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Some Fossil Ferns from the Middle Carnic Momonoki Formation, Yamaguchi Prefecture, Japan.

By

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Foreword and Acknowledgements

Many sterile fern leaves have been described from the Mesozoic plant-beds in Japan and adjacent lands under such comprehensive generic names as *Cladophlebis*. Some especially ones from the older Mesozoic plant-beds have been referred by previous authors to the European species, such as *Cladophlebis denticulata*, *C. haiburnensis* and *C. nebbensis*. However, the Japanese specimens determined as *Cladophlebis haiburnensis* and *C. nebbensis* for instance differ from the specimens from the type localities. So general revision of these determinations is needed.

This paper deals with the descriptions of *Asterotheca okafujii* sp. nov., *Todites fukutomii* sp. nov. and *T. yamanoiensis* (YOKOYAMA) comb. nov., based on the new material including good fertile leaves from two classic localities (Fig. 1) of the Momonoki Formation dated as Middle Carnic on palaeontological and stratigraphical evidences (for further detail, see TAKAHASHI & MIKAMI, 1975). In addition, we give further detail, about *Cladophlebis bitchuensis* OISHI which however remains unclassified.

We first express our sincere gratitude to Professor Emeritus Thomas M. HARRIS, F. R. S. of the University of Reading for his very helpful suggestions and critical reading over the manuscript. We wish to record here our cordial thanks to Mr. Gentaro NAITO, who has provided the *Asterotheca* specimens kept at the Miné City Museum of History and Folk-Custom (OKAFUJI's Collection) on loan for the present study. Thanks are extended to Mr. Takayoshi FUKUTOMI and Mr. Yutaka KURIHARA, who offered their *Todites* specimens for the present study. We are very much indebted to Dr. Kazuo ASAMA, Director of the Department of Geology, National Science Museum, Tokyo for giving us the facilities to publish this paper.

Systematic Description

Family Marattiaceae

Genus *Asterotheca* PRESL in CORDA, 1845: 81

Asterotheca okafujii KIMURA & OHANA sp. nov.

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

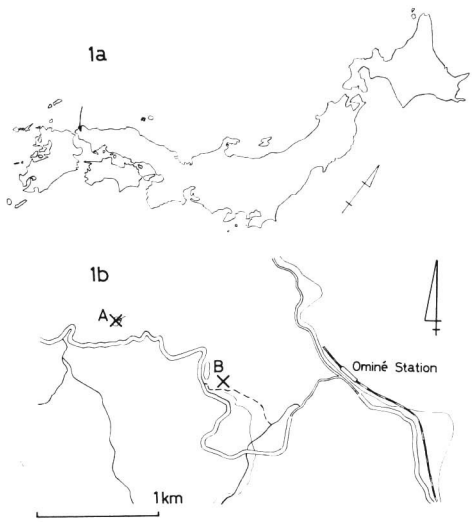


Fig. 1. The location of the plant-bearing formations in Yamaguchi Prefecture (1a), and the main localities (A and B) of fossil plants in the Middle Carnic Momonoki Formation (1b).

The following sterile leaves are indistinguishable from those of *Asterotheca okafujii*.

Japanese specimens:

Cladophlebis cfr. *raciborskii* ZEILLER: OISHI, 1931, p. 234, pl. 16, fig. 6, 6a; pl. 17, fig. 1 (Tsuchizawa, Kuruma Group); 1932a, p. 287, pl. 26, fig. 3; pl. 28, figs. 3–4 (Nariwa Group); 1932b, p.7, pl. 2, fig. 1 (Shitaka Group).

Cladophlebis raciborskii ZEILLER (pars): OISHI, 1932a, p. 286, pl. 28, fig. 2 (Nariwa Group).

Cladophlebis tenuissima OISHI: OISHI, 1932b, p. 8, pl. 3, figs. 1–2 (Shitaka Group).

?*Cladophlebis maizurensis* OISHI: OISHI, 1932b, p. 7, pl. 2, figs. 4–5 (Shitaka Group).

