

Middle Jurassic and Some Late Liassic Plants from the Toyora Group, Southwest Japan (I)

By

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(Communicated by Ikuwo OBATA)

Abstract Fossil plants are very abundant in the Middle Jurassic Utano Formation mainly of marine origin distributed to the south of the Tabe Fault, Yamaguchi Prefecture. In this paper we revised previous palaeobotanical works and described 50 plant-species belonging to 29 genera based mainly on a number of specimens newly obtained.

The flora of the upper Liassic Nishinakayama Formation directly underlying the Utano Formation consists all of southern-type elements. On the contrary, the flora of the Utano Formation characterized by the mixture of such northern elements as *Coniopteris*, *Onychiopsis elongata*, *Dictyozamites*, *Ginkgoites* and *Czekanowskia* and of such southern elements as *Phlebopteris*, *Acrostichopteris*, *Pachypteris*, *Otozamites* sp. cf. *O. klipsteinii*, *Zamites*, *Ptilophyllum*, *Nilssonia* sp. cf. *N. densinervis*, *Brachyphyllum* and *Araucarites*. The geological age of this flora is presumed to be not older than late Toarcian and no coeval flora has been found in the Japanese Islands. In addition we made in this paper detailed comparison of floristic features between the Utano flora and its coeval floras in China and other regions. Moreover we described five forms collected from the Nishinakayama Formation equivalent in this area.

Introduction and Acknowledgements

Through the Japanese Mesozoic, fossil plants are abundant in occurrence in each period, and most plant-beds are of marine origin or sandwiched in between the strata of marine origin. Thus as a matter of course geological age of the plants is far more precisely determined than that of those from the plant-beds of non-marine origin. However, Middle Jurassic plants in the Japanese Islands have only known from the Utano Formation, the youngest unit of the Toyora Group distributed in the western part of Yamaguchi Prefecture separated in northern and southern areas by the Tabe Fault of NW-SE direction (X-Y line in Fig. 1).

The Utano Formation in the northern area is of marine origin and is regarded in age as from Toarcian to Bathonian (HIRANO, 1971, '73) based on abundant ammonites and other invertebrate fossils. On the other hand the Utano Formation in the southern area is scanty of marine fossils but yields abundant fossil plants. Fossil plants in the southern area were first described by OISHI (1940) as from the Kiyosué Group. But according to the recent stratigraphical knowledge, his Kiyosué Group

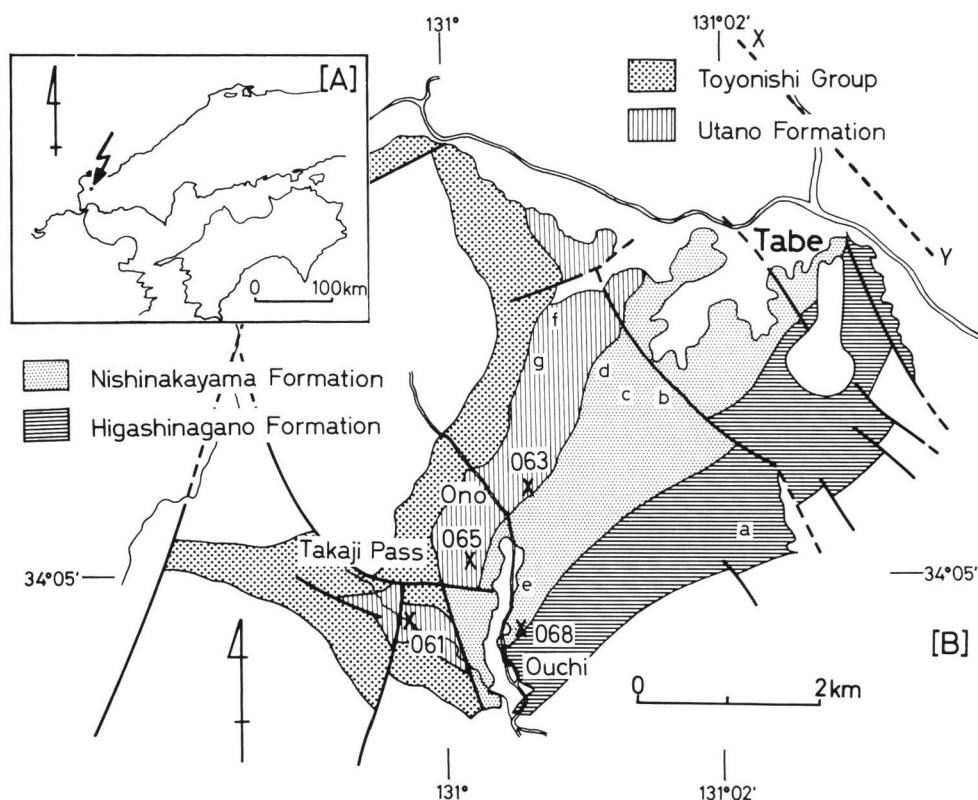


Fig. 1. [A] Map showing the studied area. [B] Brief geological map (after 'Geological maps of Yamaguchi Prefecture', Yamaguchi Prefecture, 1968) of the southern part of the Tabe Fault (X-Y), and the localities of fossil plants (061, 063, 065, 068, f- and g-points) and ammonites (a~e-points; according to the personal communication from TANABE). The boundary between the Higashinagano and Nishinakayama Formations in this area is now uncertain.

includes the real Utano Formation and the plant-bearing Kiyosué Formation (uppermost Jurassic or lowermost Cretaceous) of non-marine origin, the lower unit of the Toyonishi Group disconformably overlying the Utano Formation in this area (TAKAHASHI *et al.*, 1965).

According to TANABE (personal communication received 23rd June, 1986), he collected such ammonites as *Fucineras nakayamaensis* (MATSUMOTO) at a-point (Fig. 1), *Leioceratooides* sp. and *Protogrammoceras?* sp. at b-point (Fig. 1) and *Harpoceras* sp. at c- and d-points (Fig. 1).

TANABE (personal communication) mentioned that ammonite-fossils from a- and b-points indicated late Domerian-early Whitbian in age, and those from c- and d-points were not younger than Toarcian in age.

According to TAKAHASI *et al.* (1965) at e-point (Fig. 1) they recorded *Harpoceras okadai* (YOKOYAMA), *Fucinieras nakayamaensis* (MATSUMOTO) and *Dactylioceras cf. helianthoides* YOKOYAMA. This ammonite-assemblage is, according to TANABE (personal communication) late Domerian-early Whitbian in age. Taking TANABE's communication mentioned above and the geological structure in this area shown in Fig. 1 into consideration, the plant-bed indicated by our Loc. no. 068 is late Domerian-early Whitbian in age and those indicated by our Loc. nos. 061, 063 and 065 are possibly late Toarcian-Aalenian in age, and belong to the Nishinakayama and the lower part of the Utano Formations respectively.

According to TANABE's communication the Higashinagano Formation shown in Fig. 1 is included mostly into the Nishinakayama Formation.

A brief note on the Utano flora was mentioned by KIMURA, *et al.* (1986). Specimens here described are all kept in the National Science Museum, Tokyo.

We express our sincere gratitude to Mr. Gentaro NAITO for offering number of his specimens collected from the Utano Formation for our present study. Our thanks are extended to Prof. Hiromichi HIRANO, Waseda University and Assoc. Prof. Kazushige TANABE, Tokyo University for giving us their valuable and unpublished information on stratigraphy and palaeontology in the studied area. We are much indebted to Dr. Ikuwo OBATA, director of Department of Geology, National Science Museum, Tokyo for giving us the facilities to publish this paper.

Previous Works

The following taxa have been recorded from the same localities as ours and Toriyama (f-point in Fig. 1) and Nanami (g-point in Fig. 1) by the previous authors. Both f- and g-points are considered to belong to the middle-upper parts of the Utano Formation (*; list only, thus neglected in this paper. =; revised by us in this paper. **; accepted by us in this paper. ***; locality uncertain, thus neglected in this paper):

Marchantites yabei KRYSHTOFOVICH (OISHI, 1940, p. 185)** = *Thallites yabei* (KRYSHTOFOVICH) HARRIS (Loc. no. possibly 061; not found in our collection)

Equisetites endoi KON'NO (KON'NO, 1962, p. 31, figs. 3A-C)**

E. sp. (TAKAHASI, 1973b)*

Phlebopteris sp. (TAKAHASI *et al.*, 1965, pl. 2, fig. 2)** (Loc. no. possibly 063)

Coniopteris burejensis (ZALESSKY) SEWARD (OISHI, 1940, p. 209)***

C. hymenophylloides (BRONGNIART) SEWARD (TAKAHASI, 1973b)*

Cladophlebis denticulata (BRONGNIART) (OISHI, 1940, p. 257) = *C. sp. B* (Loc. no. possibly 061 and g-point)

C. cf. distans (HEER) YABE (TAKAHASI, 1973b)*

C. exiliformis (GEYLER) OISHI (TAKAHASI *et al.*, 1965, pl. 2, fig. 4) = *Gleichenites?* sp. (Loc. no. possibly 063 and f- and g-points)

C. lobifolia (PHILLIPS) BRONGNIART (TAKAHASI, 1973b)*

C. toyoraensis OISHI (OISHI, 1940, p. 291, pl. 23, figs. 4-5)** (Loc. no. possibly 061)

Adiantites sewardi YABE (OISHI, 1940, p. 235) = *Adiantopteris* sp. (Loc. no. possibly 061)

A. toyoraensis OISHI [OISHI, 1940, p. 235 (pars), pl. 7, figs. 2-3] = *Adiantopteris toyoraensis* (OISHI) VASSILEVSKAYA (Loc. no. possibly 061)

- Onychiopsis elongata* (GEYLER) YOKOYAMA (OISHI, 1940, p. 228, pl. 6, figs. 1–4)** (Loc. no. possibly 061); (TAKAHASI *et al.*, 1965, pl. 2, fig. 3)** (Loc. no. possibly 063 and f- and g-points); (TAKAHASI, 1973a, p. 8, pl. 2, fig. 1)** (Loc. no. possibly 063)
- Sphenopteris goepperti* DUNKER (OISHI, 1940, p. 238, pl. 8, fig. 4)=*S.* sp. C (Loc. no. possibly 063 and g-point)
- Sagenopteris petiolata* OISHI (TAKAHASI *et al.*, 1965, pl. 3, fig. 9)** (Loc. f-point)
- Otozamites beani* (LINDLEY et HUTTON) BRONGNIART (OISHI, 1940, p. 328, pl. 29, figs. 7–8a)=*O.* sp. cf. *O. klipsteinii* (DUNKER) SEWARD (Loc. no. possibly 061)
- O. klipsteinii* (DUNKER) SEWARD (OISHI, 1940, p. 331, pl. 29, fig. 8b; pl. 30, fig. 6; pl. 31, fig. 2)=*O.* sp. cf. *O. klipsteinii* (DUNKER) SEWARD (Loc. no. possibly 061)
- Dictyozamites kawasakii* TATEIWA (TAKAHASI *et al.*, 1965, pl. 2, fig. 7; pl. 3, fig. 2)=*D. naitoi* KIMURA et OHANA sp. nov. (Loc. no. possibly 063)
- D. tateiwa* OISHI (TAKAHASI *et al.*, 1965, pl. 2, figs. 8–14; pl. 3, fig. 1)=*D. naitoi* KIMURA et OHANA sp. nov. (Loc. no. possibly 063)
- Pterophyllum propinquum* GOEPPERT (TAKAHASI, 1951b, p. 192, fig. 3)=*P. heterosegmentum* KIMURA et OHANA sp. nov. (Loc. no. possibly 061 and 063)
- Zamiophyllum buchianum* (ETTINGSHAUSEN) NATHORST (OISHI, 1940, p. 354)=*Zamites* sp. B (Loc. no. possibly 061)
- Cf. *Zamites megaphyllum* (PHILLIPS) SEWARD (OISHI, 1940, p. 357)=? (Loc. no. possibly 061)
- Z. yabei* OISHI (TAKAHASI *et al.*, 1965, pl. 3, figs. 6–8)** (Loc. no. 063 and f-point)
- Ptilophyllum pecten* (PHILLIPS) MORRIS (OISHI, 1940, p. 348, pl. 32, fig. 4)=*P.* sp. cf. *P. cutchense* MORRIS (Loc. nos. possibly 061 and 063)
- P. pachyrachis* OISHI (TAKAHASI *et al.*, 1965, pl. 3, fig. 5)=*Pterophyllum* sp. (Loc. no. possibly 063 and f-point)
- P.* ? sp. (TAKAHASI, 1973b)*
- Pseudocycas* sp. (TAKAHASI, 1951b, p. 192, fig. 2; TAKAHASI *et al.*, 1965, pl. 3, fig. 4)=*Zamites varius* KIMURA et OHANA sp. nov. (Loc. no. possibly 063)
- Pseudocycas*? sp. (TAKAHASI, 1951b, p. 192, fig. 3)=*Cycadites* sp. (Loc. no. possibly 063)
- Nilssonia compta* (PHILLIPS) (TAKAHASI, 1973b)*
- N. densinerve* (FONTAINE) BERRY (OISHI, 1940, p. 300, pl. 24, fig. 2)=*N.* sp. cf. *N. densinervis* (FONTAINE) BERRY (Loc. no. possibly 063)
- N. nipponensis* YOKOYAMA (OISHI, 1940, p. 306, pl. 27, figs. 3–4)=*N.* sp. (Loc. no. possibly 061)
- N. orientalis* HEER (OISHI, 1940, p. 310)=possibly *N.* sp. cf. *N. densinervis* (FONTAINE) BERRY (Loc. no. possibly 061 and g-point)
- N. schauburgensis* (DUNKER) NATHORST var. *parvula* YABE (TAKAHASI, 1973b)*
- N.* sp. (TAKAHASI, 1973b)*
- Cf. *Pseudoctenis brevipennis* OISHI (TAKAHASI, 1951b, p. 191, fig. 1; TAKAHASI *et al.*, 1965, pl. 2, fig. 6)=*Zamites varius* KIMURA et OHANA sp. nov. (Loc. no. possibly 061)
- P. lanei* THOMAS (TAKAHASI, 1973b)*
- P.* sp. (TAKAHASI, 1973b)*
- Ginkgoites digitata* (BRONGNIART) SEWARD (TAKAHASI, 1973b)*
- G. sibirica* (HEER) SEWARD (OISHI, 1940, p. 380, pl. 38, fig. 11)=*G.* ex gr. *sibiricus* (HEER) SEWARD (Loc. no. possibly 061)
- Czekanowskia rigida* HEER (OISHI, 1940, p. 384, pl. 39, figs. 6–7)=*C.* ex gr. *rigida* HEER (Loc. no. possibly 061)
- Brachyphyllum expansum* (STERNBERG) SEWARD (OISHI, 1940, p. 391, pl. 39, figs. 10–11; pl. 40, fig. 9); TAKAHASI *et al.*, 1965, pl. 3, figs. 10–11)=*B.* ex gr. *expansum* (STERNBERG) SEWARD (Loc. nos. possibly 061, 063 and f- and g-points)
- B. toyoraensis* TAKAHASI (TAKAHASI, 1951a, p. 29, text-figs. 1–3)=? (Loc. no. possibly 061)
- B.* sp. (TAKAHASI, 1973b)*

