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

By

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Abstract: A number of fossil plants were newly collected from the Oxfordian Moné and Kimmeridgian-Tithonian Kogoshio Formations both of marine origin, of the Shishiori Group distributed in the Karakuwa Peninsula and Oshima Island, near Kesen-numa City, Miyagi Prefecture. Among the collection, 14 species (or forms) belonging to 9 genera from the Moné Formation and 36 species (or forms) to 16 genera from the Kogoshio Formation are recognized. These assemblages are undoubtedly of the Ryoseki-type, and are characterized by the presence of matoniaceous ferns, varied *Zamites* and *Ptilophyllum*, *Nilssonia*, conifers with scale-leaves and *Parasequoia* and a complete absence of ginkgoaleans, czekanowskialeans and *Podozamites* leafy-shoots. These assemblages are phytogeographically and geologically significant, because their geological ages are determined rather precisely, together with those of the Tochikubo and Oginohama Formations in the Outer Zone of Northeast Japan.

Introduction

Earlier studies are known on the fossil plants of the Shishiori Group distributed in the Karakuwa Peninsula and Oshima (or Osima) Island, near Kesen-numa City, Miyagi Prefecture (Fig. 1A). Occurrence of fossil plants from the area studied in this paper was first reported by T. WAKIMIZU (1894). Since then YABE (1922) described the specimens kept at the Tohoku University as *Cladophlebis distans* (HEER) YABE (=*C.* sp. F) and *Frenelopsis* cf. *hoheneggeri* ETTINGSHAUSEN (=*F.* sp. cf. *F. choshiensis* KIMURA, SAIKI et ARAI) (taxonomic names revised by us are shown in parenthesis).

Later YABE (1927) and SHIIDA (1940) recorded 19 species belonging to 15 genera and 60 species belonging to 26 genera respectively without descriptions and/or illustrations. OISHI (1940) described the following six taxa in his monograph: *Cladophlebis concinna* (HEER) (=*C.* sp. D), *C. matonioides* OISHI, Cf. *Zamites feneonis* BRONGNIART (=?), *Otozamites kondoi* OISHI, *Frenelopsis hoheneggeri* (ETTINGSHAUSEN) (=*F.* sp. cf. *F. choshiensis* KIMURA, SAIKI et ARAI), *Williamsonia* sp. cf. *W. whitbiensis* NATHORST (=*Weltrichia* sp.).

ASAMA (1968) discussed the changing process of *Nilssonia* leaves on the basis of the specimens obtained from the Jurassic and Lower Cretaceous plant-beds in North-

east Japan.

In 1981 and 1982, one of us (AIBA) collected a number of fossil plants from the Moné and Kogoshio Formations both of marine origin. This paper deals with the details of the fossil plant-sites (by AIBA) and description of fossil plants of the Shishiori Group, and the palaeobotanical and phytogeographical implications of the Late Jurassic floras (or assemblages) in the Outer Zone of Northeast Japan (by KIMURA and OHAHA).

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Stratigraphy

The Shishiori Group rests disconformably on the Middle Jurassic Karakuwa Group of marine origin and is divided into the Ishiwaritoge, Moné and Kogoshio Formations in upward sequence (ONUKI, 1981) (Figs. 1B and 2B). The Ishiwaritoge Formation is barren of fossils. The Moné Formation is divided into Lower and Upper parts (SHIIDA, 1940). HAYAMI (1961) determined the age of this formation as Kimmeridgian on the basis of bivalves, but KATO *et al.* (1977) fixed it as late Oxfordian on the basis of the discovery of *Perisphinctes* (ammonite) from the Upper part of the formation.

The Kogoshio Formation is divided into Lower, Middle and Upper parts (SHIIDA, 1940; TAKIZAWA, 1976). SATO (1962) determined the age of the formation as Kimmerigian-Tithonian on the basis of his ammonites present, indicating both stages.

Distribution of geological units and collection-localities are shown in Fig. 2A, whereas Fig. 2B shows columnar section of the Shishiori Group. Main localities from where collections were made for this paper are as follows:

Loc. no. 1: Road-cutting to the 200 m and 180 m east of the Tadakoshi Pass respectively.
Loc. no. 2: Road-cutting to the 500 m west of Moné Village.
Loc. no. 3: Coast to the 250 m and 10 m west of Yoraizaki respectively.
Loc. no. 4: Coast to the 300 m southwest of Oshima-Sotohama.
Loc. no. 5: Coast to the 400 m southwest of Oshima-Sotohama.
Loc. no. 6: Coast to the 580 m southwest of Oshima-Sotohama.
Loc. no. 7: Road-cutting to the 500 m northwest of Oshima-Kameyama.
Loc. no. 8: Cliff along the parking place to the north of Oshima-Ohatsudaira.

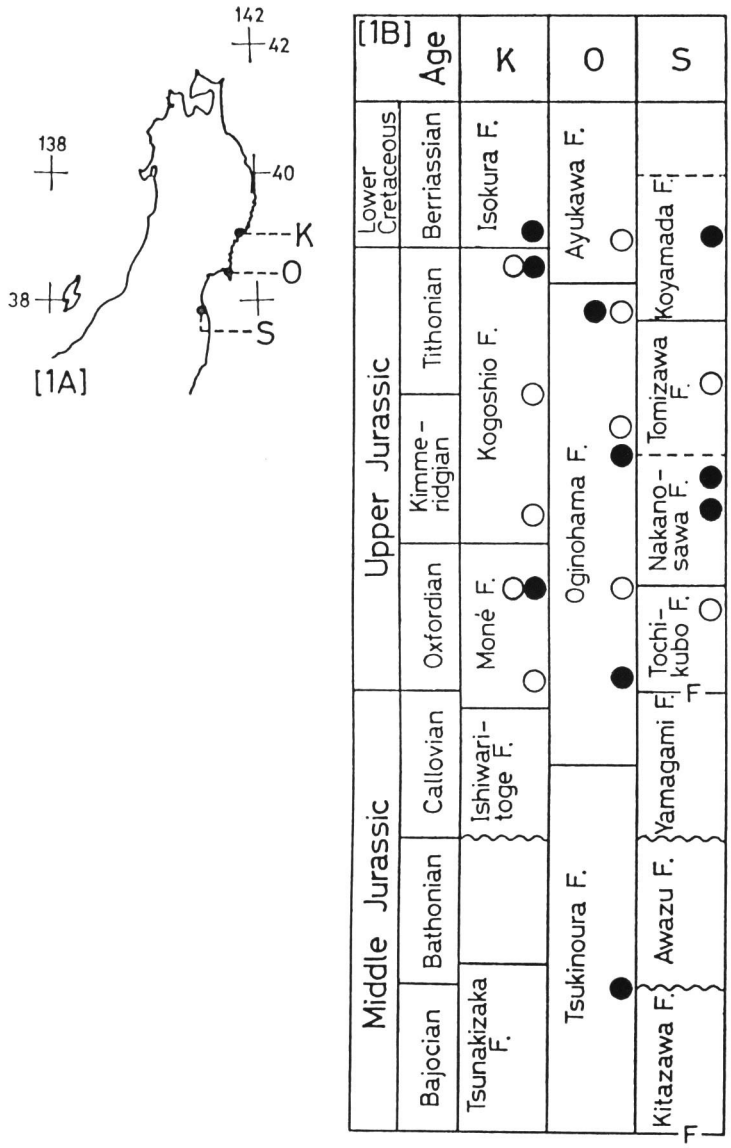


Fig. 1. 1A: Late Jurassic plant-sites in the Outer Zone of Northeast Japan. K; Karakuwa Peninsula and its adjacent area (Shishiori Group), O; Oshika Peninsula (Oshika Group), S; Soma District (Somanakamura Group).

1B: Stratigraphical units in the above-mentioned regions.

○; plant-bearing horizons, ●; guide ammonites-bearing horizons. (Reinserted from KIMURA *et al.*, 1988).