Cladophlebis raciborskii ZEILLER forma *integra* OISHI & TAKAHASHI: OISHI & TAKAHASHI, 1936, p. 119 (nomenclature); OISHI & HUZIOKA, 1938, p. 73 (Nariwa Group); OISHI, 1940, p. 283, pl. 19, fig. 1, 1a (Momonoki Formation).

Chinese specimens:

Todites williamsoni (BRONGNIART)(pars): YOKOYAMA, 1906, p. 18, pl. 3; p. 20, pl. 5, fig. 1a (Sichuan).

Cladophlebis raciborskii ZEILLER: YANG, 1978, p. 492, pl. 163, fig. 7 (Upper Triassic Xujiahe Formation, Sichuan).

Cladophlebis sp.: SZE, 1933, p. 13, pl. 6, fig. 8 (Sichuan).

Other region's specimens:

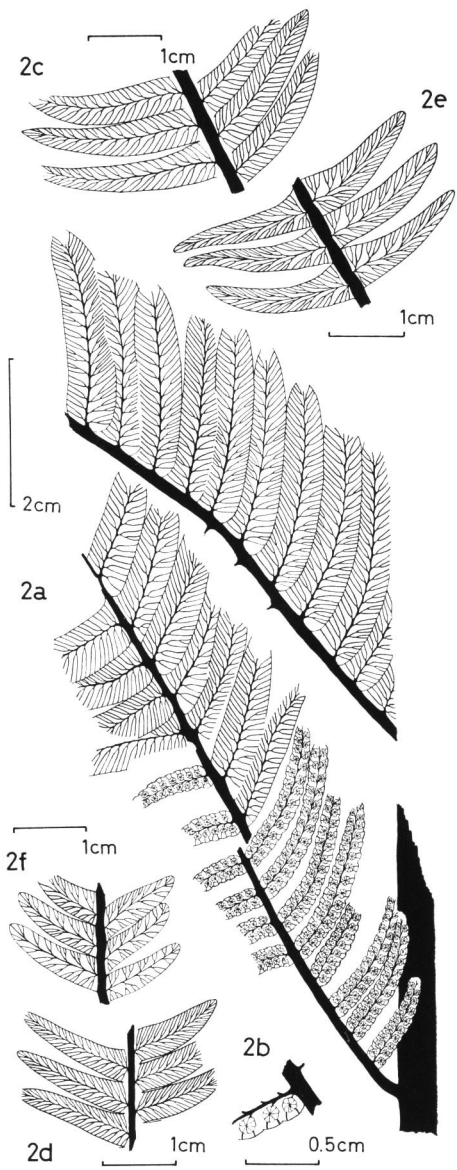
Cladophlebis kamenkensis THOMAS, 1911, p. 66, pl. 3, fig.s. 1–3 (Jurassic of Kamenka, USSR).

Material: Holotype; MMHF200002 (kept in the Miné City Museum of History and Folk-Custom). Paratypes; MMHF-200001, 200003, PP7529. *Stratum* typicum: Middle Carnic Momonoki Formation, Miné Group. *Locus typicus*: Momonoki, Ominé-machi, Miné City, Yamaguchi Prefecture (Fig. 1A). *Derivatio nominis*: This species is named after the late Mr. Goro OKAFUJI who collected its holotype, paratypes and large number of leaves during past two decades.

Diagnosis: Leaf bipinnate, large. Leaf with its petiole, 160 cm long, lamina 130 cm long and 60 cm wide, broadly lanceolate. Petiole 6 mm wide at its base, surface smooth. Pinnae nearly parallel-sided for the most part, then suddenly narrowing

towards the acute apex, 30 cm long and 5.6 cm wide at the middle portion of a leaf, attached oppositely or subopposite to the rachis at an angle of 50–90 degrees; angle reduced towards the apex. In some leaves pinnae closely set and overlapping each other laterally, in others remotely set.