- Araucarites cutchensis* FEISTMANTEL (OISHI, 1940, p. 387, pl. 39, figs. 8–9)=*A. cf. cutchensis* FEISTMANTEL (Loc. no. possibly 061)
- Elatocladus constricta* (FEISTMANTEL) OISHI (OISHI, 1940, p. 393, pl. 39, fig. 12; pl. 41, figs. 2–5)=*E. sp.* (Loc. nos. possibly 061, 063 and g-point)
- Palissia sp.* (TAKAHASI, 1973b)*
- Nageiopsis longifolia* FONTAINE [OISHI, 1940, p. 400 (pars), pl. 43, fig. 1]=*Zamites varius* KIMURA et OHANA sp. nov. (Loc. no. possibly 063)
- Cf. *Podozamites distantinervis* FONTAINE (OISHI, 1940, p. 405, pl. 43, fig. 4)=possibly *Zamites varius* KIMURA et OHANA sp. nov. (Loc. no. possibly 063)
- Podozamites lanceolatus* (LINDLEY et HUTTON) BRAUN (TAKAHASI, 1973b)*
- P. sp.* (TAKAHASI, 1973b)*
- Taeniopteris cf. richtohofeni* (SCHENK) (TAKAHASI, 1973a, p. 8, pl. 2, figs. 2–4)=*T. sp. cf. T. richtohofeni* (SCHENK) SZE (Loc. no. possibly 063)
- Carpolithus yamadai* TAKAHASHI (TAKAHASHI, 1973a, p. 8, pl. 2, fig. 5)** (Loc. no. possibly 063)
- C. spp.* (TAKAHASI, 1973a, p. 8, pl. 2, figs. 6–7)** (Loc. no. possibly 063)

List of Fossil Plants from the Utano Formation Distributed to the South of the Tabe Fault

The following taxa are recognized among our collection and are accepted from the previous works (**; taxon accepted in this paper, but not found in our collection):

1. *Thallites yabei* (KRYSHTOFOVICH) HARRIS**
2. *Equisetites endoi* KON'NO
3. *Gleichenites* ? sp.**
4. *Phlebopteris* sp.
5. *Coniopteris* sp.
6. *Polypodites* ? sp. A
7. *P.* ? sp. B
8. *Cladophlebis naitoi* KIMURA et OHANA sp. nov.
9. *C. toyoraensis* OISHI
10. *C. sp. A*
11. *C. sp. B*
12. *C. sp. C*
13. *Acrostichopteris* sp. cf. *A. longipennis* FONTAINE
14. *A. naitoi* KIMURA et OHANA sp. nov.
15. *Adiantopteris toyoraensis* (OISHI) VASSILEVSKAJA**
16. *A. sp. A*
17. *A. sp. B*
18. *Onychiopsis elongata* (GEYLER) YOKOYAMA
19. *Sphenopteris* sp. A
20. *S. sp. B*
21. *S. sp. C*
22. *S. sp. D*
23. *S. sp. E*
24. *S. sp. F*
25. *Sagenopteris petiolata* OISHI**
26. *Pachypteris* sp.
27. *Ctenozamites fukutomii* KIMURA et OHANA sp. nov.
28. *Anomozamites fukutomii* KIMURA et OHANA sp. nov.
29. *Otozamites* sp. cf. *O. klipsteinii* (DUNKER) SEWARD
30. *Dictyozamites naitoi* KIMURA et OHANA sp. nov.
31. *Pterophyllum heterosegmentum* KIMURA et OHANA sp. nov.
32. *P. sp.***
33. *Zamites varius* KIMURA et OHANA sp. nov.
34. *Z. yabei* OISHI**
35. *Z.* ? sp. A
36. *Z.* ? sp. B
37. *Z.* ? sp. C
38. *Ptilophyllum* sp. cf. *P. cutchense* MORRIS
39. *P. sp.*
40. *Williamsonia* sp.
41. *Nissonia* sp. cf. *N. densinervis* (FONTAINE) BERRY
42. *N. sp.*
43. *Cycadites* sp.
44. *Ginkgoites* ex gr. *sibiricus* (HEER) SEWARD**
45. *Czekanowskia* ex gr. *rigida* HEER**
46. *Brachyphyllum* ex gr. *expansum*

- | | |
|--|---|
| (STERNBERG) SEWARD | SZE** |
| 47. <i>Araucarites</i> sp. cf. <i>A. cutchensis</i> | 50. <i>T.</i> sp. |
| FEISTMANTEL | 51. <i>Carpolithus yamadai</i> TAKAHASI** |
| 48. <i>Elatocladus</i> sp.** | 52. <i>C.</i> spp. |
| 49. <i>Taeniopteris</i> sp. cf. <i>T. richthofeni</i> (SCHENK) | |

List of Fossil Plants from the Nishinakayama Formation Equivalent Distributed to the South of the Tabe Fault

The following five taxa are recognized among our collection (Loc. no. 068):

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| 1. <i>Gleichenites</i> ? sp. | (STERNBERG) SEWARD |
| 2. <i>Sphenopteris</i> sp. B | 5. <i>Araucarites</i> sp. cf. <i>A. cutchensis</i> |
| 3. <i>Ctenozamites</i> ? sp. | FEISTMANTEL |
| 4. <i>Brachyphyllum</i> ex gr. <i>expansum</i> | |

Characteristic of the flora of the Utano Formation

KIMURA *et al.* (1986) described fossil plants collected from the Nishinakayama Formation distributed to the north of the Tabe Fault as follows: *Phlebopteris* sp., *Otozamites micropinnatus* KIMURA, NAITO et OHANA, *O.* sp. A, *O.* sp. B, *Zamites toyoraensis* OISHI, *Z.* sp., *Pseudecten* sp., *Brachyphyllum* ex gr. *expansum* (STERNBERG) SEWARD, *Cupressinocladus* sp. A, *C.* sp. B, *Elatides* sp. and *Geinitzia* sp. These fossil plants are coexisted in occurrence with rich ammonites indicating Pliensbachian-early Toarcian in age (HIRANO, 1971, '73).

This florula is nearly coeval with the Kuruma flora distributed in the central part of Japan described in detail by KIMURA and TSUJII (1980a, b, '81, '82, '83, '84). The Kuruma flora is characterized by the presence of 1) various osmundaceous, dicksoniaceae and dipteridaceous ferns, 2) various cycadophytes, 3) ginkgo leaves and various czezanowskialeans and 4) abundant *Podozamites* leafy shoots and by the absence of such conifers with scale-leaves as *Cupressinocladus* and *Brachyphyllum*.

While the Nishinakayama florula is characterized by the various conifers with scale-leaves and by the absence of dipteridaceous ferns, ginkgo leaves, czezanowskialeans and *Podozamites*. It is worth mentioning that there is no common species between the Nishinakayama florula and the Kuruma flora. The same is in ammonites. According to HIRANO (personal communication), the rich ammonite-fauna of the Kuruma Group is of the boreal-type and that of the nearly coeval Nishinakayama Formation of the Tethys-type and there is only a single common genera between the Kuruma Group and the Nishinakayama Formation. Obviously the Nishinakayama florula is of southern-type but not of the Gondwana-type.

During the Late Jurassic and Early Cretaceous time we have two distinct floras in the Japanese Islands except the Toyora District, Yamaguchi Prefecture where the fossiliferous Toyora Group of marine origin is distributed; the Tetori-type floras in the Inner Zone (northern) of Japan and the Ryoseki-type floras in the Outer Zone (southern) of Japan (KIMURA, 1980, '84).

The Tetori-type floras are characterized by the presence of 1) various osmund-

aceous, dicksoniaceus ferns including *Raphaelia*, 2) various cycadophytes except *Zamites*, *Ptilophyllum* and *Nilssonia schauburgensis*-type leaves, 3) various ginkgo leaves and czekanowskialeans and 4) various *Podozamites* leafy shoots and conifers with needle-like leaves, and by the absence of 1) matoniaceous ferns conifers with scale-like leaves.

The Ryoseki-type floras are characterized by the presence of 1) matoniaceous ferns including *Weichselia*, 2) various *Zamites*, *Ptilophyllum* and *Nilssonia schauburgensis*-type leaves and 3) various conifers with scale-leaves and by the absence or scantiness of dicksoniaceus ferns and by the absence of 1) other older Mesozoic-type cycadophytes such as *Ctenis* and 2) ginkgo leaves, czekanowskialeans and *Podozamites*.

The Utano flora is characterized by the mixture of both the Inner Zone- and Outer Zone-type elements. Obvious Inner Zone-type elements are: *Coniopteris* sp., *Onychiopsis elongata* (see KIMURA and AIBA, 1986), *Ginkgoites* ex gr. *sibiricus* and *Czekanowskia* ex gr. *rigida*, though the last two are very rare in occurrence and not found in our vast collection.

Obvious Outer Zone-type elements are: *Phlebopteris* sp., *Acrostichopteris* sp. cf. *A. longipennis*, *A. naitoi*, *Pachypteris* sp., *Otozamites* sp. cf. *O. klipsteinii*, *Zamites varius*, *Z. yabei*, *Z. ?* sp. A, *Z. ?* sp. B, *Z. ?* sp. C, *Ptilophyllum* sp. cf. *P. cutchense*, *P. sp.*, *Nilssonia* sp. cf. *N. densinervis*, *Brachyphyllum* ex gr. *expansum* and *Araucarites* sp. cf. *A. cutchensis*. As mentioned above, it is obvious that the Utano flora is characterized by the predominance of the Outer Zone-type elements. Such mixing is recognized in the floras of the Kiyosué Formation (Uppermost Jurassic or Lowermost Cretaceous), Toyonishi Group distributed directly to the west of the Utano Formation in this area, and of the Lower Gyeongsang Group (Nadgong Formation; Lower Cretaceous) in South Korea, and also those of middle Lower Cretaceous plantbeds in Southern Primorye, eastern part of NE-China and northern-northwestern parts of China and Mongolia (KIMURA, 1986).

Accordingly such mixing in East Asia is considered to be first originated just after the deposition of the Nishinakayama Formation (late Domerian-early Whitbian in age) at the Toyora District, Yamaguchi Prefecture. The Utano flora is further characterized by the presence of various fern-like plants with *Sphenopteris*-type venation. It is highly probable that some of them belong to pteridosperms.

