5) from the Upper Jurassic Shishiori Group. Some of the present pinna fragments resemble OISHI's pinna in size and venation. But our present pinnae are far wider than OISHI's. Under the circumstances, we at present described our pinna fragments as *Zamites* sp. cf. *Z. megaphyllum*. Similar broken leaves are also common in the Tochikubo Formation.

Some of our pinna fragments resemble a broken leaf described by PERSON and DELEVORYAS (1982) from the Middle Jurassic of Oaxaca as *Pelourdia* sp.

Zamites nipponicus KIMURA et OHANA

(Pl. 2, fig. 4; Pl. 4, fig. 3; Pl. 5, figs. 2-3)

Glossozamites cf. *hoheneggeri* (SCHENK): OYAMA, 1954, p. 106, pl. 5, fig. 7 (Samenoura).

Material: Specimens examined; NSM PP-8508~8512 and many other leaf fragments. *Occurrence and locality:* Locally abundant at Samenoura.

Remarks: Our leaves are almost indistinguishable in leaf-form, size and venation from those of *Zamites nipponicus* originally described by KIMURA and OHANA (1988) from the Upper Jurassic Tochikubo Formation.

The detailed comparison of *Zamites nipponicus* with other similarly formed *Zamites* species was already made in our previous paper (KIMURA and OHANA, 1988).

Zamites sp. cf. *Z. tosanus* OISHI

(Figs. 14 a-b)

Material: Specimens examined; NSM PP-8513~8515. *Occurrence and locality:* Rare at Tomari.

Description: Obtained specimens are all delicate leaf-fragments. The rachis is comparatively thick, 3 mm wide and sends off closely set long and narrow pinnae suboppositely at an angle of 55 degrees. The pinnae are nearly parallel-sided for the most part, more than 8 cm long and 4 mm wide, and attached to the upper surface of rachis by the contracted and rounded base; pinna apices are all missing. Veins are mostly simple, but a few are dichotomously forked near the base and run in parallel; 15 in number at the middle of a pinna.

Remarks: The present leaves differ from those of *Zamites densipinnatus* described in this paper in markedly long and narrow pinnae.

The present leaves resemble those of *Ptilophyllum* sp. F bearing markedly long and narrow pinnae described from the Tochikubo Formation (KIMURA and OHANA, 1988), but are distinguished by their pinnae each with the rounded base.

The present leaves also resemble closely those of *Zamites tosanus* originally described by OISHI (1940) and later by KIMURA and OHANA (1987a) from the Lower Cretaceous Ryoseki Formation in the Outer Zone of Japan in leaf-form and size. Therefore, we describe our leaves as *Zamites* sp. cf. *Z. tosanus*.

Zamites sp. C

(Pl. 4, fig. 4; Fig. 15)

Material: Specimens examined; NSM PP-8500, 8516~8518. *Occurrence and locality:* Rather rare at Samenoura.

Description: Obtained specimens were four pinna fragments, one of which was nearly complete. Pl. 4, fig. 4 (its distal portion cut off in this figure) shows a detached pinna, 19.5 cm long and nearly parallel-sided for the most part, 1.7 cm wide, symmetri-

cally contracted at the base with a semi-amplexicaul trace of its attachment to the supposed rachis (Fig. 15). Veins are simple but some are forked once near the base and run in parallel to the unknown tip; basal marginal veins are radiated and end at the basal margins; 18 in number near the base and 34 in number (27 per cm) at the middle.

Remarks: Judging from the symmetrically contracted base, our pinnae may belong to a certain *Zamites* species. Our pinnae resemble the leaflets of *Glossophyllum? shensiense* described by SZE (1956) from the Upper Triassic Yanchang Group (or Formation), North China. However, the latter has only known from the Upper Triassic plant-beds in North China, and possibly in Kazakhstan and North Viet Nam.

The present detached pinnae are usually in association with those of *Zamites* sp. cf. *Z. megaphyllum* at the same locality.

Zamites sp. D

(Pl. 1, fig. 5)

Material: Specimen examined; NSM PP-8519. *Occurrence and locality:* Very rare at Tomari.

Description: A single poorly preserved leaf-fragment was obtained. The rachis is comparatively thick, 3 mm wide below and sends off remotely set lanceolate pinnae suboppositely and pinnately at an angle of 60 degrees. The pinnae are with obtusely pointed apex and attached to the upper sides of rachis by the symmetrically contracted base; the basal one preserved is 5.5 cm long and up to 1.2 cm wide. Veins do not converge at apex, simple or forked near the base and 21 in number at the middle of each pinna; the lateral ones are radiated.