Sterile pinnules set closely, long and narrow, nearly parallel-sided for the most



Figs. 2a–f. *Asterotheca okafujii* KIMURA & OHANA sp. nov.: 2a. A part of leaf (paratype, MMHF20001, consisting of fertile and sterile pinnules. 2b. Synangia, enlarged from 2a. 2c–f. Varied forms of sterile pinnules and their venation. 2c–d (paratype, MMHF 20003), 2e–f (paratype, PP7529).

part, then suddenly narrowing towards the acutely pointed or sometimes obtusely pointed apex, typically 3 cm long and 8 mm wide, attached katadromically to the pinna axis at an angle of 70–80 degrees, angle reduced near pinna apex, often falcate; margins entire; the first basiscopic pinnule not specialized. Venation pecopterid. Midrib distinct, persisting to the tip, sending off 13–18 pairs (rarely 6) of thin lateral veins at an angle of 50–90 degrees. Lateral veins forking twice or once.

Fertile pinnules rather remotely set, long and slender, typically 2.2 cm long and 3 mm wide, straight or bending forwards, usually on the both sides of proximal portion of pinnae at the middle and lower parts of a leaf; margins entire; apex rounded. Midrib distinct, sending off typically 13–16 pairs of lateral veins. Lateral veins once forking or sometimes simple.

Synangia on each lateral vein, midway between midrib and margin, typically consisting of 8 exannulate sporangia. about 1 mm across; sporangia free only at their apices. (Spores unknown).

Distribution and *occurrence*: *Asterotheca okafujii* is locally quite abundant in the Momonoki Formation. Some of them were preserved in the state of tufts consisting of 3–5 leaves with petioles. The sterile leaves possibly belonging to this species are known in the Middle Noric Nariwa and the Lower Jurassic Kuruma Groups and the Shitaka Group of uncertain age in Japan. Its distribution may extend to the Upper Triassic to Middle Jurassic beds in China and even in the eastern border of Ukraine.

Discussion and *comparison*: Our specimens clearly belong to the category of *Asterotheca*, because their pinnules show pecopterid venation, bearing sessile synangia made up of exannulate sporangia fused at the base but with the distal part free, but they represent a new species.

Asterotheca okafujii is characterized by its large-sized, long and narrow sterile pinnules with acutely pointed apex and typically 13–18 pairs of twice or once forking lateral veins of pecopterid-type, long and slender fertile pinnules with pointed apex and typically 13–16 pairs of once forking or simple lateral veins, and synangium consisting of typically 8 exannulate sporangia. The sterile pinnules differ considerably in form and venation in different leaves. But they agree with those having been regarded as *Cladophlebis raciborskii* ZEILLER forma *integra* OISHI & TAKAHASHI. Thus OISHI & TAKAHASHI's forma *integra* should now be included in *Astherotheca okafujii*.

The sterile leaves of this species is distinguished from *Cladophlebis raciborskii* ZEILLER by its entire pinnules with twice or once forking lateral veins, instead of serrate pinnules with usually twice forking lateral veins in *C. raciborskii*.

There are numerous Mesozoic species of *Asterotheca* all but one from the Upper Triassic. Of these, two have pinnules as large as those of *A. okafujii*, the rest differs in having smaller pinnules and in other respects also.

A) Species with large pinnules:

Asterotheca falcata DE LA SOTA & ARCHANGELSKY, 1962; Triassic of Santa Cruz, Argentina; pinnule apices rounded, synangium consisting of 5–6

sporangia.

A. virginiensis FONTAINE, 1883; Upper Triassic of Virginia, U.S.A.; pinnules larger, their apices rounded, their bases decurrent, venation neuropterid.

B) Species with smaller pinnules and fewer sporangia (but *A. cottoni* approaches group A):

A. cottoni ZEILLER, 1903; Upper Triassic of North Viet-Nam; synangium 9–11 on each side of midrib, consisting of 4–5 sporangia, see also ZHOU, 1978; YANG, 1978; Hsü et al., 1979.

A. fuchsii (ZEILLER) KURTZ; Upper Triassic of Chile (ZEILLER, 1875), also Chile (KURTZ, 1921) and Australia (TOWNROW, 1957); veins 5 pairs, synangium consisting of 3–6 sporangia.