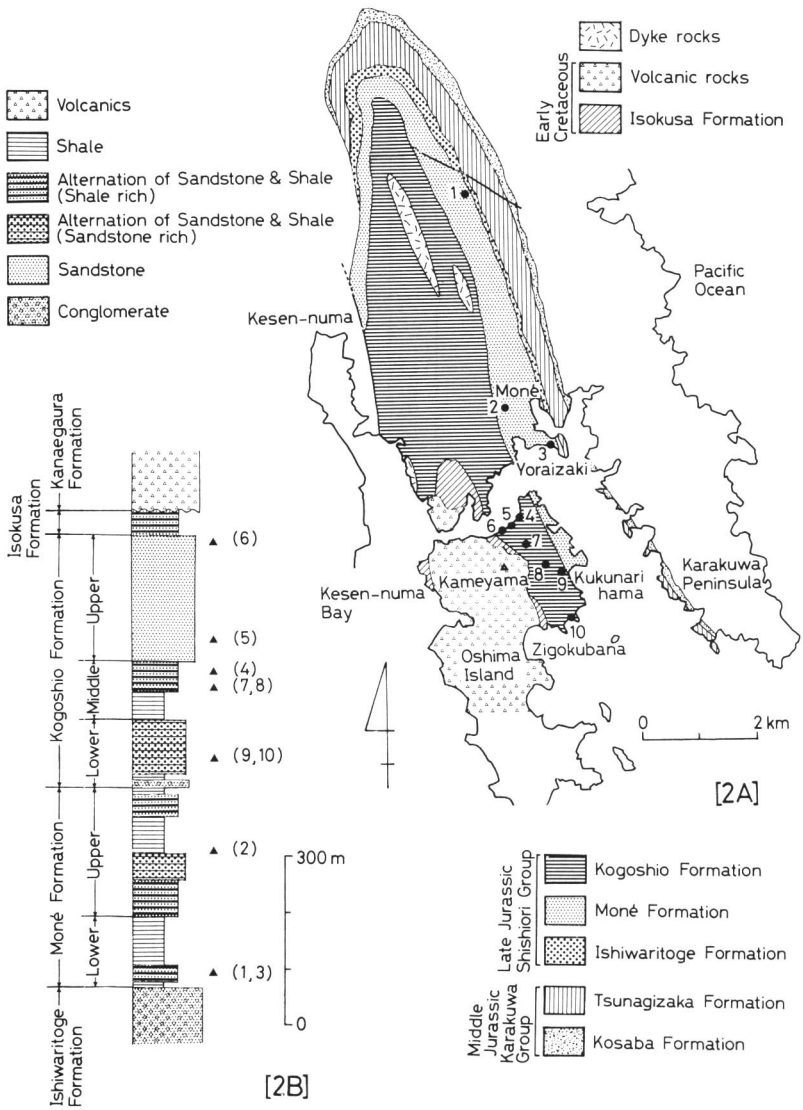


Fig. 2. Distribution of geological units and main localities of fossil plants in the Karakuwa Peninsula and its adjacent area (2A), and the brief columnar section of the Shishiori Group and plant-bearing horizons (2B). The number of each solid triangle corresponds to that of locality shown in Fig. 2A.

Loc. no. 9: Road-cutting along Kukunari Beach, Oshima.
Loc. no. 10: Coast to the 200, 250 and 300 m northwest of Oshima-Jigokuhana respectively.

Amongst above, Loc. no. 4 is classical. It does not belong to the Moné Formation as was formerly presumed, but it belongs to the Kogoshio Formation, possibly

corresponding to OISHI's Osima plant-beds (OISHI, 1940).

Materials and Methods

Although fossil plants are abundant both in the Moné and Kogoshio Formations, they are not well preserved because of the subsequent geological disturbances and intensive igneous activities. They are normally broken owing to the fairly long way of transportation by rivers to the shallow sea. Consequently, details of the reproductive organs of ferns are lost and no cuticles of gymnospermous plants are preserved. Because of the above-mentioned conditions, plant-taxa identified precisely are small in number and most taxa are with 'cf.' or 'ex gr.' or are specifically indeterminable.

The fossil plant-taxa recognized from the Moné and Kogoshio Formations are shown in Table 1 with their occurrences, together with those recognized from the Tochikubo and Oginohama Formations in the Outer Zone of Northeast Japan.

Characteristics of the Floristic Assemblages

Although recognized taxa of the Moné Formation are smaller in number than those of the Kogoshio Formation, there is no essential floristic difference between both assemblages. Accordingly we here regard both assemblages as a single flora, the Shishiori flora.

We recognized 44 species (or forms) belonging to 21 genera, of course including many form-genera. The Shishiori flora is characterized by the common presence of matoniaceous ferns and unclassified fern-leaves (possibly including some pteridosperm leaves) bearing small-sized pinnules with reflexed margins, various kinds of *Zamites*, *Ptilophyllum* and *Nilssonia* leaves (including *N. schaumburgensis* -type ones) and the abundant presence of such conifers with scale-leaves as *Frenelopsis*, *Brachyphyllum* and *Cupressinocladus*, and by the complete absence of ginkgoaleans, czekanowskialeans and *Podozamites* leafy-shoots and conifers with long needle-like leaves.

It is evident that the Shishiori flora is of the Ryoseki-type (e. g. KIMURA, 1984, 1987a, b) together with the nearly coeval floras of the Tochikubo and Oginohama Formations in the Outer Zone of Northeast Japan (KIMURA and OHANA, 1988a, b; 1989a, b), although a single species of dicksoniaceous fern is represented in this flora.

Late Jurassic Floras in the Outer Zone of Japan

1. Past status

The occurrence of fossil plants has been known from the Upper Jurassic Shishiori, Oshika and Somanakamura Groups in the Outer Zone of Northeast Japan, and the Upper Jurassic Torinosu Group (or Formation) in the Outer Zone of Southwest Japan. A small number of fossil plants of the Shishiori, Oshika and Somanakamura Groups was formerly described by YABE (1922), OISHI (1940), ENDO (1952) and OYAMA (1954).

Table 1. Fossil plant-taxa recognized from the Upper Jurassic plant-bearing formations in the Outer Zone of Northeast Japan and their occurrence. Fossil plants from the Tochikubo and Oginohama Formations were already described by KIMURA and TSUJII (1984) and KIMURA and OHANA (1988a, b), and KIMURA and OHANA (1989a, b) respectively.
Occurrence: LA; locally abundant, LC; locally common,
RR; rather rare, R; rare and VR; very rare.

Fossil plant-taxa \ Plant-bearing formations	Monê F.	Kogoshio F.	Oginohama F.	Tochikubo F.
Thallites sp. A		R		
T. sp. B		LA		
Equisetum sp. cf. *E. phillipsi* (Dunker) Brongniart			LC	
E. ? sp.	R			
Todites sp.	LC			
Gleichenites ? sp. A				R
G. ? sp. B			LC	
G. ? sp. C			LC	
G. ? sp. D		RR		
Matonidium ex gr. *goepperti* (Ettingshausen) Schenk	LC			LC
Coniopteris nipponica Kimura et Ohana, sp. nov.		LC		
Eboracia microlobifolia Kimura et Ohana			LC	LA
Onychiopsis yokoyamai (Yabe) Kimura et Aiba			LC	
O. sp. cf. *O. yokoyamai* (Yabe) Kimura et Aiba		RR		
Adiantopteris oshimaensis Kimura et Ohana, sp. nov.		LC		
Acrostichopteris sp. cf. *A. parvifolia* Fontaine			VR	
A. ? sp.				VR
Cladophlebis acutipennis Oishi			LC	RR
C. sp. cf. *C. constricta* Fontaine	RR	RR		
C. geyleriana (Nathorst) Yabe		LC		
C. matonioides Oishi		LC		
C. sp. cf. *C. matonioides* Oishi				RR
C. osimaensis Oishi		LC		
C. sp. cf. *C. virginiensis* Fontaine	R	R	LC	LA
C. sp. A				LC
C. sp. B				RR
C. sp. C			LC	
C. sp. D	RR	RR		
C. sp. E		VR		
C. sp. F		RR		
C. sp. G		RR		
C. sp. H		R		
C. sp. I		RR		
C. sp. J	R			
Sphenopteris elegans (Yokoyama) Oishi				LC
S. sp. A	R	R		
S. sp. B			LC	

Fossil plant-taxa \ Plant-bearing formations	Monè F.	Kogoshio F.	Oginohama F.	Tochikubo F.
Otozamites sp. cf. *O. kondoi* Oishi		VR		VR
Zamites sp. cf. *Z. choshiensis* Kimura et Ohana	LC	LC	LC	
Z. densipinnatus Kimura et Ohana			LA	
Z. sp. cf. *Z. megaphyllus* (Phillips) Seward		VR	LA	LC
Z. nipponicus Kimura et Ohana	RR		LA	LA
Z. sp. cf. *Z. tosanus* Oishi		LC	R	
Z. sp. A				VR
Z. sp. B				VR
Z. sp. C			RR	
Z. sp. D			VR	
Pterophyllum sp. A		RR		
Ptilophyllum jurassicum Kimura et Ohana				LA
P. linearifolium Kimura et Ohana	R	R	RR	
P. oshikaense Kimura et Ohana		RR	LC	
P. sp. F				R
P. sp. G		LC		VR
P. sp. H				R
P. sp. I		R		
Nipponoptilophyllum bipinnatum Kimura et Tsujii				LC
Weltrichia sp.			VR	
Williamsonia sp.			VR	
Pseudoctenis brevipennis Oishi				R
P. sp. cf. *P. lanei* Thomas			VR	
P. sp. A				VR
Nilssonia sp. cf. *N. canadensis* Bell		R		LC
N. sp. cf. *N. densinervis* (Fontaine) Berry		LC	LC	LC
N. longipinnata Kimura et Ohana				LC
N. sp. cf. *N. nigracollensis* Wieland		LA		
N. oblique-truncata Kimura et Ohana			R	LC
N. ex gr. *schaumburgensis* (Dunker) Nathorst		LA	LA	LA
N. sp. A		R		
Cycadites sp.				LC
Elatocladus sp. A				VR
E. sp. B			R	
E. sp. C		R		
Frenelopsis sp. cf. *F. choshiensis* Kimura, Saiki et Arai		LA		
Brachyphyllum sp. A		LC		
Cupressinocladus koyatoriensis Oishi	LA		LC	
C. sp. C	LA		C	
Parasequoia sp. cf. *P. cretacea* Krassilov	RR		LC	LC
Pagiophyllum ? sp.				LC
Taeniopteris sp. F			RR	
T. sp. G		LC		
Carpolithus sp.				LC

Although a number of plant-fragments have been collected from the Torinosu Group, at present only *Zamites* sp. cf. *Z. choshiensis* KIMURA et OHANA is identified (MIMOTO, 1989).