Remarks: The present leaf-fragment looks like some leafy-shoot of *Podozamites*, but we now think it belongs to *Zamites*, because of its pinnate habit, symmetrically contracted base and veins not converging at apex. No comparable *Zamites* leaves have been found. Then we describe our leaf-fragment as *Zamites* sp. D.

(To be continued on the next issue)

Explanation of Plates

(All natural size, unless otherwise indicated)

Plate 1:

- Figs. 1–2. *Equisetum* sp. cf. *E. phillipsi* (DUNKER) BRONGNIART: 1 A. An aerial stem-fragment. 1 B. A vertically preserved nodal region (NSM PP-8424; Tomari). 2 A. A detached diaphragm. 2 B. A vertically preserved nodal region (enlarged twice; NSM PP-8430; Tomari).
- Fig. 3. *Gleichenites* ? sp. B; showing a sterile leaf-fragment (NSM PP-8433; Tomari).
- Fig. 4. *Acrostichopteris* sp. cf. *A. parvifolia* FONTAINE; showing a single broken pinna (enlarged twice; NSM PP-8467; Tomari).
- Fig. 5. *Zamites* sp. D; showing a single leaf-fragment (NSM PP-8519; Tomari).

Plate 2:

- Fig. 1. *Gleichenites* ? sp. C; showing a fertile leaf-fragment (NSM PP-8446; Tomari).
 Fig. 2 A. *Onychiopsis yokoyamai* (YABE) KIMURA et AIBA: An incompletely preserved sterile leaf-fragment.
 Fig. 2 B. *Cladophlebis* sp. C; showing several broken pinnae (NSM PP-8453; Samenoura).
 Fig. 3. *Zamites* sp. cf. *Z. choshiensis* KIMURA et OHANA; showing a thick rachis and the mode of attachment of pinnae (NSM PP-8472; Tomari).
 Fig. 4. *Zamites nipponicus* KIMURA et OHANA; showing the middle part of a leaf (NSM PP-8509; counterpart of the specimen shown in Pl. 5, fig. 2; Samenoura).

Plate 3:

- Figs. 1–2. *Zamites* sp. cf. *Z. choshiensis* KIMURA et OHANA:
 1. A lower part of a leaf (NSM PP-8473; Samenoura).
 2. A lowermost part of a leaf and its thick petiole with swollen base (NSM PP-8632; Samenoura).
 Fig. 3. *Zamites* sp. cf. *Z. megaphyllus* (PHILLIPS) SEWARD; showing a broken leaf (NSM PP-8500; Samenoura).

Plate 4:

- Fig. 1. *Gleichenites* ? sp. B; showing a detached fertile pinna (NSM PP-8434; enlarged twice; Tomari).
 Fig. 2. *Zamites* sp. cf. *Z. choshiensis* KIMURA et OHANA; showing the upper part of a leaf (NSM PP-8474; Samenoura).
 Fig. 3. *Zamites nipponicus* KIMURA et OHANA; showing the middle part of a leaf (SAM-002; kept in Tokyo Gakugei University).
 Fig. 4. *Zamites* sp. C; showing a detached pinna. Its distal part cut off in this figure (NSM PP-8500; Samenoura)

Plate 5:

- Fig. 1. *Gleichenites* ? sp. B; showing a detached fertile pinna (NSM PP-8436; enlarged twice; Tomari).
 Figs. 2–3. *Zamites nipponicus* KIMURA et OHANA: 2. Middle part of a leaf (SAM-019, kept in Tokyo Gakugei University; counterpart of the specimen shown in Pl. 2, fig. 4). 3. Lower part of a leaf and petiole (reduced in 1/2; NSM PP-8508; Samenoura).

Plate 6:

- Fig. 1. *Equisetum* sp. cf. *E. phillipsi* (DUNKER) BRONGNIART; showing a vertically and laterally compressed nodal region (enlarged twice; NSM PP-8427; Tomari).
 Fig. 2. *Zamites densipinnatus* KIMURA et OHANA sp. nov.; showing two detached broken leaves; one with petiole preserved (indicated by an arrow) (paratype; NSM PP-8481; Samenoura).

Plate 7:

- Figs. 1–2. *Zamites densipinnatus* KIMURA et OHANA sp. nov.:
 1. An incompletely preserved and large-sized leaf (reduced in 1/2; paratype; SAM-303, kept in Tokyo Gakugei University; Samenoura). 2. A typical leaf, but both ends were missing (holotype; NSM PP-8480A; Samenoura).

Plate 8:

- Fig. 1. *Zamites densipinnatus* KIMURA et OHANA sp. nov.: showing an unusually large-sized leaf; both ends are missing (ONA-602, kept in Tokyo Gakugei University; Onagawa).