The following have as a rule 4 sporangia in a synangium: *A. denmeadi* WALKOM; Upper Triassic of Australia (WALKOM, 1928), *Pecopteris* (? *Asterotheca*) *hillae* WALKOM; Upper Triassic of Australia (WALKOM, 1928), *A. hilariensis* MENÉNDEZ; Upper Triassic of Argentina (MENÉNDEZ, 1957), *A. meriani* (BRONGNIART) STUR; Upper Triassic of Europe (BRONGNIART, 1834; STUR, 1885 and others).

The following are incompletely known and the sporangium number is uncertain: *A. latepinnata* (LEUTHARDT) HSÜ; Upper Triassic of Europe (LEUTHARDT, 1904=*Pecopteris latepinnata*) and China (HSÜ et al., 1979), *A. penticarpa* (FONTAINE); Upper Triassic of U.S.A. (FONTAINE, 1883=*Asterocarpus penticarpa*) and China (FENG et al., 1979), *A. szeiana* (P'AN); Upper Triassic of China (P'an, 1936=*Cladophlebis szeiana*; He et al., 1979) and *A. truempyi* FRENGUELLI; Upper Triassic of Argentina (FRENGUELLI, 1943).

Asterotheca naktongensis originally described by OISHI (1939) from the Lower Cretaceous Gyeongsang Group (formerly Naktong or Nagdong Group) of Korea, may belong to *Gleichenia* (or *Gleichenites*).

Asterotheca okafujii is not compared with the Palaeozoic species of *Asterotheca*, but as far as we know none of them have such large and acutely pointed pinnules.

Family Osmundaceae

Genus *Todites* SEWARD, 1900: 86

Todites fukutomii KIMURA & OHANA sp. nov.

Pl. 3, figs. 1–2; Pl. 4, figs. 2–3;
Pl. 6, fig. 1; Figs. 3a–c

The following sterile leaves are indistinguishable from those of *Todites fukutomii*.

Japanese sterile specimens:

Asplenium roesserti PRESL: YOKOYAMA, 1891, p. 241, pl. 32, figs. 1–2, 5 (non figs. 3, 4); pl. 34, fig. 2 (Yamanoi Formation).

Cladophlebis nebbensis (BRONGNIART) NATHORST: YOKOYAMA, 1905, p. 3, pl. 1, figs. 1–3 (Yamanoi Formation): YABE, 1922, p. 14 (Yamanoi Formation): OISHI, 1931, p. 231, pl. 16, figs. 4, 4a (Tsuchizawa, Kuruma Group): 1932a, p. 285, pl. 24, figs. 4–5; pl. 27; pl. 29, fig. 1; pl. 30, fig. 1;

pl. 39, fig. 5C (Nariwa Group): 1932b, p. 5, pl. 1, fig. 4; pl. 2, fig. 3 (Shitaka Group): 1932c, p. 57 (Momonoki and Yamanoi Formations): 1940, p. 277 (general remarks).

Cladophlebis sp.: YOKOYAMA, 1905, p. 11, pl. 3, figs. 2, 4, 7 (Nariwa Group).