Comparison of the Utano Flora with Coeval Floras in East Asia

Unfortunately no coeval flora has been known in the Japanese Islands and Southern Primorye. Fig. 2 shows the distribution of Middle Jurassic fossil plant-localities according to ZHANG, Z. C. (1985) on the palaeogeographical map during the Early-Middle Jurassic time shown by CHEN, P. J. (1985).

Middle Jurassic floras in China are known mostly from the non-marine deposits except the lower part of the Longzhaogou Group partly of marine origin (Loc. no. 30 in Fig. 2). Accordingly it is difficult to determine the precise age of these floras.

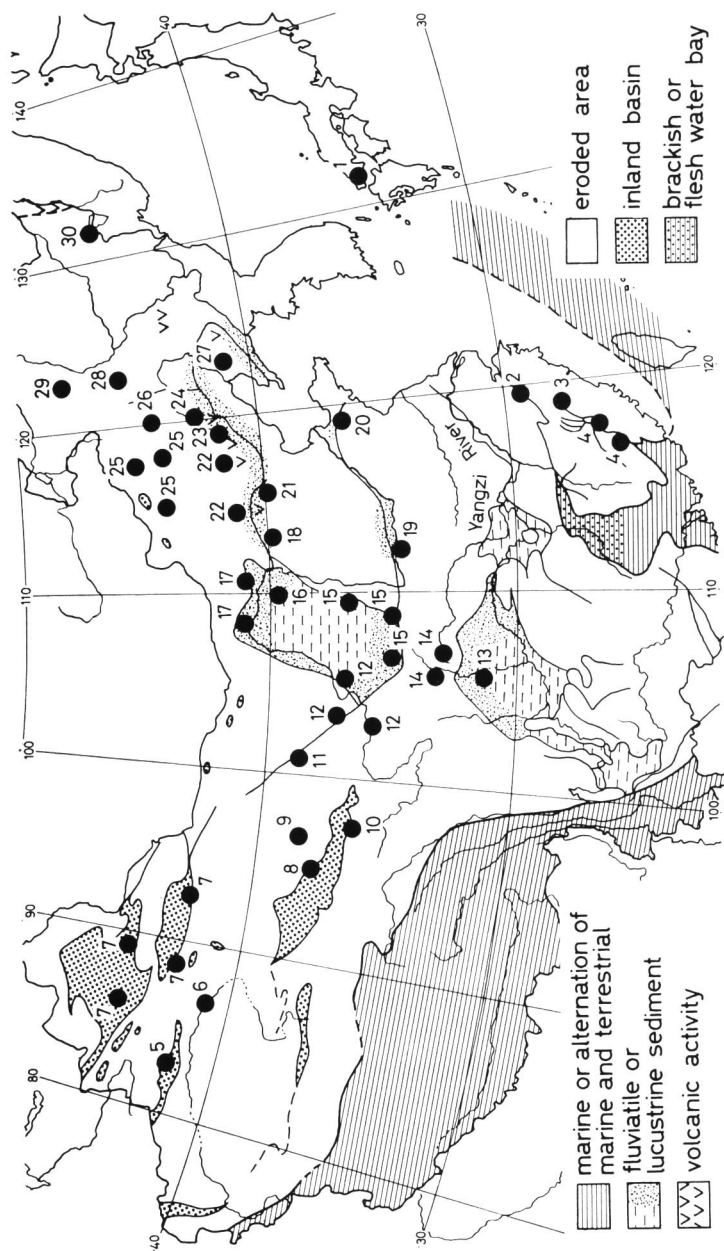


Fig. 2. Palaeogeographical map during Early and Middle Jurassic in China (after CHEN, P. J., 1985) and the main localities of Middle Jurassic plants in China (after ZHANG, Z. C., 1985) and Japan. (F; Formation, G; Group) 1. Utano F., Yamaguchi Prefecture. 2. Yushanjiang F., Zhejiang. 3. Maonong F., W-Zhejiang. 4. Zhangping F., Fujian. 5. Kejileinuer F., N-Talimu, Xinjiang. 6. Tashendian F., Boshentenghu, Xinjiang. 7. Xishanyao F. (Shuixigou G.), S-Zhungegar Basin, Xinjiang. 8. Dameigou F., N-Caidamu Basin, Xinjiang. 9. Dashankou G., W-Gansu. 10. Jiucang F., Tianjun, Qinghai. 11. Qingtujing F., Alashan, Neimeng (Inner Mongolia). 12. Yaojie F., Lanzhou, Gansu. 13. Qiantoyan F., N-Sichuan. 14. Longjiagou F., SE-Gansu and S-Shaanxi. 15. Yanan and Zhiluo F., N-Shaanxi and Huating, Gansu. 16. Dongsheng F., Yikezhaomeng, Neimeng. 17. Shaogou F. (Shiguai G.), Baotou, Neimeng. 18. Dadong and Yungang F., Dadong, Shanxi. 19. Yima F., W-Henan. 20. Fangzi F., Shandong. 21. Yaopo and Longmen F., Xishan, Beijing. 22. Xiahuayuan and Shicheng F. and Middle Luaping G., N-Hebei (Some Chinese geologists regard the Xiahuayuan F. as Late Liassic and the Luaping G. as Late Jurassic in age). 23. Guojidian F., Lingyuan, W-Liaoning. 24. Haifanggou and Lanqi F., W-Liaoning. 25. Alatangeli G. (Manitemiao G.), Xilin, Neimeng. 26. Yingzi and Xinmin F., Zhaowudamengta, Neimeng. 27. Dabao F., E-Liaoning. 28. Wanbao F., W-Jilin. 29. Yanjiagou G., Daxinganling, Heilongjiang. 30. Lower part of Longzhaogou G., E-Heilongjiang.

As a whole, Middle Jurassic floras distributed to the north of the Yangzi (or Yangtze) River (Loc. nos. 5~30 in Fig. 2) are different in floristic composition from the Utano flora. Because these floras are characterized by the predominance of dicksoniaceous and dipteridaceous ferns, ginkgo leaves, czekanowskialeans and *Podozamites*, and by the absence of *Zamites* and *Ptilophyllum*, and the absence or rarity of conifers with scale-leaves.

In South China, according to ZHANG, Z. C. (1985), the Yushanjiang Formation (Loc. no. 2 in Fig. 2) yields the following fossil plants (list only): *Equisetites* sp., *Neocalamites* sp., *Coniopteris burejensis* (ZALESSKY) SEWARD, *C. hymenophylloides* (BRONGNIART) SEWARD, *C. quinqueloba* (PHILLIPS) SEWARD, *C. simplex* (LINDLEY et HUTTON) HARRIS, *Klukia* cf. *exilis* (PHILLIPS) RACIBORSKI, *Scleropteris* sp., *Cladophlebis* cf. *argutula* (HEER), *C. denticulata* (BRONGNIART), *C. sp.*, *Sphenopteris* sp., *Anomozamites* sp., *Pterophyllum* sp., *Ptilophyllum* sp., *Nilssonia* sp., *Ginkgoites* sp., *Baiera* sp., *Pagiophyllum* sp., Cf. *Thomasiocladus zamioides* (LECKENBY) FLORIN and *Podozamites lanceolatus* (LINDLEY et HUTTON) BRAUN.

So far as the above list is concerned, this flora is characterized by the presence of various dicksoniaceous ferns and its most taxa are of the northern-type except for *Ptilophyllum* sp. Thus this flora differs in floristic composition from the Utano flora. Accordingly there is no coeval flora in China similar in floristic composition to the Utano flora.

Comparison of the Utano Flora with Coeval or Nearly Coeval Floras in Other Regions

1) Yorkshire flora

Detailed description of the Yorkshire flora was made by HARRIS (1961, '64, '69, '79) and HARRIS *et al.* (1974). We are of the opinion that the Yorkshire flora is characterized by the mixture of nearly the same number of both northern and southern (not Gondwana) elements. However, the Yorkshire flora differs from the Utano flora because the Yorkshire flora is characterized by the presence of various dicksoniaceous ferns, ginkgo leaves and czekanowskialeans and of *Podozamites* (*Lindleycladus*).

2) Flora of the upper part of Shemshak Formation (North Iran)

This flora was described by BARNARD and MILLER (1976) in detail. They recognized 27 species in this flora. We are of the opinion that this flora is fundamentally of the southern-type (not Gondwana), though its scantiness of pteridophytes, and thus this flora differs in floristic composition from the Utano flora.

3) Late Liassic-early Middle Jurassic flora in Karatau, South Kazakhstan

This flora was described by DOLUDENKO and ORLOVSKAJA (1976) in detail. This flora is fundamentally of the northern-type and differs in floristic composition from the Utano flora. However, it is worth mentioning that in this area both northern- and southern-types of elements are mixed in the Upper Jurassic plant-beds.

4) Middle Jurassic flora of the Orsk Coal-Basin, East Ural

In this flora 90 taxa or forms were described by GENKINA (1963). We are of the opinion that this flora is fundamentally of the northern-type, but includes two types of matoniaceous ferns and three *Ptilophyllum* species. But this flora differs from the Utano flora, because this flora contains various dicksoniaceous ferns, ginkgo leaves, czekanowskialeans and conifers with needle-like leaves.

5) Middle Jurassic flora of Mangwishlak

In this flora, PROSVIRJAKOVA (1966) described 64 taxa. This flora is characterized by the presence of various dicksoniaceous and dipteridaceous ferns, ginkgo leaves, czekanowskialeans, *Podozamites* and conifers with needle-like leaves together with three species of *Ptilophyllum*. We are of the opinion that this flora is fundamentally of the northern-type and differs in floristic composition from the Utano flora.

6) LORCH (1967) described interesting fossil plants from the Bathonian-Bajocian plant beds of marine origin in Israel as follows: *Equisetum columnare* BRONGNIART, *Piazopteris branneri* (WHITE) LORCH (Matoniaceae), *Sellingia microloba* LORCH (Schizaeaceae), *Onychiopsis tenuiloba* LORCH, *Aspidistes beckeri* LORCH, *Sphenopteris* cf. *fittoni* SEWARD, Cf. *Cladophlebis stricta* CARPENTIER, *Otozamites ramonensis* LORCH, *O. feistmanteli* ZIGNO, *O.* cf. *mimetes* HARRIS, Cf. *Ptilophyllum actifolium* MORRIS, *P.* cf. *cutchense* MORRIS, *P.* sp., *Williamsonia atractylis* LORCH, *Elatocladus ramonensis* LORCH, *Brachyphyllum* cf. *mamillare* BRONGNIART, Cf. *Podozamites* sp. and two types of seeds.

So far as the above list is concerned, we are of the opinion that this flora is of the southern-type except for a doubtful record of Cf. *Podozamites* sp.