The fossil plants collected from these groups are preserved only as impressions, because of subsequent geological disturbances and intensive igneous activities. Therefore, we could not make preparations for their cuticular and reproductive characters. However, it is worth mentioning that these plant-beds of these groups are of marine origin or sandwiched between the strata of marine origin. These strata yield ammonites and other marine animals which are, as a matter of course, useful for precise age-determination.

On the other hand, many plant-bearing formations said to be of Late Jurassic age have been known in the Middle East, Central and Southeast Asia, India and China. But it is difficult to determine their precise geological ages, because of their non-marine origin.

2. Present status

Under the circumstances, we tried to make the detailed Late Jurassic floristics in the Outer Zone of Japan and we succeeded to get over 10,000 specimens from those groups with the help of many graduate and undergraduate students of the Tokyo Gakugei University for five years.

Amongst above, fossil plants of the Tochikubo Formation of the Somanakamura Group and those of the Oginohama Formation of the Oshika Group were already described by KIMURA and TSUJII (1984) and KIMURA and OHANA (1988a, b), and KIMURA and OHANA (1989a, b) respectively. Fossil plants of the Moné and Kogoshio Formation of the Shishiori Group are described in this paper. In addition, KIMURA *et al.* (1988) made brief remarks on the Late Jurassic floras in the Outer Zone of Northeast Japan.

Fig. 1 shows the geographical and stratigraphical situations of the plant-bearing formations in the Outer Zone of Northeast Japan (reinserted from KIMURA *et al.*, 1988). Unfortunately we could not collect identifiable fossil plants from the Tomizawa Formation of the Somanakamura Group.

3. Characteristics of the Late Jurassic flora in the Outer Zone of northeast Japan

We recognized 79 species (or forms) belonging to 30 genera as shown in Table 1.

Although the constituent of the plant taxa is somewhat different according to the localities and horizons, we are of the opinion that the fossil plants recognized from the Somanakamura, Oshika and Shishiori Groups belong to the same flora as a whole.

The geological age of this flora ranges from early Oxfordian to late Tithonian. In this duration (ca. 20Ma), no marked stratigraphical difference is recognizable. Characteristics of this flora are as follows:

1) Ferns

a) Gleicheniaceous ferns are varied and common. But it is difficult to establish their precise identities.

b) Matoniaceous fern is represented by *Matonidium* ex gr. *goepperti*. It is common in occurrence. *Weichselia* has not been found so far. However, it is rather common in the Early Cretaceous plant-beds in the Outer Zone of Southwest Japan.

c) Dicksoniaceous ferns are restricted in occurrence and two species belonging to two genera are recognized. Dicksoniaceous ferns have not been found from the Early Cretaceous plant-beds in the Outer Zone of Japan except for the Ayukawa Formation.

d) *Onychiopsis* is represented by *O. yokoyamai* and is rather rare, but is abundant in the Early Cretaceous plant-beds of the Outer Zone of Japan. This species is different from *Onychiopsis elongata* (GEYLER) YOKOYAMA, a characteristic species of the Late Jurassic -Early Cretaceous floras of the Inner Zone of Japan (KIMURA and AIBA, 1986).

e) *Adiantopteris* and *Acrostichopteris* are locally common and rare respectively, and the latter may belong to pteridosperm.

f) Fern-like sterile leaf-fragments or poorly preserved fertile leaf-fragments are varied and abundant. In our papers these are placed unavoidably in Form-genera *Cladophlebis* and *Sphenopteris*. It is highly probable that some of them belong to pteridosperms.

2) Gymnosperms

g) Bennettitalean genera, *Zamites* and *Ptilophyllum* are varied and abundant. Both genera have not been found in the Late Jurassic-Early Cretaceous floras in the Inner Zone of Japan. As mentioned before (e. g. KIMURA, 1987a, b), *Ptilophyllum pachyrachis* originally described by OISHI (1940) from the Upper Jurassic Kuzuryu Group in the Inner Zone of Japan is not *Ptilophyllum* but *Pterophyllum*. *Dictyozamites* and *Neozamites* leaves have not been found, but they are varied and abundant in the Late Jurassic-Early Cretaceous fllras in the Inner Zone of Japan.

h) Cycadalean genus, *Nilssonia* is varied and abundant, and *N. schaumburgensis*-type leaves are common or locally very abudant. However, this type of *Nilssonia* leaves have not been found in the Late Jurassic-Early Cretaceous floras in the Inner Zone of Japan. *Ctenis* leaf has not been found. It is one of the important genus in the Early Cretaceous floras of the Inner Zone of Japan.

i) Ginkgoaleans and czekanowskialeans have not been found. A single species described by OISHI (1940) as *Baiera brauniana* (DUNKER) from the Lower Cretaceous pant-bed in the Outer Zone of Southwest Japan, may belong to *Acrostichopteris* or *Adiantopteris*.

j) Conifers with scale-leaves are varied and abudant, and they are represented by *Frenelopsis*, *Brachyphyllum* and *Cupressinocladus*. On the other hand, those with needle-like or elongate leaves are rare except for *Parasequoia* and *Elatocladus*.

Conifers with scale-leaves have not been found in the Late Jurassic-Early Cretaceous floras in the Inner Zone of Japan.

k) No *Podozamites* leaf or leafy-shoot has been found. Most leafy-shoots described as *Podozamites lanceolatus* from the Lower Cretaceous plant-beds in the Outer Zone of Japan, belong not to *Podozamites*, but to *Podocarpus* (*Nageia*) (KIMURA, OHANA and MIMOTO, 1988; OHANA, KIMURA and KAWAZOÉ, 1989). *Podozamites* is varied and abundant in the Late Jurassic-Early Cretaceous floras in the Inner Zone of Japan, together with ginkgoaleans and czekanowskialeans.

The above-mentioned characteristics show that the Late Jurassic flora of the Outer Zone of Northeast Japan is clearly of the Ryoseki-type (KIMURA, 1987a, b). There is no common species between the Late Jurassic Ryoseki-type flora of the Outer Zone and the coeval Tetori-type flora of the Inner Zone of Japan.

4. Floras similar in floristic composition to the Late Jurassic flora of the Outer Zone of Japan

1) Early Cretaceous floras of the Outer Zone of Japan

Early Cretaceous plant-sites are known from Omoto, Iwate Prefecture, Northeast Japan to Yatsushiro, Kumamoto Prefecture, Southwest Japan for about 1,500 km long in the Outer Zone of Japan (KIMURA, 1987a, figs. 1–2). These plant-beds are of marine origin or sandwiched between the strata of marine origin, and yield unexceptionally the Ryoseki-type fossil plants including *Weichselia* (KIMURA, 1987a, b). Therefore, the Ryoseki-type flora had kept its floristic character without marked geographical and stratigraphical changes from early Oxfordian to late Albian in age (for about 67Ma).

2) Early Cretaceous floras of Southern Primorye

Early Cretaceous plant-sites are known from the regions mainly along the Suchan and Sujfun Rivers. The latest knowledge of the floras was brought out by KRASSILOV (1967).

In these regions, the floras known from the lower horizons appear to be completely of the Ryoseki-type, but those from the upper horizons appear to include a few Tetori-type taxa (KIMURA, 1987a, table 1).

3) Early Cretaceous floras of China

In South China, these are no floras that can be positively asserted in age as Late Jurassic. The Early Cretaceous floras are widely distributed and are clearly of the Ryoseki-type (KIMURA, 1987a, fig. 2).

In southeastern part of Northeast China (Yanbian, Jixi, Boli, Dongning and Wandashan areas), the floras before middle Early Cretaceous are of the Tetori-type, but those after middle Early Cretaceous include the Ryoseki-type taxa (KIMURA, 1986a, table 1, fig. 2).

The Early Cretaceous floras in Northwestern and Northern China are essentially of the Tetori-type, but include several Ryoseki-type taxa. Therefore, they are of the mixed-type like the Earliest Cretaceous Kiyosué flora of Southwest Japan and the

Early Cretaceous Nagdong (or Naktong) flora of South Korea (KIMURA, 1987a, table 1, fig. 2).

4) In southeast Asia, several floras regarded in age as Late Jurassic -Early Cretaceous have been known. They are unexceptionally of the Ryoseki-type (KIMURA, 1987a, fig. 2; 1987b).

5) Central Asia

In Central Asia, floras which can be positively asserted in age as Late Jurassic are few. DOLUDENKO and ORLOVSKAJA (1976) described Jurassic fossil plants from the Karatau Mountains, east of the Caspian Sea. Among them, fossil plants from the Borolsai and Karabastau Formations are said to be of Late Jurassic age. We are of the opinion that both plant-assemblages are of mixed-type, because both contain Tetori-type genera, such as *Coniopteris*, *Ginkgoites*, *Baiera*, *Sphenobaiera*, *Eretmophyllum*, *Czekanowskia*, *Phoenicopsis* and *Podozamites* in addition to the typical Ryoseki-type taxa.

6) Western Canada

According to BELL (1956), the geological age of the floras in Western Canada ranges from early Early Cretaceous to late Early Cretaceous. We are of the opinion that they are of mixed-type. Recently HILLS and his student discovered Early Cretaceous flora in northeastern British Columbia (HILLS, 1990; personal communication). In our opinion, it might be of the Tetori-type.