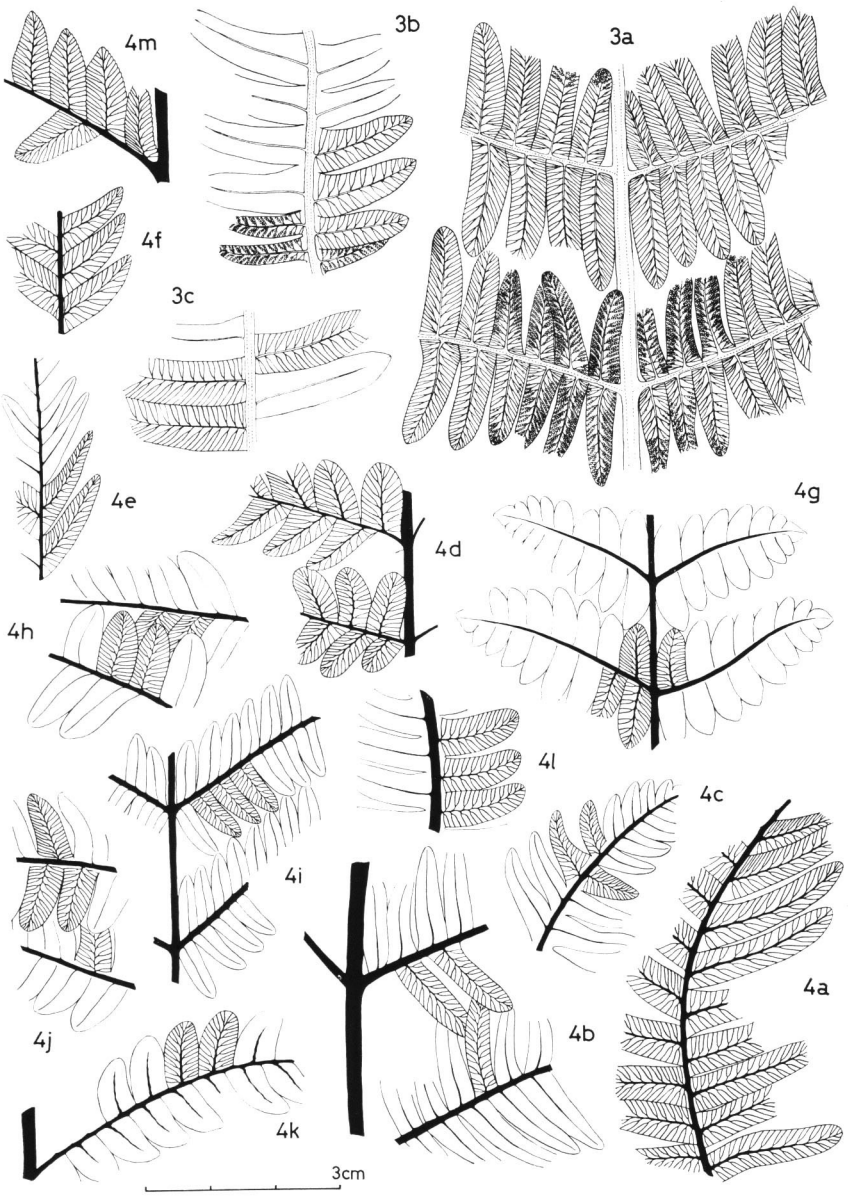
Material: Holotype; PP7530. Paratypes; PP7531–7532. *Stratum typicum*: Middle Carnic Momonoki Formation, Miné Group. *Locus typicus*: Momonoki, Ominé-machi, Miné City, Yamaguchi Prefecture (Fig. 1B). *Derivatio Nominis*: This species is named after Mr. Takayoshi FUKUTOMI who collected its specimens in 1979.

Diagnosis: Leaves bipinnate. Most leaves probably wholly fertile or wholly sterile but some only partly fertile. Rachis slender, 4 mm wide, grooved above, rounded below. Pinnae opposite, arising at an angle of 75 degrees, straight, nearly parallel-sided, probably almost uniformly wide up to the unknown apex, pinna rachis up to 2 mm wide, somewhat channelled above.

Pinnules commonly arising at right angle to the pinna rachis, katadromic in order, basal pinnules not specialized but their both margins usually slightly contracted at base. Typical size of pinnules 1.6 cm long and 5.3 mm wide, usually finger-shaped or when small elongate-triangular, often slightly curving forwards, basal margin often slightly contracted at pinna rachis, upper margin usually expanded; lateral margins entire, apex rounded. Pinnules set closely, usually in contact or overlapping. Midrib arising at the centre of base of pinnule, persisting to the tip, sending off typically 13–14 pairs of lateral veins; first lateral vein arising from the base of midrib or from the pinna rachis. Lateral veins forking once. but basal one or two pairs often forking twice.