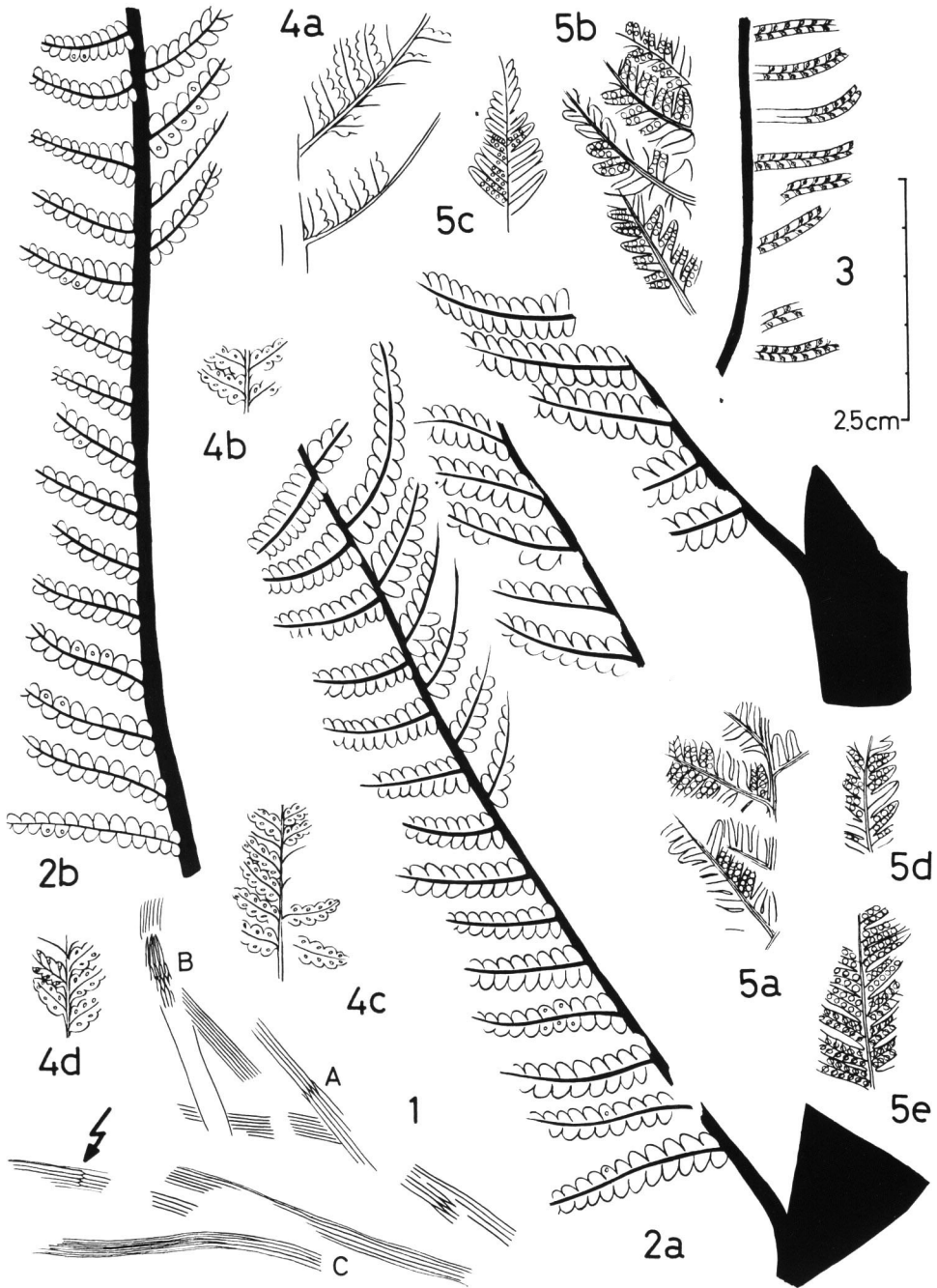
7) In Siberia, most Middle Jurassic floras are, according to VAKHRAMEEV (1966), characterized by their uniformity and the predominance of various *Coniopteris* (Dicksoniaceae) species, *Raphaelia*, ginkgo leaves, czekanowskialeans, *Podozamites* and *Pityophyllum* (needle-like leaves of conifers) and by the absence of *Otozamites*, *Zamites*, *Dictyozamites*, *Sphenozamites* and *Cycadites*.

8) Middle Jurassic flora of Mexico

This flora described by PERSON and DELEVORYAS (1982) from Oaxaca, Mexico is rather close in floristic character to the Utano flora, because this flora contains a few northern-type elements (*Coniopteris*) and many southern-type taxa such as *Piazopteris*, *Zamites* and *Ptilophyllum*. However, the Utano flora is unique in its floristic com-

Text-figs. 1-5 ($\times 2/3$).

1. *Equisetites endoi* KON'NO: Drawn from NSM-PP 7959. Loc.; about 500 m NW of Loc. no. 063.
2. *Gleichenites?* sp.: Loc.; 068. 2a. Drawn from NSM-PP 7963. 2b. Drawn from a counterpart of NSM-PP 7963.
3. *Phlebopteris* sp.: Drawn from NSM-PP 7965. Loc.; 063.
4. *Polypodites?* sp. A: Loc.; 063. 4a-d. Drawn from NSM-PP 7969, 7967, 7971 and 3690 respectively.
5. *Polypodites?* sp. B: Loc.; 063. 5a-e. Drawn from NSM-PP 7972, 7976, 7972 and 7973 respectively.



position and so far as we know, there is no coeval flora closely comparable or being agreed with it. Now we have much knowledge about the Jurassic floras in Eurasia and other regions. We will make our detailed floristic analyses about the Jurassic floras in our separate paper to provide effective materials for the geotectonics and land-drifts in this period.

Systematic Description

Specimens here described are kept in the National Science Museum, Tokyo.

Pteridophyta

Equisetales

Genus *Equisetites* STERNBERG, 1833: 43

Equisetites endoi KON'NO

Text-fig. 1

Equisetites endoi KON'NO: KON'NO, 1962, p. 31, figs. 3A–C (According to KON'NO, these specimens were said to be collected from Ochi; middle part of the Utano Formation. This locality would correspond to that of our Loc. no. 063).

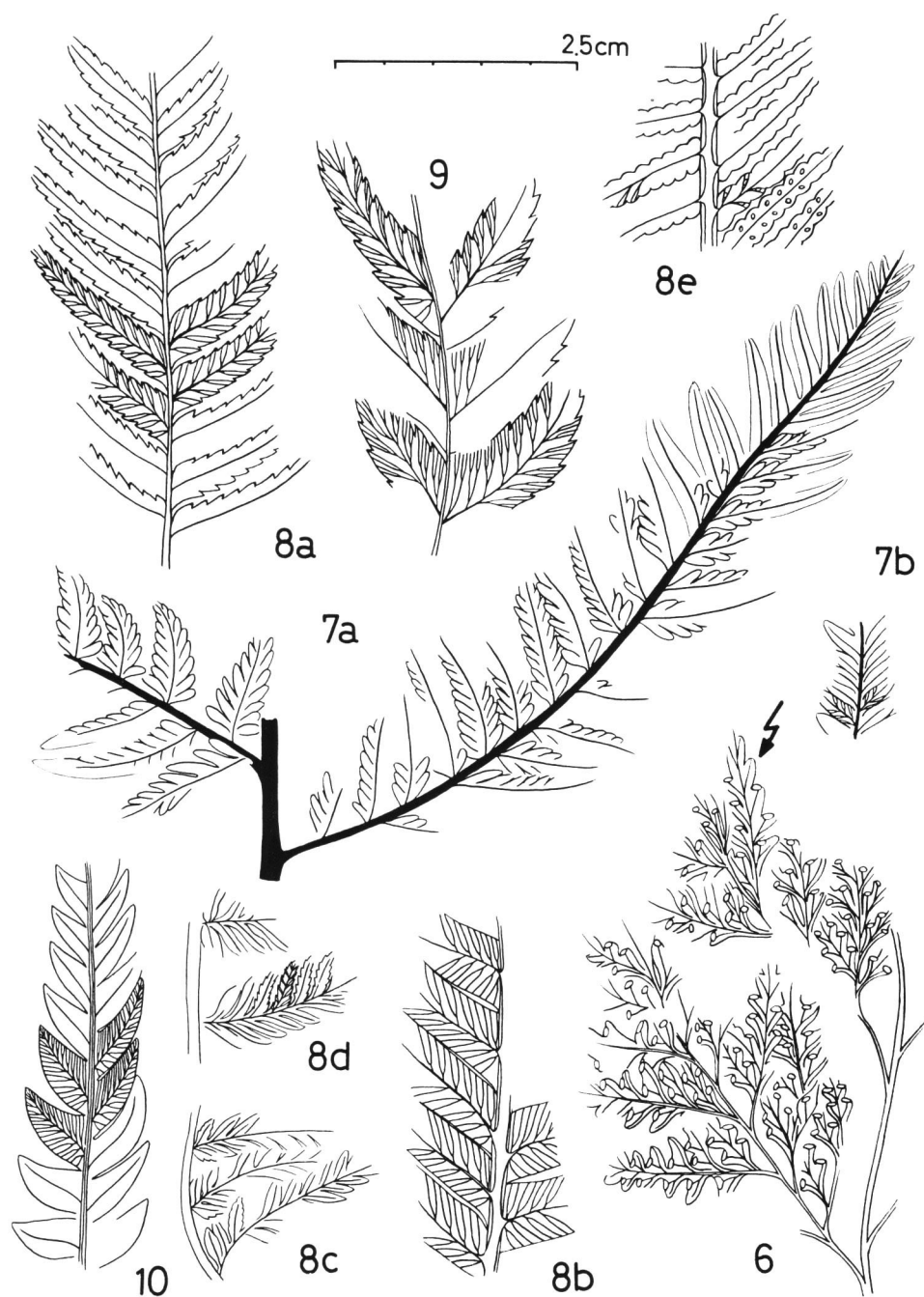
Material: NSM-PP 7957~7962, and many other fragments of aerial branches and rhizomes (about 500 m NW of Loc. no. 063). *Occurrence*: Locally common.

Description: Obtained are impressions of lateral aerial branch- and rhizome-fragments in pieces. Text-fig. 1a shows an aerial branch with nodal region without scars of further lateral branches. Text-fig. 1b shows an apical part (bud ?) of lateral branch showing three nodes with very short internodes and converging leaves at the tip. Text-fig. 1c possibly shows rhizomes with a nodal region (pointed by an arrow) but without tubers.

Remarks: Our specimens are all incomplete, but those shown in Text-fig. 1a agree well with the lateral aerial branches of *Equisetites endoi* originally described by KON'NO (1962) from the Loc. no. 63 in their size, form and leaf-sheath composed of eight characteristic leaf-segments. KON'NO (1962) made the detailed comparison of *Equisetites endoi* with such younger Mesozoic species as *E. ushimarensis* (YOKOYAMA), *E. nakdongensis* TATEIWA, *E. burchardti* (DUNKER) and *E. yokoyamae* SEWARD. All of them have rhizomes with distinct tubers.

Text-figs. 6–10 ($\times 2/3$).

6. *Coniopteris* sp.: Drawn from NSM-PP 7966. Loc.; 063.
7. *Cladophlebis naitoi* KIMURA et OHANA sp. nov.: Loc.; 063. 7a–b. Drawn from NSM-PP 7978 (holotype) and 7980 (paratype).
8. *Cladophlebis toyoraensis* OISHI: Loc.; 063. 8a–e. Drawn from NSM-PP 7987, 7992, 7998, 7994 and 7997 respectively.
9. *Cladophlebis* sp. A: Drawn from NSM-PP 7999. Loc.; 063.
10. *Cladophlebis* sp. B: Drawn from NSM-PP 8002. Loc.; 063.



Filicales

Genus *Gleichenites* GOEPPERT, 1836: 172*Gleichenites* ? sp.

Pl. 1, fig. 1; Text-figs. 2a–b

Material: NSM-PP 7963. *Locality*: 068. *Occurrence*: Rare.

Description: Obtained is a big leaf-fragment (NSM-PP 7964 is a counterpart) with markedly thick rachis, up to 1.1 cm wide. Leaf is obviously tripinnate. Penultimate pinnae are long and narrow, more than 8.5 cm long, sending alternately off rather remotely set ultimate pinnae at a wide angle. Ultimate pinnae are also long and narrow, nearly parallel-sided for the most part, but narrowing gradually towards the apex; about 2 cm long and up to 4 mm wide, often falcate and sending katadromically off more than 12 pairs of pinnules. Pinnules are semicircular or rectangular in form, 1.5–2.5 mm long and up to 2 mm wide at base, attached to the pinna axis by the whole base at a wide angle. Veins are not visible. Sometimes a small-sized circular object (sorus ?) is observed on the centre of pinnule.

Remarks: The general habit of our leaf reminds us of its belonging to *Gleichenites*. Because our leaf resembles in general feature *Gleichenites nipponensis* OISHI, 1940 and *G. yuasensis* KIMURA et KANSHA, 1978 known commonly from the Lower Cretaceous of Inner Zone and Outer Zone respectively. But in our leaf, as there is no positive proof that it belongs to Gleicheniaceae, we at present regard it provisionally as *Gleichenites* ? sp. *Gleichenites nitida* HARRIS described by Z. Y. ZHOU (1984) from the Lower Liassic Guanyintan Formation, Hunan, China is similar in leaf-form to ours, but is smaller in size and its main rachis is not known.

Genus *Phlebopteris* BRONGNIART, 1836: 371*Phlebopteris* sp.