7) Western parts of the United States of America

The occurrence of fossil plants has been known from the Shasta Formation, northern California and Oregon, the Kootanie Formation, Montana and the Lakota Formation, South Dakota (e. g. FONTAINE in WARD, 1905; BERRY, 1911). These formations are of non-marine origin and therefore, it would be difficult to determine their precise geological ages. But we feel that they might be Latest Jurassic or Early Cretaceous in age. So far as FONTAINE's and BERRY's works are concerned, they look to be of the Ryoseki-type, however, including angiospermous plants. From Japanese Lower Cretaceous, angiospermous plants have not been found, except for a doubtful *Phyllites* sp. represented by a single leaf (or leaflet) (OISHI, 1940) from the Lower Cretaceous of the Outer Zone of Southwest Japan.

The Oaxaca flora in Mexico said to be Middle Jurassic in age (e. g. WIELAND, 1914–1916; PERSON and DELEVORYAS, 1982) is, in our opinion, of the Ryoseki-type.

Although our knowledge about the Jurassic-Early Cretaceous Western North American floras is insufficient, the transitional zone of mixed-type floras appear to exist widely between the southern Ryoseki-type floristic zone and the northern Tetori-type floristic zone including Alaska.

It would be worth mentioning that the many Ryoseki-type taxa in Japan are very close in external appearance to those known from the Ryseki- or mixed-type floras in Western North America: They are, such as *Equisetum* sp cf. *E. phillipsi* (DUNKER) BRONGNIART, *Acrostichopteris* sp. cf. *A. parvifolia* FONTAINE, *Cladophlebis* sp. cf. *C. constricta* FONTAINE, *C.* sp. cf. *C. virginiensis* FONTAINE, *Zamites* sp. cf. *Z.*

choshiensis KIMURA et OHANA, *Z.* sp. cf. *Z. megaphyllus* (PHILLIPS) SEWARD, *Nilssonia* sp. cf. *N. canadensis* BELL, *N.* sp. cf. *N. densinervis* (FONTAINE) BERRY, *N.* sp. cf. *N. nigracollensis* WIELAND, *N.* ex gr. *schaumburgensis* (DUNKER) NATHORST, *Frenelopsis* sp. cf. *F. choshiensis* KIMURA, SAIKI et ARAI known from the Late Jurassic flora in the Outer Zone of Japan.

It is presumed that the Ryoseki-type floras in Japan and those in Western North America had flourished in the same climatic region in some Pacific area during the Jurassic-Early Cretaceous time.

8) Late Jurassic flora in France

The Kimmeridgian flora in France was described by BARALE (1981). This flora is, in our opinion, of the Ryoseki-type except for the presence of *Baiera verrucosa*. The 'Wealden floras' distributed in the middle-south Europe are clearly of the Ryoseki-type.

9) Late Jurassic flora of Scotland

Recently the Late Jurassic flora in Scotland was reinvestigated and revised by VAN der BURGH and VAN K. der van CITTERT (1984), and VAN K. der van CITTERT and VAN der BURGH (1989). This flora is, in our opinion, of the mixed-type as well as the Middle Jurassic Yorkshire flora (KIMURA and OHANA, 1987b, p. 49).

Systematic Description

Specimens described herein are stored in the National Science museum, Tokyo.

Bryophyta

Form-genus ***Thallites*** WALTON, 1925

Thallites sp. A

(Fig. 3)

Material: NSM PP-8635, 8636 (counterpart). *Horizon* and *locality*: Middle part of the Kogoshio Formation. Loc. no. 7. *Occurrence*: Rare.

Description: Only a single specimen was obtained without visible fine details. Thalli are fragmental and preserved in crowds on a bedding plane. Thallus is flat with a thick median rib with entire or irregularly undulated margin; more than 10 cm long and up to 8 mm wide; branching by equal dichotomy, branches are divergent. The median rib (or vein) is varied in width, 1–3 mm wide; the wider part becomes indistinct.

Comparison: The present thalli are distingished by their divergent branches from those of *Thallites yabei* (KRYSHTOFOVICH) HARRIS known from the Lower Cretaceous Oguchi Formation (OISHI, 1940) in the Inner Zone of Japan and the coeval Lower part of Gyeongsang Group (Nagdong or Naktong Formation), South Korea.

Figs. 3–7. (Each bar indicates 1 cm scale) 3, *Thallites* sp. A: Two isolated thalli; NSM PP–8635. 4, *Thallites* sp. B: A repeatedly branched thallus; NSM PP–8637. 5, *Todites* sp.: A part of leaf with densely crowded sporangia (5a; wrong side view) and venation (5b). 5a–b; NSM PP–8648. 6, *Gleichenites* ? sp. D: A part of sterile leaf; NSM PP–8654. 7, *Matonidium* ex gr. *goepperti* (ETTINGSHAUSEN) SCHENK: 7a; an arm (or rachis) with closely set pinnae; NSM PP–8661. 7b; a long petiole with an incompletely preserved arm (or rachis); NSM PP–8656. 7c; showing fertile pinnules (wrong side view); NSM PP–8662.

They also distinguished from *Thallites* sp. B described in this paper because of their width being twice as much as the latter.

Thallites sp. B

(Fig. 4)

Material: NSM PP-8637 ~ 8643. *Horizon* and *locality*: Lower part of the Kogoshio Formation. Loc. no. 10. *Occurrence*: Locally abundant.
Description: The thalli are fragmental and preserved in crowds, sometimes thickly massed and appressed. The thallus is repeatedly branched by equal dichotomy, at intervals of 1–2 cm. The branches are up to 4 mm wide each with a distinct median rib (or vein) and entire margin. No fine details are visible.
Comparison: The comparison of the *Thallites* sp. B with *T.* sp. A is already made. The present thalli resemble in general appearance those of *Thallites zeilleri* (SEWARD) HARRIS as described by BELL (1956) from the Lower Cretaceous of Western Canada.

Pteropsida

Equisetales

Genus ***Equisetum*** LINNAEUS

Equisetum ? sp.

Material: NSM PP-8644. *Horizon* and *locality*: Lower part of the Moné Formation. Loc. no. 1. *Occurrence*: Rare, many aerial or subterranean stem-fragments.
Description: Imperfectly preserved stem-fragments are obtained. One of them is 5 cm long and up to 5 mm wide with three internodes and two leaf-sheaths, but free teeth are missing.
Remarks: It is highly probable that our specimens belong to *Equisetum*, but they are too poorly preserved to make the precise generic identity.

Filicales

Family Osmundaceae

Genus ***Todites*** SEWARD, 1900

Todites sp.

(Figs. 5a–b)

Material: NSM PP-8645 ~ 8655. *Horizon* and *locality*: Lower part of the Moné Formation. Loc. no. 1. *Occurrence*: Locally common.
Description: Many fragments obtained are of fertile leaves. The leaf is bipinnate and medium-sized. The rachis is rather thick, up to 4 mm wide near the base and

with a median furrow throughout. The pinnae are alternate, set closely, attached to the rachis at an angle of about 45 degrees and nearly parallel-sided for the most part, more than 6 cm long and typically 8.5 mm wide. The pinnules are deltoid or elongate-deltoid in form, sometimes falcate, typically 1 cm long and 5 mm wide at base, with entire margins, and attached by whole base to the pinna axis katadromically at an angle of 40–50 degrees. Midnerve is distinct, persisting to the tip, givin off typically 7–8 alternate pairs of once forked laterals directed forward.

The sporangia are small and distributed in groups on the lower surface except for the marginal region of pinnule. The details of sporangia are unknown.

Remarks: The distributional pattern of sporangia in the present leaves is like in *Todites*. The present leaves somewhat resemble in the form of pinnules and venation some sterile leaves of *Cladophlebis* described in the Ryoseki-type floras, such as *C.* sp. (NATHORST, 1890; Lower Cretaceous of Kochi Prefecture) and *C. nathorsti* YOKOYAMA (YOKOYAMA, 1894; ditto).

Family Gleicheniaceae

Genus ***Gleichenites*** GOEPPERT, 1936

Gleichenites ? sp. D

(Fig. 6)

Material: NSM PP-8649 ~ 8655. *Horizon* and *locality*: Middle part of the Kogoshio Formation. Loc. no. 4. *Occurrence*: Rather rare.

Description: Many leaf-fragments with fertile pinnules were obtained. The entire leaf is unknown. The pinnae are long and narrow, nearly parallel-sided, flexible, more than 4.3 cm long and up to 4.7 mm wide and attached rather remotely and alternately to the axis at a wide angle and at intervals of 1 cm. The pinnules are nearly semi-circular or broadly deltoid in form, typically 2 mm long and 2.5 mm wide at base. They are attached katadromically and rather remotely to the pinna axis at a right angle; margins are entire, but strongly reflexed. The veins are of the *Sphenopteris*-type; the midnerve sends off 2–3 pairs of simple laterals. The pinnules examined are fertile, but their details are indistinct. Therefore, in our line-drawing (Fig. 6), the position and form of sporangia are not shown.

Remarks: Many gleicheniaceous ferns have been known from the Ryoseki-type floras in the Outer Zone of Japan. Unfortunately, it is difficult or impossible to make their specific identities because of poor preservation of their reproductive organs. Therefore, we regarded the present leaves as *Gleichenites* ? sp. D.