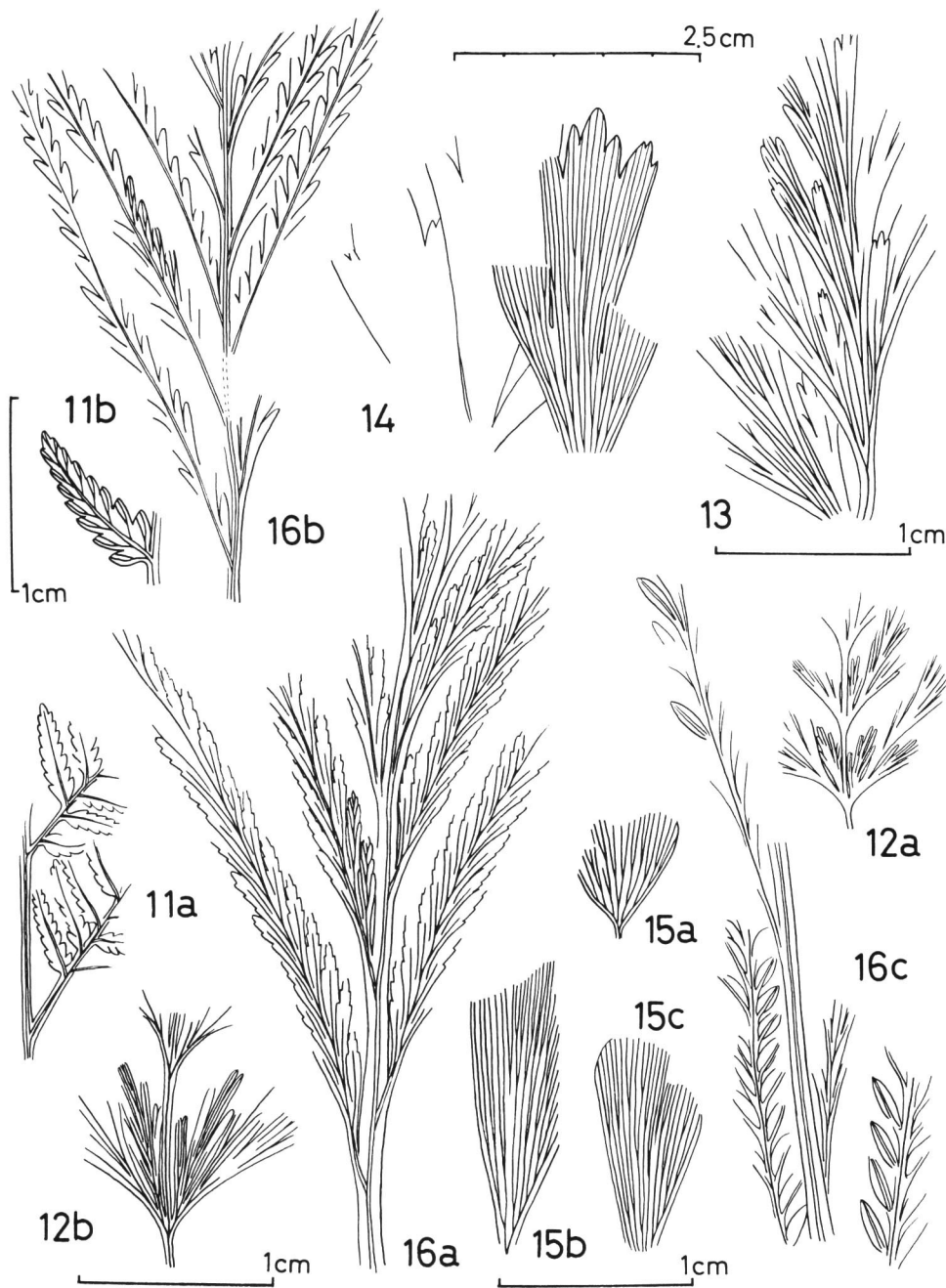
Text-fig. 3

Material: NSM-PP 7965. *Locality*: 063. *Occurrence*: Very rare.

Description: Obtained is a single and ill-preserved fertile pinna fragment. Pinna axis is comparatively thick, 1 mm wide, sending off remotely set pinnules at a wide

Text-figs. 11–16 ($\times 2/3$, unless otherwise indicated).

11. *Cladophlebis* sp. C: 11a–b. Drawn from NSM-PP 8003. Loc.; 065.
12. *Acrostichopteris* sp. cf. *A. longipennis* FONTAINE: 12a–b. Drawn from NSM-PP 8006 (12b; partly enlarged.) Loc.; 063.
13. *Acrostichopteris naitoi* KIMURA et OHANA sp. nov.: Drawn from NSM-PP 8008. Loc.; 063.
14. *Adiantopteris* sp. A: Drawn from NSM-PP 8008. Loc.; 063.
15. *Adiantopteris* sp. B: 15a–c. Drawn from NSM-PP 8010. Loc.; 063.
16. *Onychiopsis elongata* (GEYLER) YOKOYAMA: Loc.; 063. 16a–c. Drawn from NSM-PP 8013, 8014 and 8013 respectively.



angle. The pinnules are long and narrow, more than 1.1 cm long, nearly parallel-sided, 1.5 mm wide; all apices are missing; midnerve is rather distinct but laterals are invisible. Fructification is superficial in position, small, circular or oblong, about 0.5 mm in diameter, arranged on both sides of midnerve as shown in Text-fig. 3.

Remarks: Because of insufficiency of our material, nothing is mentionable beyond the existence of Matoniaceous fern in this flora. The present fertile pinna differs in form of pinnule from those known from the Nishinakayama Formation as *Phlebopteris* sp. (KIMURA, NAITO and OHANA, 1986).

Genus *Coniopteris* BRONGNIART, 1849: 26

Coniopteris sp.

Pl. 1, fig. 2; Text-fig. 6

Material: NSM-PP 7966 (collected by T. FUKUTOMI). *Locality:* 063.
Occurrence: Rare.

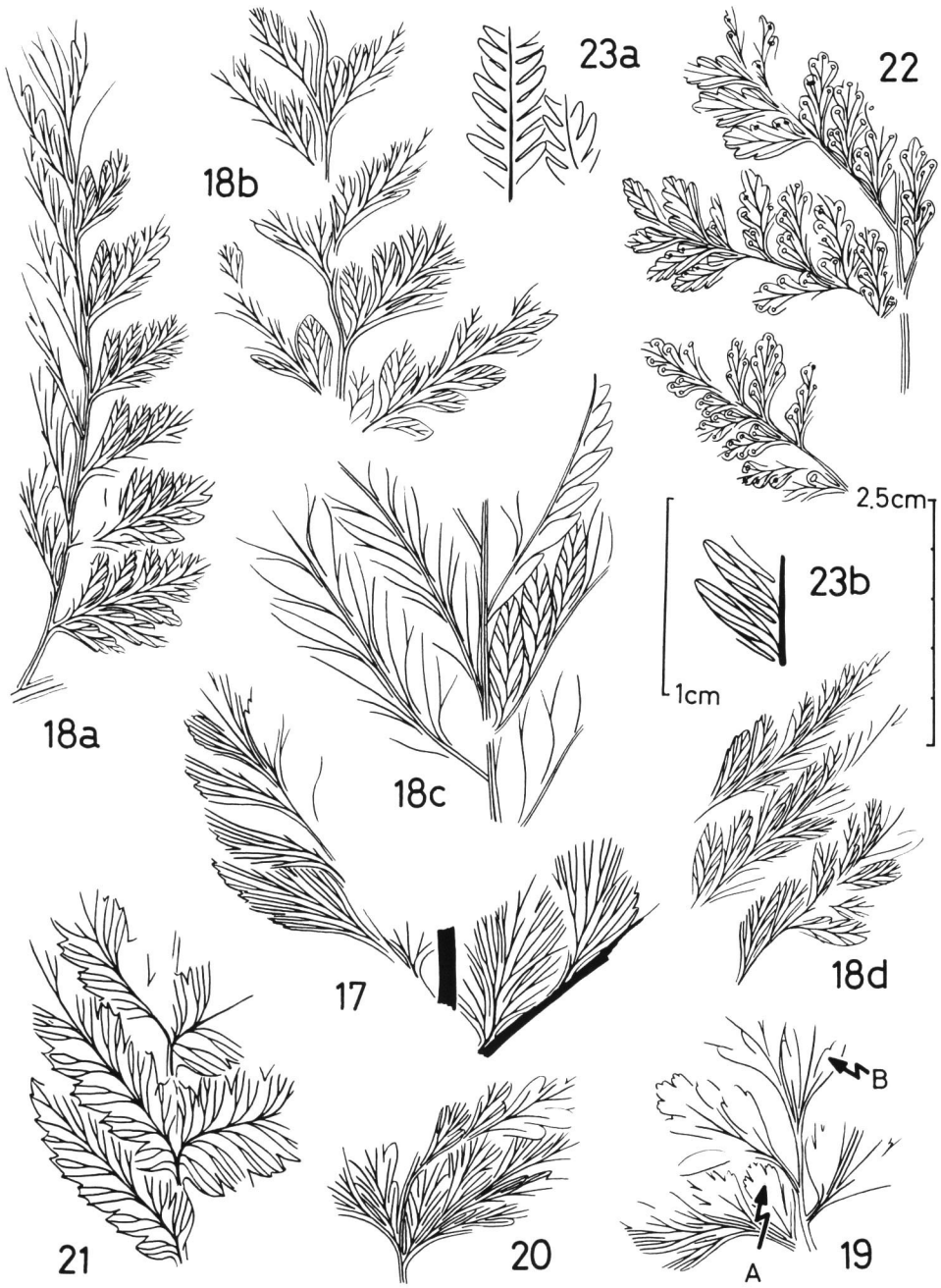
Description: Obtained is a single fertile leaf-fragment. Leaf is delicate, at least tripinnate, with slender main rachis, 0.7 mm wide, sending alternately off penultimate pinnae at an angle of about 35 degrees. Ultimate pinnae are set closely, 1.8 cm long or more, sending off closely set pinnules. Pinnules are varied in form and size according to the position of an ultimate pinna or penultimate pinna. Proximal pinnules are 0.8 cm long, with two or three alternate pairs of lobes in katadromic order; midnerve persists to the tip, sending off two or three pairs of simple lateral veins. Sori are marginal, one at the tip of each lobe. Apical pinnules are triangular, 0.2 cm long, often falcate, with once forked single vein; basiscopic branch persists to the tip and acroscopic one runs to the acroscopic basal margin to supply a single marginal sorus. Detail of sorus is not known.

Remarks: Most of our leaf is represented by fertile part, but apical parts of some pinnules or ultimate pinnae are sterile as indicated by an arrow in Text-fig. 6.

It would be clear that our leaf belongs to *Coniopteris* because of presenting marginal sori, but owing to its ill-preservation it is difficult to make its specific identity. Thus we at present regard our leaf as *Coniopteris* sp. The present *Coniopteris* sp. resembles in general habit *C. neiridaniensis* originally described by KIMURA and TSUJII (1981) from the Upper Liassic Negoya Formation of the Kuruma Group and the

Text-figs. 17–23 ($\times 2/3$, unless otherwise indicated).

17. *Sphenopteris* sp. A: Loc.; 063. Drawn from NSM-PP 8018.
18. *Sphenopteris* sp. B: 18a, b and d. Drawn from NSM-PP 8019, 8020 and 8021 respectively. Loc.; 063. 18c. Drawn from NSM-PP 8022. Loc.; 068.
19. *Sphenopteris* sp. C: Drawn from NSM-PP 8026. Loc.; 063.
20. *Sphenopteris* sp. D: Drawn from NSM-PP 8028. Loc.; 063.
21. *Sphenopteris* sp. E: Drawn from NSM-PP 8029. Loc.; 063.
22. *Sphenopteris* sp. F: Drawn from NSM-PP 8031. Loc.; 063.
23. *Pachypteris* sp.: Drawn from NSM-PP 8032. Loc.; 065. 23b. Showing the venation enlarged.



Iwamuro Formation, but the venation of the latter pinnules is of typical *Sphenopteris*-type (sympodial branching).

Genus *Polypodites* GOEPPERT, 1836: 175

Polypodites ? sp. A

Pl. 4, fig. 1; Text-figs. 4a–d

Material: NSM-PP 7962–7971. *Locality*: 063. *Occurrence*: Rare.

Description: Our specimens are represented all by small pinna-fragments of which one is sterile. Pinnules are subulate in form, often falcate and with 4–6 alternate pairs of lobed margins, typically 0.65 cm long and 2 mm wide. Veins are invisible. Reproductive organs are superficial and represented by small-sized and oblong impressions, 0.5 mm long; each lobe has one impression on its centre.

Remarks: Unfortunately no detail of reproductive organ has been made because of insufficiency of our material. *Polypodites* ? sp. A is distinguished from *P.* ? sp. B here described together by its pinnules with lobed margins and small-sized and oblong impressions of its reproductive organs. Externally similar fern leaves were described as *Klukia canadensis* by BELL (1956) from the Lower Cretaceous of Western Canada and as '*Polypodites*' *polysorus* PRYNADA by KRASSILOV (1967) from the Lower Cretaceous Lipovetz Formation, Southern Primorye. But the latter species is distinguishable from ours by its pinnules with undulated margins. Some specimens of *Polypodium oregonense* FONTAINE (in WARD, 1905) (e.g. his pl. 10, fig. 4) from the so called Jurassic of Oregon are also similar in external form.

Polypodites ? sp. B

Text-figs. 5a–c

Material: NSM-PP 7972–7977. *Locality*: 063. *Occurrence*: Rare.

Description: Leaf is at least bipinnate and small-sized. Pinnae are 2 cm long and typically with about 10 alternate pairs of pinnules. Pinnules are closely set, variable in form and size according to the position of a leaf; triangular to subulate, sometimes falcate, with obtusely pointed apex; margins are entire. Midnerve persists to the tip, sending off 3–10 alternate pairs of simple lateral veins. Reproductive organ is superficial and is represented by circular impression, 0.75 mm in diameter, each on the midway of a lateral vein.

Remarks: Unfortunately no detail of reproductive organ has been made because of insufficiency of our material. Externally our leaves resemble those of *Polypodites verestchaginii* originally described by KRASSILOV (1967) from the Lower Cretaceous Strosuchan Formation, Southern Primorye. Some fertile specimens of *Pecopteris browniana* DUNKER described by YOKOYAMA (1894) from Kaisekiyama [Lower Cretaceous, Kochi Prefecture (e.g. his pl. 27, fig. 1, 1a)] are similar in external form to ours.

Our leaves also resemble those of *Dicksoniopteris naumanni* NATHORST described by YOKOYAMA (1894) from the Lower Cretaceous of Kochi Prefecture, in the arrangement of reproductive organs, but it is difficult to make its identity because our reproductive organs are represented only by circular impressions.

Form-genus *Cladophlebis* BRONGNIART, 1849: 105

Cladophlebis naitoi KIMURA et OHANA sp. nov.

Pl. 2, fig. 3; Pl. 3, fig. 1; Text-figs. 7a-b

Material: Holotype; NSM-PP 7978. Paratypes; NSM-PP 7979, 7980. Other specimen; NSM-PP 7981. *Stratum typicum:* Utano Formation. *Locus typicus:* Loc. no. 063. *Derivatio nominis:* After G. NAITO. *Occurrence:* Locally common.

Diagnosis: Leaf at least tripinnate, medium-sized, with rather slender rachis, 1.5 mm wide, sending alternately off closely set penultimate pinnae at an angle of 60–70 degrees. Penultimate pinnae elongated, 9 cm long, nearly parallel-sided for the most part, 2.3 cm wide, but abruptly narrowing distally and gradually narrowing proximally, sending typically off 22 alternate pairs of ultimate pinnae and distal pinnules. Ultimate pinnae on the proximal part of penultimate pinna deltoid or elongate-deltoid in form, 1.1 cm long and 0.6 cm wide at base, divided katadromically into 8–9 pairs of small-sized pinnules. Ultimate pinnae on the middle part linear or elongate-deltoid in form, 1.3 cm long and 0.45 cm wide, divided into 9–10 pairs of pinnules, but distal pinnae not divided into lobes and passing into simple pinnules; some ultimate pinnae on the distal part divided into small-sized pinnules proximally but not divided distally. Pinnules oblong or deltoid in form, contiguous basally each other, with obtusely pointed apex, directed forwards but not doing so in proximal one or two pairs. Midnerve distinct, persisting to the tip, sending off 4–5 alternate pairs of laterals mostly forking once. Fructification not known.

Comparison and discussion: The present leaves closely resemble those of *Cladophlebis acutipennis* originally described by OISHI (1940) from the Lower Cretaceous in the Outer Zone of Japan. But OISHI's species is distinguished from our species by its oppositely disposed penultimate and ultimate pinnae, pinnules with acuminate apex and lateral veins forking possibly once. *Cladophlebis koraiensis* YABE and *C. triangularis* OISHI known from the lower part of Lower Cretaceous Gyeongsang Group (Nagdong Formation), Korea and the Oguchi Formation in the Inner Zone of Central Japan respectively also resemble our species, but are distinguished by the more elongated ultimate pinnae and rather shallowly dissected pinnules in the former and the specialized basal acroscopic pinnules and mostly simple lateral veins in the latter. Under the circumstances we regard our species as a new species, *Cladophlebis naitoi* though this dealing is palaeobotanically less significant.

Cladophlebis toyoraensis OISHI

Pl. 2, figs. 1–2; Text-figs. 8a–e

Cladophlebis toyoraensis OISHI: OISHI, 1940, p. 291, pl. 23, figs. 4, 5, 5a (Takaji; our loc. no. 061).

Material: NSM-PP 7982–7998 and many pinna fragments. *Locality*: 063 (OISHI originally described this species from Loc. 061). *Occurrence*: Locally abundant.

Emended diagnosis: Leaf bipinnate, more than 15 cm long; rachis thick, 5 mm wide proximally; pinnae alternate or subopposite, remotely set, being 3 cm distant on each side of rachis, linear lanceolate, acuminate at apex, narrowing towards the base, broadest near the middle portion, and attached to the rachis at a wide angle, sometimes perpendicular; sterile pinnules long and narrow, linear, straight or slightly falcate, acuminate at apex, closely set, and attached katadromically to the pinna axis by the whole of the base at a wide angle, typically 2 cm long and 4.5 mm wide at base; margins serrate; midnerve distinct, persisting to the tip, sending off up to 10–12 alternate pairs of once forked lateral veins at an acute angle; each serration receiving a single set of lateral vein. Fertile pinnules, long and narrow and with acuminate apex, the longest one 2 cm long and 3 mm wide; margins shallowly undulated; midnerve distinct, persisting to the tip, sending off up to 8 alternate pairs of once forked lateral veins; each undulation receiving a single set of lateral vein. Reproductive organ oblong in form, 0.75 mm long and 0.3 mm wide, located singly at the branching point of each lateral vein. (Detail of reproductive organ unknown.)

Discussion: Although our fertile pinna is not in organic connection with sterile part of the leaf, it is obvious that our fertile pinna belongs to *Cladophlebis toyoraensis* originally established only by sterile leaves, because their pinnules are nearly the same size with similar venation and the present fertile pinna is in close association with the sterile leaves in occurrence.

The present sterile pinnules are close in form to *Todites denticulatus* or *Cladophlebis denticulata* as formerly mentioned by OISHI (1940), but judging from the position and shape of the present reproductive organs, *Cladophlebis toyoraensis* is not related to *Todites denticulatus* belonging to Osmundaceae but to other fern-taxon.

However, we could not make the botanical affinity of *Cladophlebis toyoraensis* clear because its reproductive organs were preserved merely by insufficient impressions.

Cladophlebis sp. A

Pl. 2, fig. 4; Text-fig. 9

Material: NSM-PP 7999, 8000. *Locality*: 063. *Occurrence*: Rare.

Description: Obtained are sterile fragments of two pinnae sending alternately off large-sized pinnules. The pinnules are deltoid or elongate triangular in form, attached to the pinna axis at an angle of 40 degrees by their whole bases, mostly falcate

and with obtusely pointed apex: the shorter one is 1.6 cm long and 0.8 cm wide at base and the longer one is 2.5 cm and 0.8 cm wide. Margins are shallowly serrate; serration is 5–6 pairs, each directed forwards. Venation is of *Cladophlebis*-type; midnerve is distinct, persisting to the tip, sending katadromically off 5–9 pairs of laterals forking twice; each serration receives a set of lateral vein. Fructification is not known.

Remarks: Owing to the insufficiency of the present specimens, we provisionally regard them as *Cladophlebis* sp. A. *Cladophlebis* sp. A is characterized by its large-sized pinnules with 5–9 pairs of twice forked lateral veins. The pinnules of *Cladophlebis* sp. A resemble sterile pinnules of *Todites fastuosus* known from the Upper Liassic Kuruma Group and Iwamuro Formation (KIMURA and TSUJII, 1980), but is distinguished by the coarsely serrate margins in the former.

Cladophlebis sp. B

Pl. 2, fig. 5; Text-fig. 10

Material: NSM-PP 8001, 8002. *Locality:* 063. *Occurrence:* Rare.

Description: Obtained are sterile fragments of two pinnae sending off medium-sized and closely set pinnules at angle of about 35 degrees. The pinnules are deltoid in form, falcate, 1 cm long and 0.5 cm wide, attached to the pinna axis by their whole bases and with acutely pointed apex; margins are entire. Venation is of *Cladophlebis*-type; midnerve is distinct, persisting to the tip, sending katadromically off 9 pairs of laterals forking once. Fructification is not known.

Remarks: Because of the insufficiency of the present specimens, we provisionally regard them as *Cladophlebis* sp. B. The pinnules of *Cladophlebis* sp. B also resemble in form and venation those of *Todites fastuosus* (KIMURA and TSUJII, 1980) in part. The leaves with similar pinnules have been known; such as those of *Cladophlebis vaccensis* WARD and some pinnules of *C. denticulata* (BRONGNIART) FONTAINE and *C. williamsoni* (BRONGNIART) SEWARD.

Cladophlebis sp. C

Pl. 3, figs. 2–3; Text-figs. 11a–b

Material: NSM-PP 8003, 8004. *Locality:* 065. *Occurrence:* Rare.

Description: Obtained are two broken sterile leaves which are at least bipinnate. Main rachis is slender, 1 mm wide with a median furrow, giving alternately off closely set pinnae at an angle of 35 degrees. Pinnules are katadromic in order, rather remotely set; the largest one is 0.9 cm long and 3 mm wide near the base, markedly constricted at base; margins are lobed, consisting of 7 alternate pairs of lobes. Midnerve is distinct, persisting to the tip, sending off once forked lateral veins directed forwards; each lobe receives one set of lateral vein.

Remarks: *Cladophlebis* sp. C is characterized by the lobed pinnules and is distinguished from *C. acutipennis* OISHI bearing pinnules with lobed margins known from the Lower Cretaceous plant-beds in the Outer Zone of Japan by its lobes with rounded or obtusely pointed apex, instead of triangular lobes with acutely pointed apex in the latter. *Cladophlebis parvula* OISHI known also from the Lower Cretaceous plant-beds in the Outer Zone of Japan represents similar lobed pinnules, but they are more elongated, nearly parallel-sided for the most part and with *Sphenopteris*-type venation (OISHI, 1940). The lobed pinnules of FONTAINE's *Cladophlebis alata* are similar to those of *C. sp. C*, but the venation of the former is different. The venation of FONTAINE's *Cladophlebis crenata* is similar to that of *C. sp. C*, but the pinnules of the former is not markedly constricted at base.

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

Acrostichopteris sp. cf. *A. longipennis* FONTAINE

Pl. 2, fig. 7; Pl. 3, fig. 8; Text-figs. 12a-b

Comparable specimens:

Acrostichopteris longipennis FONTAINE: BERRY, 1911, p. 225, pl. 23, figs. 1-2; pl. 24, fig. 7 (Lower Cretaceous of Maryland and Virginia).

Material: NSM-PP 8005, 8007. *Localities:* 061 (8005) and 063 (8006, 8007).

Occurrence: Rather rare.

Description: Obtained are sterile leaf-fragments. Leaf is at least quadri-pinnate and delicate in habit. Main rachis is slender, sending off the first pinnae which are more than 5 cm long. The second pinnae are opposite or subopposite, sending off the third pinnae, up to 2 cm long at an angle of 35 degrees. Pinnules are narrowly wedge-shaped and decompound proximally, but becoming simpler distally. Decompound pinnules 0.9 cm long and divided into four narrow and linear divisions terminated by two shallowly divided teeth; each tooth is with rounded or obtusely pointed apex. Apical pinnules consist of small number of linear divisions and not divided into teeth at apex. Vein is originated at the base of each pinnule, forking dichotomously; each division or tooth receives a single vein.

Remarks: Our leaves resemble in size, venation and external appearance *Acrostichopteris longipennis* FONTAINE redefined by BERRY (1911). According to BERRY (1911), *Acrostichopteris longipennis* bears reproductive organ at the basiscopic base of each ultimate pinna (e.g. FONTAINE, 1889, pl. 170, figs. 10-11). As such organ has not been found in our leaves, we at present regard our leaves as *Acrostichopteris* sp. cf. *A. longipennis*.

In 1979, KIMURA and MATSUKAWA described similar leaves as *Acrostichopteris longipennis* from the Lower Cretaceous Sebayashi Formation, in the Outer Zone of Japan. But we now think these are distinct from Fontaine's species because these are larger in size and each division of a pinnule receives four parallel veins instead of a single vein.

Acrostichopteris naitoi KIMURA et OHANA sp. nov.

Pl. 3, fig. 7; Text-fig. 13

Material: Holotype; NSM-PP 8008. Paratype; NSM-8009. *Stratum typicum*: Utano Formation. *Locus typicus*: 063. *Derivatio nominis*: After G. Naito. *Occurrence*: Rare.

Diagnosis: (Whole leaf unknown.) Pinnules wedge-shaped, typically 1.3 cm long, divided anadromically into six or more principal segments directed forwards; each segment split up into normally three alternate, linear and subordinate wedge-shaped divisions; each division terminated by three teeth with acutely or obtusely pointed apex. Veins thin but distinct, a single vein at the base of pinnule, then repeatedly forking dichotomously; each division and tooth receiving a single vein. (Fructification not known.)

Discussion and comparison: Our pinnules are characterized by their wedge-shaped and alternate segments and divisions based on numerical number three. Our specimens are all represented by small pinna-fragments, but characteristic features as mentioned above are so distinct that we here propose *Acrostichopteris naitoi* sp. nov.