Gleichenites yuasensis KIMURA et KANSHA is the representative species in the Early Cretaceous Ryoseki-type floras in the Outer Zone of Japan. The present *Gleichenites* ? sp. D is distinguised from *G. yuasensis* by its much larger size of pinnules.

Family Matoniaceae

Genus *Matonidium* SCHENK, 1871

Matonidium ex gr. *goepperti* (ETTINGSHAUSEN) SCHENK

(Figs. 7a–c)

Material: NSM PP-8656～8665. *Horizon* and *locality*: Lower part of the Moné Formation. Loc. no. 1. *Occurrence*: Locally common.

Description: The leaf is rather small-sized and has a long stalk (or petiole), more than 8 cm long and 2 mm wide, which at tip branches into two long, nearly horizontal rachises (or arms). Each rachis bears about 15 pinnae outwardly directed at a narrow angle and at intervals of 2.5 mm. The pinna rib (or arms) is delicate, 0.8 mm wide and bears pinnules. The pinnules are varied in form according to the position of pinna and are attached at right angles to the pinna axis; those on the distal half of pinna are deltoid, 5 mm long and 2 mm wide at middle, and those on the proximal half of pinna are usually smaller in size and semi-circular, typically 1 mm long and 1.3 mm wide at base. The midnerve is distinct, persisting to the tip, but laterals are invisible. The reproductive organs are 7–10 alternate pairs in number, superficial and arranged on both sides of the midnerve. They are raised and appear to be square in surface view owing to lateral compressions. The details of reproductive organs (sori ?) are unknown.

Remarks: YABE (1927) recorded *Matonidium goepperti* SCHENK in his fossil list of Shima (corresponding to our Loc. nos. 4–6). But it is difficult to compare with YABE's species which has neither description nor illustration.

Although, details of our reproductive organ are not known, it is highly probable that our leaves belong to the genus *Matonidium* on the basis of their leaf-architecture.

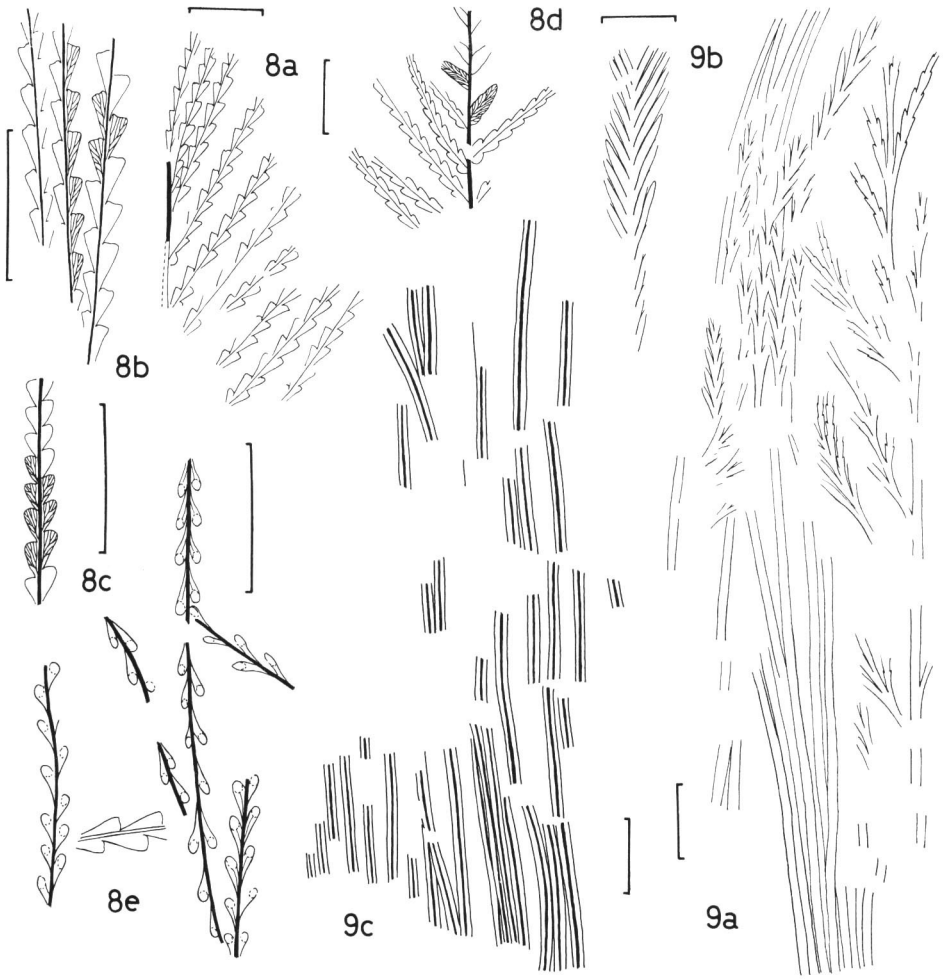
As our shorter pinnules resemble externally some of *Matonidium goepperti* (ETTINGSHAUSEN) illustrated by HARRIS (1961), we at present regard our leaves provisionally as *M.* ex gr. *goepperti*, but the longer pinnules commonly represented in European *M. goepperti* have not been found in our leaves.

Similar leaves with elongate pinnules were described as *Matonidium* ex gr. *goepperti* by KIMURA and OHANA (1988a) from the Upper Jurassic Tochikubo Formation. It was the first record of the genus in Japan.

At any rate, it is true that the matoniaceous ferns had existed in the Late Jurassic floras in the Outer Zone of Japan.

Family Dicksoniaceae

The dicksoniaceous ferns are varied and very abundant in the Tetori-type floras of the Inner Zone of Japan, but are absent in the Early Cretaceous Ryoseki-type floras in the Outer Zone of Southwest Japan and rare in occurrence in the Late Jurassic-Early Cretaceous Ryoseki-type floras of the Outer Zone of Northeast Japan.



Figs. 8–9. (Each bar indicates 1 cm scale) 8, *Coniopteris nipponica* KIMURA et OHANA, sp. nov.: Varied forms of sterile leaves and venation (8a–d), and detached fertile pinnae (8e). 8a; NSM PP–8715, 8b; enlarged from 8a, 8c, e; NSM PP–8701 (a part of holotype), 8d; NSM PP–8714 (paratype). 9, *Onychiopsis* sp. cf. *O. yokoyamai* (YABE) KIMURA et AIBA: A part of sterile leaf-bundle (9a), elongate sterile pinnules (9b) and petioles (9c). 9a; NSM PP–8794, 9b; NSM PP–8802, 9c; NSM PP–8800.

The only known species was *Eboracia microlobifolia* KIMURA et OHANA from the Lower Cretaceous Ayukawa Formation (KIMURA and OHANA, 1987a) and from the Upper Jurassic Tochikubo Formation (KIMURA and OHANA, 1988a). In addition we recognized the second dicksoniaceous species as mentioned below.

Genus *Coniopteris* BRONGNIART, 1849

Coniopteris nipponica KIMURA et OHANA, sp. nov.

(Figs. 8a–e)

Material: Holotype; NSM PP-8701. Paratype; NSM PP-8714. Other specimens examined; NSM PP-8702 ~ 8713, 8715. *Stratum typicum*: Lower part of the Kogoshio Formation. *Locus typicus*: Loc. no. 9. *Derivatio nominis*: After Nippon (meaning 'Japan' in Japanese). *Occurrence*: Locally common at Loc. no. 9.

Diagnosis: Leaf at least bipinnate with very slender rachis. Sterile pinnae delicate, long and narrow, nearly parallel-sided for the most part, typically 5 cm long and 0.3 mm wide and attached alternately and rather remotely to the axis at a narrow angle; angle reduced distally. Sterile pinnules closely set, mostly wedge-shaped (or asymmetrically deltoid) but some asymmetrically semi-circular in form. In wedge-shaped pinnules, acroscopic margin straight and nearly perpendicular to the pinna axis and basiscopic margin decurrent; the basal basiscopic one usually semi-circular, attached katadromically to the pinna axis by the whole base nearly perpendicular, basiscopic margin 2.5 mm long and acroscopic margin 1.1 mm long. Veins being of the *Sphenopteris*-type; midnerve originating at a narrow angle from the decurrent part of pinnule, dichotomously forked 3–4 times sympodially and entire at the margin.

Fertile pinnules usually remotely set, directed forward; lamina markedly reduced laterally with a single vein and with a single terminated sorus, 0.3–0.8 mm in diameter.

Discussion and *comparison*: Unfortunately we could not study the details of soral character because of poor preservation, but similarity in between the present fertile pinnules and those of *Coniopteris* species hitherto known is noticeable. Therefore, it is highly probable that the present leaves belong to the genus *Coniopteris*.

The present sterile leaves differ in form from those of other *Coniopteris* species hitherto hnown. Accordingly, we propose *Coniopteris nipponica* to accommodate the present leaves.

At the distal part of leaves, the length of sterile pinnae is reduced suddenly to form elongated pinnules with entire or shallowly undulated margins (Fig. 8d).

Unclassified ferns

Genus *Onychiopsis* YOKOYAMA, 1889

Onychiopsis sp. cf. *O. yokoyamai* (YABE) KIMURA et AIBA

(Figs. 9a–c)

Material: NSM PP-8793 ~ 8805. *Horizon* and *locality*: Middle part of the Kogoshio Formation. Loc. no. 7. *Occurrence*: Rather rare.