Acrostichopteris was instituted by FONTAINE (1889) together with *Baieropsis*. At the same time FONTAINE described 5 *Acrostichopteris* species and 7 *Baieropsis* species and its three varieties. Afterwards except a part of *Baieropsis expansa*, BERRY (1911) united them into 5 *Acrostichopteris* species; *A. cyclopteroides*, *A. expansa* (Fontaine), *A. longipennis*, *A. parvifolia* and *A. pluripartita* (Fontaine), but BERRY's treatment had not been fully accepted (e.g. BELL, 1956).

Our *Acrostichopteris naitoi* is distinguished from all of BERRY's species by its mode of dissection of pinnule as mentioned above, instead of dichotomously dissected pinnules (based on numerical number two) in BERRY's species. *Acrostichopteris nervosa* (HEER) described by TEIXEIRA (1948) resembles *A. naitoi* in the mode of dissection of pinnule, but is distinguished from the latter by its inequilateral pinnules with elongated ultimate segments (or divisions). As mentioned before, KIMURA and MATSUKAWA (1979) described *Acrostichopteris longipennis* FONTAINE from the Lower Cretaceous Sebayashi Formation. This is easily distinguished from *Acrostichopteris naitoi* by its ultimate segments of pinnule with four veins and with rounded apex. KRASSILOV (1967) described *Acrostichopteris pluripartita* (FONTAINE) BERRY from the Lower Cretaceous of Southern Primorye. In this ultimate segments of pinnule are also with plural veins. *Acrostichopteris* leaves had been known to be restricted from the Early Cretaceous Ryoseki-type (or Wealden-type) floras. So the occurrence of *Acrostichopteris naitoi* from the Utano Formation might be the oldest record of the genus with uncertain affinity.

Form-genus *Adiantopteris* VASSILEVSKAJA, 1968: 49

Adiantopteris toyoraensis (OISHI) VASSILVESKAJA

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

(Takaji; corresponding to our Loc. no. 061).

Remarks: OISHI (1940) instituted *Adiantites toyoraensis* based on two leaf fragments from Takaji and a single fragment from the Lower Cretaceous Ryoseki Formation. Unfortunately we could not find the specimens agreeing with OISHI's species in our collection. OISHI's specimen figured in his pl. 7, fig. 4 and 4a from the Ryoseki Formation is distinct. KIMURA and OHANA (1987) instituted *Adiantopteris sawamurae* based on a specimen newly obtained from the Ryoseki Formation together with OISHI's specimen mentioned above.

Adiantopteris sp. A

Pl. 3, fig. 4; Text-fig. 14

Material: NSM-PP 8008, 8009. *Locality:* 063. *Occurrence:* Rare (pinna fragments only).

Description: Pinnules are rhombic in form, about 3.7 cm high and probably 3.5 cm wide, divided into three wedge-shaped divisions by deep and narrow gaps; the central division is larger, higher and broader than lateral ones which are unequal in size one another. Each division is shallowly divided into a central lobe and two lateral lobes distally; the central lobe is larger in size than the laterals. Each lobe is terminated by three teeth of which the central one is also larger in size and higher than the laterals. Unfortunately bases of pinnules are all missing. Veins are divergent from the base, repeatedly forking dichotomously at all levels; density is 18 per cm at the distal part of the division. Fructification is unknown.

Remarks: *Adiantopteris* sp. A is characterized by its mode of division of pinnule based on the cardinal number of three. This habit resembles that of Late Palaeozoic *Triphyllopteris* SCHIMPER, 1869. Accordingly, *Adiantopteris* sp. A is distinguished from *A. sewardi* (YABE) known from the Lower Cretaceous of Korea and of the Inner Zone of Japan and Takaji (OISHI, 1940, p. 235; but not illustrated) in which pinnules are not toothed at apex. *Adiantum expansum* SAPORTA known from the Lower Cretaceous of Portugal resembles in the mode of division of pinnule *Adiantopteris* sp. A, but is distinguished by its fan-shaped pinnules with a central division which is narrower in width than the laterals. We think that *Adiantopteris* sp. A is distinct but we at present reserve to give it a new specific name because of insufficiency of our present material in number and quality.

Adiantopteris sp. B

Text-figs. 15a-c

Material: NSM-PP 8010, 8011. *Localities:* 061 (8010) and 063 (8011). *Occurrence:* Rare.

Description: Obtained are four sterile, small-sized and asymmetrically bilobed

pinnules without petiole. The pinnules are wedge-shaped and dissected into two lobes by a rather deep and narrow sinus, more than 1.5 cm long. Apices of all lobes are missing. A vein is originated from the base, forking dichotomously near the base of pinnule and running along both basal margins to form marginal veins. The branch veins are originated from the marginal veins, forking dichotomously once to thrice; vein-density is 32 per cm at the bottom of the sinus.

Remarks: We think that our specimens belong not to *Ginkgo* and its allies but to a fern-genus *Adiantopteris* because of lack of petiole. *Adiantopteris* sp. B resembles in form of pinnule *A. seawardi* (YABE), but is distinguished by its venation; in *A. seawardi* all veins are divergent from the base of pinnule. *Adiantopteris yuasensis* (YOKOYAMA) known from the Lower Cretaceous of the Outer Zone of Japan and of Southern Primorye is also distinguished by its pinnules only with a single basal marginal vein sending off branch veins. *Adiantopteris toyoraensis* (OISHI) is distinguished by its pinnules not with marginal veins but with numerous divergent veins. So far as we know, other *Adiantopteris* species hitherto known, veins are all divergent from the base of pinnule. Thus the present *Adiantopteris* sp. B seems to be distinct, but here we reserve to give it a new specific name because our specimens are insufficient in number and quality.

Genus *Onychiopsis* YOKOYAMA, 1889: 27

Onychiopsis elongata (GEYLER) YOKOYAMA

Pl. 4, figs. 3–4; Text-figs. 16a–c

Japanese specimens:

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

Adiantites GEYLER: Ditto, p. 225, pl. 30, figs. 2b, 3 (Ibid.).

Dicksonia gracilis HEER: YOKOYAMA, 1889, p. 24, pl. 1, fig. 5, 5a; pl. 12, fig. 13 (Kuwashima and Okamigo, Oguchi Formation).

Dicksonia acutiloba HEER var.: YOKOYAMA, 1889, p. 24, pl. 1, figs. 1b, 2, 2a (Kuwashima).

Onychiopsis elongata (GEYLER) YOKOYAMA: YOKOYAMA, 1889, p. 27, pl. 2, figs. 1–3, 4a–c; pl. 3, fig. 6d; pl. 12, figs. 9–10 (Kuwashima and Okamigo); OISHI, 1940, p. 228 (pars), pl. 6, figs. 1–4 (Takaji; probably our Loc. no. 061), fig. 5 (Rokumanbo; probably from the Kiyosué Formation), fig. 6 (Yanagidani, Oguchi Formation); KIMURA, 1958, p. 14 (Kuzuryu Group); 1975, p. 77, pl. 6, figs. 6–7 (Tamodani, Akaiwa Formation); KIMURA and SEKIDO, 1976b, p. 359, pl. 36, fig. 1; text-fig. 4 (Bettokuzure and Osugidani, Akaiwa Formation).

Korean specimens:

Onychiopsis elongata (GEYLER) YOKOYAMA: YABE, 1905, p. 22, pl. 1, figs. 9–14; pl. 3, fig. 15 (Oguchi Formation, Japan and Lower Gyeongsang Group).

Onychiopsis mantelli (BRONGNIART) NATHORST: TATEIWA, 1929, plate, fig. 7 (Lower

Gyeongsang Group).

Material: NSM-PP 8012~8017. *Localities:* 061 (8012~8014) and 063 (8015~8017). *Occurrence:* Locally abundant.

Description: Obtained are sterile and fertile leaf-fragments. Among them Text-fig. 16b shows an apical part of a leaf or a penultimate pinna with several ultimate pinnae, each bearing small-sized and triangular pinnules directed forwards of which laminae are connected basally. Basal pinnules are markedly decurrent; margins are entire. Venation is simple; each pinnule receives a single vein proximally, forking dichotomously near the base; basiscopic one is mostly forking again. Text-fig. 16a shows a middle-basal part of a leaf or a penultimate pinna with several ultimate pinnae preserved, each bearing elongate-lanceolate pinnules directed forwards of which margins of apical two-thirds are with 3-4 pairs of serrations but those of basal part are entire. Each pinnule receives a single vein basally, then repeatedly forking dichotomously; each serration receives a single branch vein. Text-fig. 16c shows a fertile part of a leaf, associated with the sterile leaf-fragments. The fertile ultimate pinna bears rather remotely set and short stalked 'elliptical bodies', typically 5.5 mm long and 1.5 mm wide, each with a marked median keel on the abaxial surface; the keels are markedly decurrent on the pinna axis. No detail of the 'elliptical body' has been made.

Remarks: Our sterile leaves agree well with those of *Onychiopsis elongata* described by YOKOYAMA (1889), OISHI (1940), KIMURA (1958, '75) and KIMURA and SEKIDO (1976b) from the upper Middle Jurassic-Lower Cretaceous plant-beds in the Inner Zone of Central Japan and by YABE (1905) and TATEIWA (1929) from the Lower Cretaceous of Korea. But our fertile leaves differ slightly from those known from the plant-beds in the Inner Zone of Japan and in Korea in that our stalks of 'elliptical bodies' are more shorter than those mentioned above. It is worth mentioning that in *Onychiopsis elongata* pinnules appear to be not katadromic but anadromic in order. The specific name, *Onychiopsis elongata* had been extended to the sterile fern leaves of bipinnate habit known abundantly from the Upper Jurassic-Lower Cretaceous plant-beds in the Outer Zone of Japan (NATHORST, 1890; YABE, 1913; OISHI, 1940; KIMURA, 1976; KIMURA and KANSHA, 1978; KIMURA and MATSUKAWA, 1979).

However, recently KIMURA and AIBA (1986) made it clear that these fern leaves belonged not to *Onychiopsis elongata* but to *O. yokoyamai* (YABE), according to their discovery of *Onychiopsis*-type fertile pinnae with sessile 'elliptical bodies' in organic connection of these sterile leaves, and made detailed comparison among the known *Onychiopsis* species. TAKAHASHI (1973a) described a single and small fertile pinna-fragment as *Onychiopsis elongata* from Ono (corresponding possibly to our Loc. no. 063).

Form-genus *Sphenopteris* STERNBERG, 1825: 15

We regarded fern leaves with *Sphenopteris*-type venation as *Sphenopteris* and recognized 6 forms including a single fertile form, but unfortunately we could not give their specific names because of insufficiency in their number and quality of speci-

mens. However, we made detailed observation of them and added detailed sketches of them. According to the previous authors most insufficient fern leaves with *Sphenopteris*-type venation known from the Mesozoic plant-beds of Japan had been regarded as *Sphenopteris goepperti* DUNKER. But none of the present specimens agree with the original specimens of *Sphenopteris goepperti* (DUNKER, 1846).

We think that such form as *Sphenopteris* sp. B belongs possibly to *Pachypteris*, a pteridospermous genus, because the pinnules of *S.* sp. B resemble closely in form and venation those of *Pachypteris specifica* FEISTMANTEL redescribed by BOSE and BANERJI (1984) from Kachchh.

Key to the *Sphenopteris* species

- | | | |
|-----|---|-----------------|
| 1. | Margins of pinnules mostly entire | <i>S.</i> sp. B |
| 1'. | Margins of pinnules serrate or lobed | 2 |
| 2. | Pinnules wedge-shaped | 3 |
| 2'. | Pinnules oblong | <i>S.</i> sp. E |
| 3. | Apex of lobe rounded | 4 |
| 3'. | Apex of lobe serrate | 5 |
| 4. | Lobes elongated | <i>S.</i> sp. D |
| 4'. | Lobes not elongated (each with a single reproductive organ) | <i>S.</i> sp. F |
| 5. | Serration 2 pairs | <i>S.</i> sp. A |
| 5'. | Serration 1 pair | <i>S.</i> sp. C |

Sphenopteris sp. A

Pl. 4, fig. 2; Text-fig. 17

Material: NSM-PP 8018. *Locality:* 063. *Occurrence:* Rare.

Description: Obtained is a tiny leaf-fragment which is at least bipinnate. Rachis is 1.5 mm wide, sending alternately off pinnae at an angle of about 35 degrees. Pinna is more than 4.2 cm long and about 2 cm wide, sending suboppositely off closely set pinnules. Proximal pinnules are rhomboidal in form, about 2 cm long and up to 1.2 cm wide, shallowly dissected into 3–5 anadromic-ordered pairs of lobes; each lobe is irregularly serrated at apex. Apical pinnules are rhomboidal or wedge-shaped, with irregularly toothed apical margins. Venation is typical *Sphenopteris*-type; midnerve is rather distinct in the proximal half of pinnule, sending anadromically off twice or thrice forked and denser lateral veins at a narrow angle; in apical half of pinnule, veins are forking repeatedly and radiate to the apical margin; each tooth receives a single branch-vein. Vein-density is 20–26 per cm at the middle of pinnule. Reproductive organ is not known.