Description: The leaves are bipinnate, each with fairly long petiole (Figs. 9a, c). The petiole and rachis are slender, 1.5 mm wide with a median furrow. The pinnae are long and narrow, attached to the rachis at a narrow angle, with large and small

pinnules directed forward. The large pinnules are 1.8 cm long and 1.8 mm wide, with 4 pairs of shallowly dissected lobes; each lobe is directed forward (Fig. 9a). The small pinnules are elongate-oblong, 4.3 mm long and 0.7 mm wide, with entire margins and also directed forward (Fig. 9b). Veins are invisible.

Remarks: In Japan, there were two *Onychiopsis* species: *O. elongata* (GEYLER) YOKOYAMA with tripinnate leaves known in the Tetori-type floras of the Inner Zone of Japan and in the Middle Jurassic Utano flora, Toyora District, Southwest Japan, and *O. yokoyamai* (YABE) KIMURA et AIBA with bipinnate leaves known in the Ryoseki-type floras of the Outer Zone of Japan.

The present leaves, though represented only by sterile leaves, are delicate in habit and resemble those of *Onychiopsis yokoyamai* of bipinnate habit. But, as the present leaves are poorly preserved, we refrain from making their specific identity with *O. yokoyamai*.

Form-genus ***Adiantopteris*** VASSILEVSKAJA, 1968

Adiantopteris oshimaensis KIMURA et OHANA, sp. nov.

(Figs. 10a–c)

Material: Holotype; NSM PP-8666. Paratypes; NSM PP-8667, 8668. Other specimens examined; NSM PP-8669～8679. *Stratum typicum*: Middle part of the Kogoshio Formation. *Locus typicus*: Loc. no. 4. *Derivatio nominis*: After Oshima Island. *Occurrence*: Locally common.

Diagnosis: Leaf pinnate (whole leaf not known). Rachis thin, 1 mm wide with a median furrow and with opposite or subopposite pinnae at a narrow angle. Apical pinnae in two pairs oblanceolate in outline, sessile, typically 3.2 cm long and up to 1.1 cm wide and with broadly rounded apices. Other pinnae short stalked, deeply divided into 3–5 oblanceolate segments (or pinnules) similar in shape and size to the apical pinnae. Margins of pinnae and segments entire, but the apices finely serrated. Venation distinct, originated by a single vein at the pinna base, then repeatedly forking dichotomously at all levels, radiating and ending at margins; density 22–28 per cm at the middle; at apex each serration recieving a single vein. (Reproductive organ not hnown).

Discussion and *comparison*: On the basis of opposite or subopposite pinnae and the pinna form, we are inclined to identify our leaves with the form-genus *Adiantopteris*.

Many leaves resembling those of recent *Adiantum* have been described from the Jurassic-Cretaceous plant-beds under the names of *Adiantites* and *Adiantopteris*. So far as we hnow, the present leaves are unique in pinna form. Therefore, we propose the name, *Adiantopteris oshimaensis*.

Adiantites gracillis originally described by VASSILEVSKAJA (1757) from the Lower Cretaceous plant-beds in the lower course of the Lena resembles *Adiantopteris oshimaensis* in leaf-architecture, but the former is distinguished in its small-sized and wedge-shaped pinnae and segments.

Form-genus ***Cladophlebis*** BRONGNIART, 1849

Cladophlebis sp. cf. ***C. constricta*** FONTAINE

(Fig. 11)

Material: NSM PP-8781～8785. *Horizons* and *localities*: Lower part of the Moné Formation (Loc. no. 1) and middle part of the Kogoshio Formation (Loc. no. 4). *Occurrence*: Rather rare.

Description: The leaf is bipinnate, medium-sized as known from the fragments. The rachis is rather thick, 2 mm wide with alternate or subopposite pinnae at a wide angle. The pinnae are 6 cm long and 1.5 cm wide at base and have more than 14 katadromic pairs of pinnules at a wide angle. The pinnules are broadly deltoid or rhomboidal in outline with markedly constricted base and obtusely pointed apex; margins are entire. Midnerve shows slightly zigzag course, persisting to the tip and with 6–7 pairs of once forked laterals directed forward.

Remarks: The present leaves resemble closely those of *Cladophlebis constricta* originally described by FONTAINE (1889) from the Lower Cretaceous Potomac Group. However, we refrain from making full identity with the American species, because of poor preservation of our specimens.

Cladophlebis geyleriana (NATHORST) YABE

(Fig. 12)

Pecopteris geyleriana NATHORST: NATHORST, 1890, p. 8, pl. 4, fig. 1; pl. 6, fig. 1.

Material: NSM PP-8650, 8771～8773. *Horizon* and *locality*: Middle part of the Kogoshio Formation. Loc. no. 4. *Occurrence*: Locally common.

Description: The leaf is possibly tripinnate, but our specimens are all represented by broken penultimate pinnae. The ultimate pinnae are long and narrow, nearly parallel-sided for the most part, closely set, more than 5 cm long and 1.2 cm wide and attached to the penultimate pinna axis at a wide angle. The pinnules are rather remotely set, finger-shaped, often falcate, typically 6 mm long and 2 mm wide and attached to the pinna axis at a wide angle. Veins are indistinct.

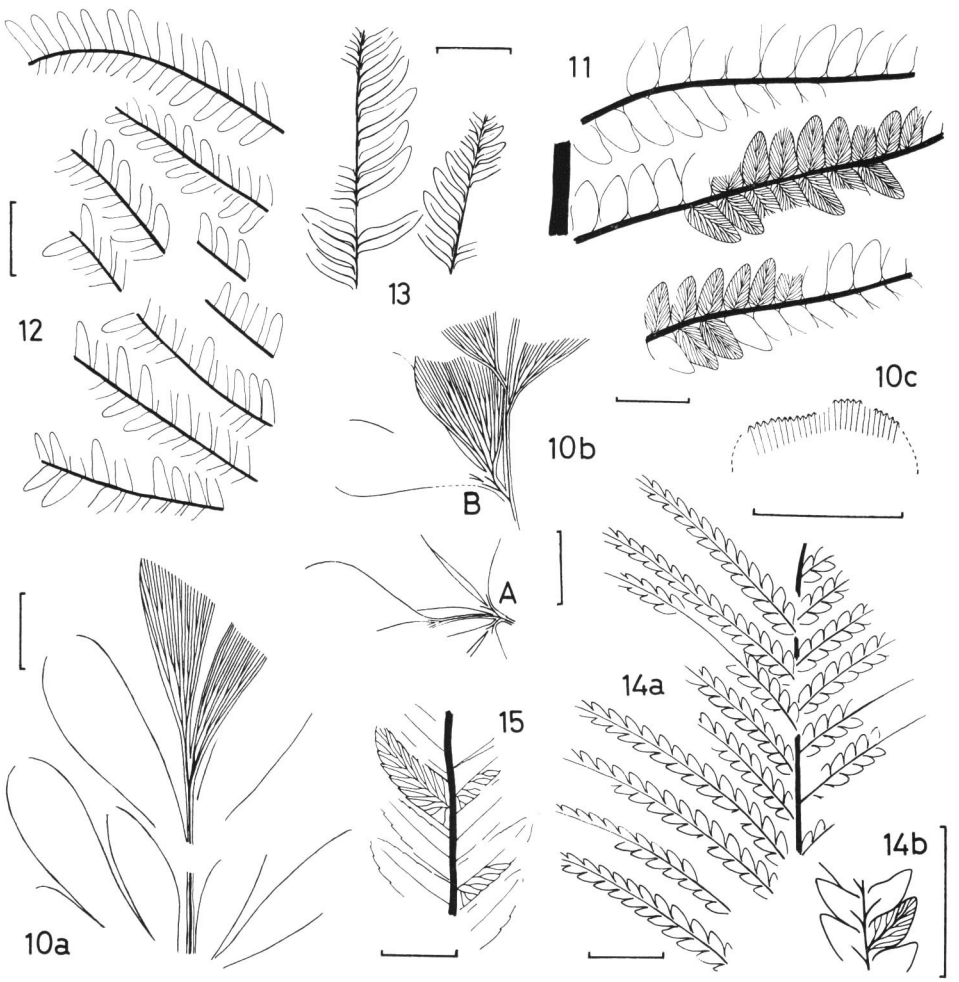
Remarks: Although the swelling basal basiscopic margin of pinnules, which is characteristic feature of this species, is not clearly discernible, the present leaves agree in other external aspects with those of *Cladophlebis geyleriana* known widely from the Lower Cretaceous plant-beds in the Outer Zone of Japan.

Cladophlebis matonioides OISHI

(Fig. 13)

Cladophlebis matonioides OISHI: OISHI, 1940, p. 274, pl. 19, figs. 4, 4a; pl. 20, fig. 4.

Material: NSM PP-8743～8758. *Horizon* and *locality*: Middle part of the Kogoshio Formation. Loc. no. 4. *Occurrence*: Locally common.



Figs. 10–15. (Each bar indicates 1 cm scale) 10, *Adiantopteris oshimaensis* KIMURA et OHANA, sp. nov.: 10a; a part of typical sterile leaf of which apical two pairs of pinnae are not dissected, and dissected lower pair of pinnae; NSM PP–8666 (holotype). 10b; dissected pinnae (A and B); NSM PP–8668 (paratype). 10c; fine serration seen at the apical margin of a segment; NSM PP–8674. 11, *Cladophlebis* sp. cf. *C. constricta* FONTAINE: A part of sterile leaf; NSM PP–8782. 12, *Cladophlebis geyleriana* (NATHORST) YABE: A part of poorly preserved leaf; NSM PP–8650. 13, *Cladophlebis matonioides* OISHI: Two poorly preserved ultimate pinnae; NSM PP–8750. 14, *Cladophlebis osimaensis* OISHI: A part of sterile leaf (14a) and venation enlarged (14b); NSM PP–8721. 15, *Cladophlebis* sp. cf. *C. virginiensis* FONTAINE: A part of sterile pinna and venation; NSM PP–8786.

Description: The leaves are bipinnate or tripinnate, but whole leaf is unknown. The rachis is 2.5 mm wide and sends off the pinnae with thin pinna axis, 0.6 mm wide at a wide angle. The pinnules are elongated, finger-shaped, sometimes falcate, with

reflexed entire margins and obtusely pointed or rounded apices and attached to the pinna axis at a wide angle. Veins are indistinct.

Remarks: The present leaves agree well with those of *Cladophlebis matonioides* originally described by OISHI (1940) on the basis of those collected from the Upper Jurassic Shishiori (the same locality as ours) and Oshika Groups.

The external form of the present pinnules resembles that of *Matonidium* ex gr. *goepperti* described in this paper, but the present leaves are not pedate as in those of the latter but pinnate.

Cladophlebis osimaensis OISHI

(Figs. 14a–b)

Cladophlebis osimaensis OISHI: OISHI, 1940, p. 278, pl. 20, figs. 1–3.

Material: NSM PP-8724~8742. *Horizon* and *locality*: Middle part of the Kogoshio Formation. Loc. no. 4. *Occurrence*: Locally common.

Description: The preserved part of the leaf is bipinnate. The rachis is thin, less than 1 mm wide, and develops alternate pinnae at an angle of 40–50 degrees and at intervals of 6 mm. The pinnae are long and narrow, linear, 4 cm long and up to 3 mm wide. The pinnules are small-sized, arranged in katadromic order, closely set, typically deltoid in outline; margins are entire. Veins are of the *Sphenopteris*-type with four alternate pairs of once forked laterals.

Remarks: The present leaves agree with those of *Cladophlebis osimaensis* originally described by OISHI (1940) on the basis of specimens from the Shishiori (locality may correspond to our Loc. no. 3) and Oshika Groups. However, we could not find this species from the Oshika Group. Nevertheless the present leaves, however, differ from Oishi's original leaves, because most pinnules are directed forward except those on the proximal part of a pinna.

Cladophlebis sp. cf. ***C. virginiensis*** FONTAINE

(Fig. 15)

Material: NSM PP-8786, 8687. *Horizons* and *localities*: Lower part of the Moné Formation (Loc. no. 1) and lower part of the Kogoshio Formation (Loc. no. 9). *Occurrence*: Rare.

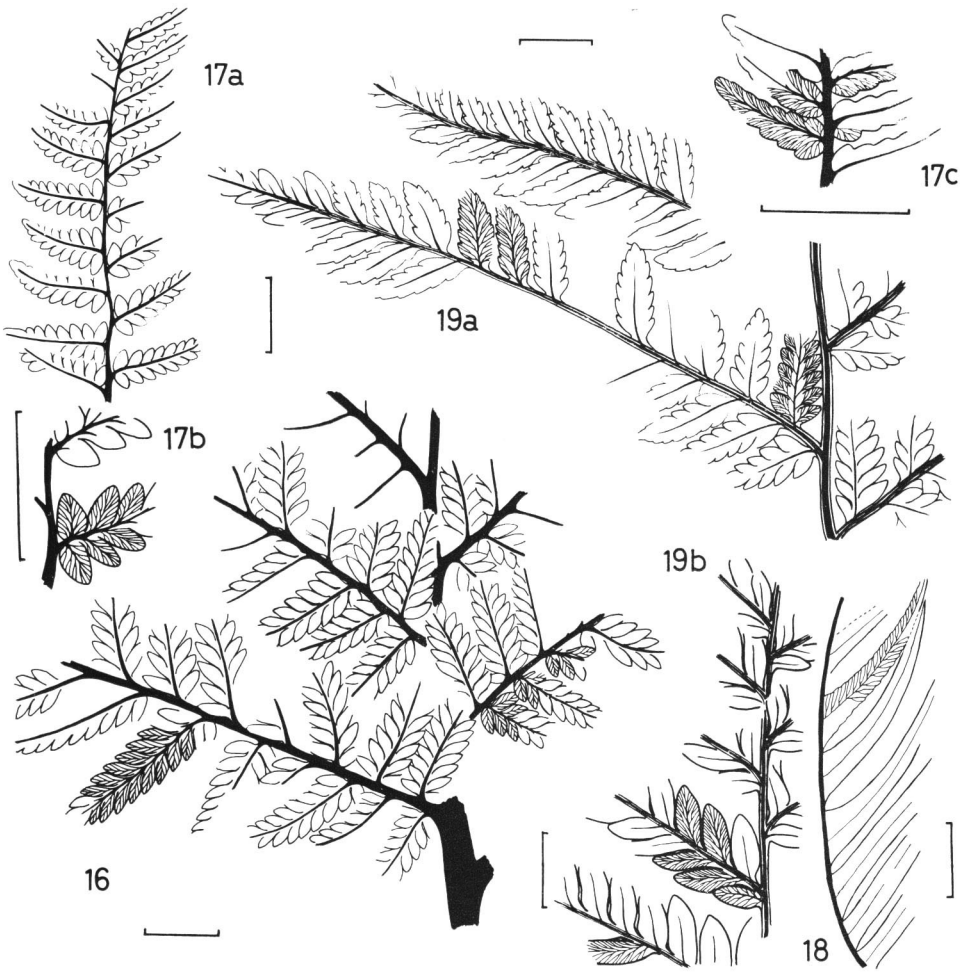
Description: Only several broken sterile pinnae are obtained. The pinnules are elongate-triangular in outline, falcate, attached to the pinna axis at an angle of 50 degrees and with acutely pointed apex and serrate margins on the distal half; each serration directed forward. Midnerve is distinct and sends off 7–8 pairs of once forked laterals; the first basiscopic one is forked twice.

Remarks: It is possible that the present pinnules represent the sterile ones of *Todites* sp. described in this paper. But in the fertile pinnules of the latter, the marginal serration is not discernible.

Cladophlebis sp. D

Fig. 16)

Material: NSM PP-8759～8770. *Horizons* and *localities*: Lower part of the Moné Formation (Loc. nos. 1, 3) and lower part of the Kogoshio Formation (Loc. no. 9). *Occurrence*: Rather rare.



Figs. 16–19. (Each bar indicates 1 cm scale) 16, *Cladophlebis* sp. D: A part of tripinnate leaf and venation; NSM PP-8763. 17, *Cladophlebis* sp. E: A part of sterile penultimate pinna (17a), venation enlarged (17b), and six apical lobed pinnae and venation (17c). 17a–b; NSM PP-8775, 17c; NSM PP-8774. 18, *Cladophlebis* sp. F: A poorly preserved pinna and venation; NSM PP-8791. 19, *Cladophlebis* sp. G: A leaf with lobed or dissected penultimate pinnae (19a), and pinnules on the apical penultimate pinna with entire margins (19b). 19a; NSM PP-8779, 19b; NSM PP-8777.

Description: The preserved portions of leaves are tripinnate. The rachis is thick, 4 mm wide and bears closely set penultimate pinnae alternately at a wide angle and at intervals of 2 cm. The ultimate pinnae are elongate-triangular, typically 2.5 cm long and 7 mm wide at base, attached alternately to the axis at a wide angle, and bear 8 pairs of closely set pinnules in katadromic order at an angle of about 40 degrees. The pinnules are typically elongate-ovoid, 4 mm long and 2 mm wide with obtusely pointed or rounded apices and with entire margins; the basal acroscopic one is slightly longer and wider than others. Venation is of *Sphenopteris*-type; the midnerve has 3–4 pairs of simple laterals directed forward.

Remarks: OISHI (1940) described a single broken leaf as *Cladophlebis concinna* (HEER) from Oshima (corresponding possibly to our Loc. no. 4). In general form, OISHI's pinnae resemble the present ultimate pinnae, but the former is twice as large as the latter and the lateral veins of the former are, according to OISHI (1940), once forked.

Cladophlebis sp. E

(Figs. 17a–c)

Material: NSM PP-8774～8776. *Horizon* and *locality*: Lower part of the Kogoshio Formation. Loc. no. 9. *Occurrence*: Very rere.