Remarks: The present leaf is characterized by the rhomboidal or wedge-shaped pinnules with shallowly dissected, anadromic-ordered and toothed lobes and with denser *Sphenopteris*-type veins. So far as we know, our leaf is distinct, but owing

to the insufficiency of our leaf, it is difficult to make its specific identity. So we at present regard it as *Sphenopteris* sp. A. Some leaves of Permian *Angaridium* ZALESKY, 1933 and *Eremopteris* SCHIMPER, 1869 resemble externally our leaf in the mode of dissection of pinnule and venation.

Sphenopteris sp. B

Pl. 3, fig. 6; Text-figs. 18a–d

Material: NSM-PP 8019~8022. *Localities:* 063 (8019–8021) and 068 (8022). *Occurrence:* Rather rare.

Description: Several broken penultimate pinnae were obtained. They appear to be delicate in habit and are 7.8 cm long, with slender pinna axis, sending alternately off short and triangular ultimate pinnae at an angle of 55 degrees. Proximal pinna consists of 5–6 or more alternate pairs of pinnules and apical pinna of 5–6 alternate pairs of pinnules or lobes in anadromic order. Generally pinnules on the acroscopic side are well developed. Full-grown pinnules are oblong in form, typically 0.9 cm long and up to 2.5 mm wide with shallowly lobed or entire margins, and with decurrent base. Venation is rather *Sphenopteris*-type; midnerve persists to the tip, sending off 3 alternate pairs of lateral veins. Acroscopic lateral veins are mostly once forked, but basiscopic ones mostly simple; most of lateral veins are directed forwards. In the lobed pinnules, each lobe receives one lateral vein. Fructification is not known.

Remarks: Our leaf is characterized by its anadromic-ordered pinnules and venation. It is difficult to make specific identity to our leaves because of the insufficiency of our material. Thus we at present regard our leaves provisionally as *Sphenopteris* sp. B.

Sphenopteris sp. C

Pl. 1, fig. 3; Text-fig. 19

Material: NSM-PP 8023~8027 and many other pinna fragments. *Locality:* 063. *Occurrence:* Locally common.

Description: The whole leaf is unknown because the specimens on hand are all of sterile penultimate pinna fragments. Text-fig. 19 shows a fragment of penultimate pinna, sending alternately off rather short ultimate pinnae at an angle of 35 degrees proximally, then bending outwards, and with 4–5 alternate pairs of pinnules. Pinnules are anadromic in order, closely set and rhomboidal or wedge-shaped. The larger pinnule (indicated by arrow A) is rhomboidal in form, 0.9 cm long and 5 mm wide, dissected into 2 pairs of lobes directed forwards; each lobe is further shallowly dissected once near the apex; these small lobes are with rounded, truncated or obtusely pointed apex. The smaller pinnule (indicated by arrow B) is wedge-shaped or oblanceolate and with a single pair of shallowly and simply dissected lobes at its apical

part. Veins are delicate, each major lobe receives a single lateral vein.

Remarks: *Sphenopteris* sp. C is characterized by its rhomboidal or wedge-shaped pinnules dissected into lobes with apical small lobes. Such pinnules of *Sphenopteris*-type form with apical small lobes strongly remind us of those of some *Coniopteris* species, such as *C. vachrameevii* originally described by VASSILEVSKAJA (1967) from the Lower Cretaceous of the Lena Basin. Indeed, *Sphenopteris*-type leaves with similar pinnules have been known from the Lower Cretaceous Oguchi Formation, the Tetori Supergroup in the Inner Zone of Japan (KIMURA, in WATANABE *et al.*, 1978). *Sphenopteris* sp. C is distinguished from a comprehensive species regarded as *S. goepperti* DUNKER or *Ruffordia goepperti* (DUNKER) SEWARD by the fact that so far as we know, no such apical small lobes have been found in the pinnules of the latter species.

Sphenopteris sp. D

Pl. 3, fig. 5; Text-fig. 20

Material: NSM-PP 8028. *Locality:* 063. *Occurrence:* Rare.

Description: Obtained is a single tiny sterile pinna fragment. Leaf is delicate, at least bipinnate. Pinnae are more than 2 cm long and about 1 cm wide, sending anadromically off closely set pinnules. Proximal pinnules are wedge-shaped or obdeltoid, 1.1 cm long and up to 0.5 cm wide; margins are deeply dissected into 2–3 anadromic pairs of lobes with rounded apex. Midnerve is delicate, sending off once forked lateral veins directed forwards; each lobe receives a set of lateral vein. Distal part of a pinna is shallowly lobed; each lobe (or pinnule) is with rounded apex and with a simple or once forked midnerve. Generally pinnules on the acroscopic side of pinna are well developed.

Remarks: The present leaf, though wrongly preserved, is characterized by its anadromic-ordered proximal pinnules with 2–3 pairs of deeply segmented lobes and shallowly lobed apical part of pinna. Most probably the present leaf might be distinct but we at present reserve to make its specific identity and regard it as *Sphenopteris* sp. D.

Sphenopteris sp. E

Pl. 1, fig. 4; Pl. 2, fig. 6; Text-fig. 21

Material: NSM-PP 8029, 8030 (counterpart). *Locality:* 063. *Occurrence:* Rare.

Description: A single sterile leaf-fragment was obtained. Leaf is bipinnate and medium-sized; rachis is 5 mm thick, sending off pinnae at an angle of 35 degrees. Pinnae are incomplete, more than 12 cm long and up to 3 cm wide, sending suboppositely off pinnules. Pinnules are rather large-sized, elongate-oval in form, 2.8 cm long up to 1.2 cm wide but varied in size according to the position of a pinna, and

markedly constricted at base. Margins are singly serrate in the distal half of a pinnule and doubly serrate in the proximal half, but basiscopic basal one is singly lobed; serration is katadromic in order. Venation is rather *Sphenopteris*-type; midnerve is thin, persisting to the tip, sending off 6–7 pairs of lateral veins; proximal lateral veins are mostly forking twice, but distal ones once or simple; each serration receives a single ultimate branch vein. Basiscopic basal lobe is obtusely pointed and has a single vein below and once forked vein above; these three ultimate laterals tend to converge at apex of the lobe. Two forked ultimate branches are occasionally united before reaching a serration forming an elongate-oval mesh. Reproductive organ is not known.

Remarks: Our leaf is characterized by its pinnules with singly or doubly serrated margins and with occasionally united ultimate lateral veins. So far as we know, such characteristic leaf has not been recorded from the Mesozoic plant-beds. However, we at present reserve to mention its systematic affinity and regard it provisionally as *Sphenopteris* sp. E.

The pinnules of *Zamiopsis sujfunensis* (KRYSHTOFOVICH et PRYNADA) (= *Palibiniopteris inaequipinnata* PRYNADA, 1956) with uncertain affinity described by KRASSILOV (1967) from the Lower Cretaceous of Southern Primorye somewhat resembles those of ours. But they are distinguished by their singly serrate margins.

Zamiopsis dentata (FONTAINE) BERRY also somewhat resembles our *Sphenopteris* sp. E, but is distinguished by its pinnules with crowded and thrice forked veins.

Sphenopteris sp. F

Text-fig. 22

Material: NSM-PP 8031. *Locality:* 063. *Occurrence:* Rare.

Description: Obtained is a single leaf-fragment. The leaf is delicate, at least bipinnate, with slender rachis, 0.5 mm wide with a median ridge on the wrong-side. Pinnae are rather remotely set alternately, more than 3 cm long and 1.5 cm wide, attached to the rachis at an angle of 45 degrees. Sterile pinnules are seen on the apical half of a pinna, rhomboidal in form, 0.8 cm long and up to 0.5 cm wide, with markedly constricted base and with shallowly lobed margins; lobes are directed forwards, consisting of anadromic-ordered three or four pairs; each with obtusely pointed or rounded apex. Midnerve persists to the tip, sending off three or four alternate pairs of once forked simple lateral veins; thus each lobe receives a single lateral vein.

Fertile pinnules are more slender than sterile ones, with deeply lobed margins; each lobe is with rounded apex; acroscopic basal lobes are further shallowly lobed near the tip. Each lobe receives a single lateral vein. Reproductive organs are situated near the tip of lobe, but not marginal, most lateral veins end with the reproductive organs, but occasional ones extend to the tip of lobe. Owing to the ill-preservation, detail of the reproductive organ is not made out.

Remarks: The present leaf is characterized by its anadromically arranged and lobed pinnules with sparse lateral veins and with small-sized reproductive organs each located near the tip of lobe. But under existing circumstances on the nature of our reproductive organ, it is difficult to mention the botanical affinity of our leaf. So we at present regard our leaf provisionally as *Sphenopteris* sp. F. General habit of our leaf might remind us of that of *Prynadaeopteris* RADCZENKO, 1955 known from the Upper Palaeozoic of Sayan-Altai Ranges, U.S.S.R.

Gymnosperms

Pteridospermales

Genus *Pachypteris* BRONGNIART, 1828: 31

Pachypteris sp.

Text-fig. 23a-b

Material: NSM-PP 8032. *Locality:* 065. *Occurrence:* Rare.

Description: Obtained are two sterile pinna fragments; one with 8 alternate pairs of pinnules and another with 4 alternate pairs of them. Pinnules are closely set, elongate-triangular in form, with obtusely pointed apex, sometimes falcate, contiguous laterally at base; 6 mm long and 1.5 mm wide near the base; margins are entire. A vein arises near the basiscopic basal margin, forking at once dichotomously near base, then basiscopic one is forking once, ending at the basiscopic margin; acroscopic one is forking once at the middle part of pinnule and upper branch is forking again, all ending at the distal margin. Cuticle is not preserved.

Remarks: Judging from the venation of our pinnules, it is highly probable that our pinnae do not belong to ferns but to *Pachypteris* with pteridosperm-affinity. Because similar venation is seen in such *Pachypteris* species as *P. indica* (OLDHAM et MORRIS) ROY et BOSE (e.g. BOSE and BANERJI, 1984, text-fig. 19C). However, our pinnae are too incomplete to make their specific identity. Thus at present we regard our pinnae as *Pachypteris* sp. Such *Ctenozamites* (or *Ctenopteris*) species as *C. wolfiana* (GOTHAN) HARRIS (GOTHAN, 1914) has similar venation-pattern to ours.

Explanation of Plates

(All natural size)

Plate 1

1. *Gleichenites*? sp.: NSM-PP 7964. Loc.; 068.
2. *Coniopteris* sp.: NSM-PP 7966. Loc.; 063.
3. *Sphenopteris* sp. C: NSM-PP 8026. Loc.; 063.
4. *Sphenopteris* sp. F: NSM-PP 8031. Loc.; 063.

Plate 2

- 1-2. *Cladophlebis toyoraensis* OISHI: NSM-PP 7988 and 7985. Loc.; 063.
3. *Cladophlebis naitoi* KIMURA et OHANA sp. nov.: NSM-PP 7980 (paratype). Loc.; 063.

4. *Cladophlebis* sp. A: NSM-PP 7999. Loc.; 063.
5. *Cladophlebis* sp. B: NSM-PP 8002. Loc.; 063.
6. *Sphenopteris* sp. E: NSM-PP 8030. Loc.; 063.
7. *Acrostichopteris* sp. cf. *A. longipennis* FONTAINE: NSM-PP 8005. Loc.; 061.

Plate 3

1. *Cladophlebis naitoi* KIMURA et OHANA sp. nov.: NSM-PP 7978 (holotype). Loc.; 063.
- 2–3. *Cladophlebis* sp. C: NSM-PP 8004 and 8003. Loc.; 065.
4. *Adiantopteris* sp. A: NSM-PP 8008. Loc.; 063.
5. *Sphenopteris* sp. D: NSM-PP 8028. Loc.; 063.
6. *Sphenopteris* sp. B: NSM-PP 8020. Loc.; 063.
7. *Acrostichopteris naitoi* KIMURA et OHANA sp. nov.: NSM-PP 8008 (holotype). Loc.; 063.
8. *Acrostichopteris* sp. cf. *A. longipennis* FONTAINE: NSM-PP 8006. Loc.; 063.

Plate 4

1. *Polypodites?* sp. A: NSM-PP 7869. Loc.; 063.
2. *Sphenopteris* sp. A: NSM-PP 8018. Loc.; 063.
- 3–4. *Onychiopsis elongata* (GEYLER) YOKOYAMA: An arrow in Fig. 3 indicates fertile part.
Fig. 4 shows fragments of long petioles. NSM-PP 8013 and 8012. Loc.; 061.