Description: The leaf is possibly tripinnate as seen from preserved material. The penultimate pinna axis is thin, 1 mm wide and bears alternately and remotely set ultimate pinnae at a wide angle and at intervals of 7 mm. The ultimate pinnae are elongate-triangular, slightly falcate and with rounded apex, typically 1.7 cm long and 6 mm wide. The lamina of pinnae is dissected into elongate-oblong pinnules with constricted base on the proximal half of a pinna, but is shallowly lobed on the apical half of a pinna; the pinnae on the apical part of the penultimate pinna are not dissected but shallowly lobed or entire. The pinnules are typically 3 mm long and 1.8 mm wide. Veins are of *Sphenopteris*-type. In the elongate-oblong pinnules, the midnerve sends off 3–4 pairs of once forked laterals; the first basiscopic lateral vein is usually originated directly from the ultimate pinna axis. In the undissected pinnae, the midnerve bears 7–8 pairs of twice forked laterals directed forward (Fig. 17c).

Remarks: The present leaves resemble those of *Cladophlebis parvula* originally described by OISHI (1940) from the Lower Cretaceous plant-bed in the Outer Zone of Japan. But in OISHI's species, pinnae are with acutely pointed apex and pinnules are directed forward with obtuse apex.

Cladophlebis sp. F

(Fig. 18)

Material: NSM PP-8788～8792. *Horizon* and *locality*: Lower part of the Kogoshio Formation. Loc. no. 9. *Occurrence*: Rather rare.

Description: Several pinna fragments were obtained. The pinnules are long and narrow, 3 cm long and 3 mm wide at middle, gradually narrowed to the acuminated apex, often falcate and with expanded base; margins are entire. The midnerve is distinct with 17–18 pairs of once forked laterals.

Remarks: The present leaves resemble those described by YABE (1922) as *Cladophlebis distans* (HEER) from Oshima (corresponding possibly to our Loc. no. 4). But it is difficult to make the precise specific identity between the two. Because both are poorly preserved. Typical sterile leaves referable to *Cladophlebis distans* are abundant in the Tetori-type floras in the Inner Zone of Japan.

Cladophlebis sp. G

(Figs. 19a–b)

Material: NSM PP-8777～8780. *Horizons* and *localities*: Lower and middle parts of the Kogoshio Formation. Loc. nos. 9 and 8. *Occurrence*: Rather rare.

Description: The leaves are tripinnate. The main rachis is thin, 1.7 mm wide with a median furrow, with alternate penultimate pinnae at an angle of about 50 degrees at intervals of 2.5 cm. The penultimate pinnae are elongate triangular in outline bearing 16–17 pairs of katadromically arranged ultimate pinnae at a wide angle. The proximal 1–2 pairs of ultimate pinnae on the middle-proximal portions of a leaf are dissected into small-sized triangular pinnules, but other ultimate pinnae are constricted at base and are with shallowly lobed or entire margins. Undissected pinnae are typically elongate-oval in form, 1.7 cm long and 4 mm wide at middle. The ultimate pinnae on the apical part of the leaf are smaller in size and not dissected. Venation is of *Cladophlebis*-type; in the small-sized pinnae, midnerve is distinct, having 6–7 pairs of once/twice forked laterals directed forward.

Remarks: The present leaves are characterized by varied forms of ultimate pinnae. So far as we know, similar sterile leaves have not been found from the Mesozoic plant-beds in East Asia.

Cladophlebis sp. H

(Figs. 20a–b)

Material: NSM PP-8716～8720. *Horizon* and *locality*: Lower part of the Kogoshio Formation. Loc. no. 9. *Occurrence*: Rare.

Description: Leaves are tripinnate as preserved. The main rachis is thick, 3.5 mm wide with the penultimate pinnae at right angles. The ultimate pinnae are alternate, long and narrow, closely set and attached to the penultimate pinna axis at an angle of 45 degrees. The pinnules are small-sized, semi-circular or oblong, katadromically arranged, set closely, 3 mm long and 1.5 mm wide, with entire margins. Venation is of *Sphenopteris*-type; the midnerve bears 3–4 pairs of simple laterals.

Remarks: The present leaf is characterized by thick main rachis, semi-circular or

oblong pinnae and the *Sphenopteris*-type venation. But, being poorly preserved its identity is difficult.

Cladophlebis sp. I

(Figs. 21a–b)

Material: NSM PP-8680～8682. *Horizon* and *locality*: Middle part of the Kogoshio Formation. Loc. no. 7. *Occurrence*: Rather rare.

Description: Several leaf/pinna fragments are obtained. The leaf is possibly tripinnate. The pinna axis is thin, 0.5 mm with alternate ultimate pinnae at an angle of about 45 degrees. The ultimate pinnae are lanceolate or elongate-triangular in outline, 2 cm long and 5 mm wide at base. The pinnules are in katadromic order, set closely, triangular in outline, directed forward, typically 3.5 mm long and 1.5 mm wide at middle and with entire margins. Venation is of *Sphenopteris*-type; the midnerve has 3–4 pairs of simple laterals.

The reproductive organ (sorus ?) is elliptical in form and superficial, located on the first acroscopic lateral vein, but its details are not known.

Remarks: The present leaves are characterized by their small size, triangular pinnules directed forward with superficial reproductive organs. Their identity is impossible, because of poor preservation.

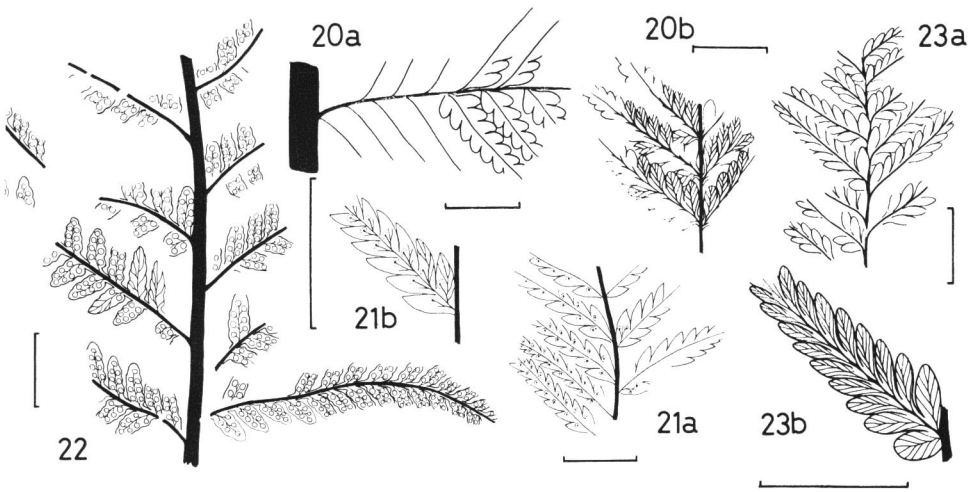
Cladophlebis sp. J

(Fig. 22)

Material: NSM PP-8683～8688. *Horizon* and *locality*: Lower part of the Moné Formation. Loc. no. 1. *Occurrence*: Rare.

Description: The preserved pieces of leaves are mostly fertile and bipinnate. The rachis is rather thick, 1.7 mm wide with remotely disposed alternate pinnae at an angle of about 45 degrees. The pinnae are lanceolate in outline, bending outward distally, typically 5 cm long and 8 mm wide at middle having about 15 pairs of pinnules in katadromic order. The pinnule is finger-shaped or elongate-deltoid, constricted at base, decurrent forming a narrow wing, with undulate margins. Venation is of *Cladophlebis*-type; the midnerve originates from the basiscopic side of the base of pinnule and develops 3–4 pairs of once forked or simple laterals. The reproductive organ (sorus ?) is 0.5–0.7 mm in diameter, superficial and located on each lateral vein. Details of reproductive organ are not known.

Remarks: The present leaves are characterized by comparatively large-sized reproductive organs. In external appearance, the present leaves resemble those of '*Polypodites polysorus*' PRYNADA described by KRASSILOV (1967) from the Lower Cretaceous of Southern Primorye.



Figs. 20–23. (Each bar indicates 1 cm scale) 20, *Cladophlebis* sp. H: A part of sterile penultimate pinna (20a) and venation (20b). 20a; NSM PP–8716, 20b; NSM PP–8717. 21, *Cladophlebis* sp. I: A poorly preserved fertile penultimate pinna (21a) and venation enlarged (21b); NSM PP–8680. 22, *Cladophlebis* sp. J: A part of poorly preserved fertile leaf; NSM PP–8683. 23, *Sphenopteris* sp. A: A part of poorly reserved leaf (23a) and venation enlarged (23b); NSM PP–8700.

Form-genus ***Sphenopteris*** STERNBERG, 1825

Sphenopteris sp. A

(Figs. 23a–b)

Material: NSM PP-8689～8700. *Horizons* and *localities*: Lower part of the Moné Formation (Loc. no. 3) and middle part of the Kogoshio Formation (Loc. no. 4). *Occurrence*: Rare.

Description: The leaves obtained are all tiny fragments. The main axis preserved is thin, 0.5 mm wide and sends off alternate and elongate-triangular ultimate pinnae at an angle of 45 degrees and at intervals of about 7 mm. The pinnules are katadromic in order, varied in form, finger-shaped proximally and asymmetrically rectangular distally; the basiscopic basal one is usually elliptical; margins are entire. Venation is of typical *Sphenopteris*-type and distinct; the midnerve shows 3–5 pairs of simple laterals directed forwars. The reproductive organ is superficial and without details.

Remarks: The present leaves are characterized by varied forms of pinnules and distinct *Sphenopteris*-type venation.

The persent leaves are distinct among the fern or fern-like leaves obtained from the Moné and Kogoshio Formations, but we refrain to make their specific identity, because of their poor preservation.

(To be continued)