Figs. 3a–c. *Todites fukutomii* KIMURA & OHANA sp. nov.: 3a. A part of bipinnate leaf with fertile and sterile pinnules; several pinnules show the transitional process from sterility to fertility. Basal one or two pairs of lateral veins are forked twice. Rachises are all slender, grooved above and rounded below. Holotype (PP7530). 3b. A part of pinna with fertile and sterile pinnules; in fertile pinnules their width is usually reduced. Lateral veins are all forking once. Paratype (PP7531). 3c. A part of pinna with sterile pinnules. Lateral veins are all forking once. Paratype (PP 7532).

Figs. 4a–l. Fossil sterile leaves having been regarded as *Asplenium roesserti*, *Cladophlebis nebbensis* or *C.* sp. by the previous authors from the Japanese older Mesozoic plant-beds. They are now referable to *Todites fukutomii*. Unfortunately the features of their rachises are uncertain. 4a. YOKOYAMA's specimen regarded by him as *Cladophlebis nebbensis* from the Yamanoi Formation. Redrawn partly from his pl. 1, fig. 1 (1905). 4d. Ditto. Redrawn from his pl. 1, fig. 2 (1905). 4b. YOKOYAMA's specimen regarded first by him as *Asplenium roesserti* from the Yamanoi Formation. Redrawn partly from his pl. 32, fig. 2 (1891). 4c. Ditto. Redrawn partly from his pl. 32, fig. 5 (1891). 4e. Ditto. Redrawn partly from his pl. 34, fig. 2 (1891). 4f. YOKOYAMA's specimen regarded by him as *Cladophlebis* sp. from the Nariwa Group. Redrawn from his pl. 3, fig. 7 (1905). 4g. OISHI's specimen regarded by him as *Cladophlebis nebbensis* from the Nariwa Group. Redrawn partly from his pl. 24, fig. 4 (1932a). 4h. Ditto. Redrawn partly from his pl. 39, fig. 5c (1932a). 4i. Ditto. Redrawn partly from his pl. 27 (1932a). 4j. Ditto. Redrawn partly from his pl. 29, fig. 1 (1932a). 4k. OISHI's specimen regarded by him as *Cladophlebis nebbensis* from the Shitaka Group (exact age unknown). Redrawn partly from his pl. 1, fig. 4 (1932b). 4l. OISHI's specimen regarded by him as *Cladophlebis nebbensis* from the Kuruma Group (Tsuchizawa). Redrawn partly from his pl. 16, fig. 4, 4a (1931). 4m. *Pecopteris nebbensis* redrawn partly from BRONGNIART's pl. 98, fig. 3 (1834) for comparison; margins of pinnules are finely dendate.


4m
3b
3a
4f
3c
4e
4d
4g
4h
4l
4c
4i
4a
4j
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3cm

Fertile pinnules similar in size and other features to sterile ones but usually convex above and reflexed at margins. Sporangia borne in a single file on each vein, in partly fertile pinnules confined to its apical part but usually covering whole under surface. Sporangia ovoid, whole apical third of wall composed of thickened cells. (Spores not known).

Distribution and *occurrence*: Fertile leaves are restricted to the Upper Triassic Momonoki Formation of Japan, but sterile leaves resembling these fertile ones are more abundant in the Momonoki Formation and occur also in the Lower Jurassic of Japan.

Discussion and *comparison*: In Japan and adjacent lands, the sterile fern leaves with the following diagnostic features, have been regarded as *Cladophlebis nebbensis* (BRONGINART) by previous authors: Frond bipinnate. Pinnae opposite or subopposite to the slender rachis. Pinnules nearly parallel-sided or gradually narrowing forwards, ending rounded or obtusely pointed apex. Margins entire or finely dentate. Lateral veins once forking.

These sterile leaves described from Japan mentioned on p. 77–78 (see also Figs. 4a–l) may well belong to *Todites fukutomii*. The only difference noted between these sterile leaves and the present ones is the venation; in above mentioned sterile leaves, lateral veins are all once forking, while in our leaves, basal one or two pairs are often twice forking and some have finely denticulate margins.

The sterile pinnules of *Todites fukutomii* are distinguished from those of original specimen of *Cladophlebis* (*Pecopteris*) *nebbensis* illustrated by BRONGNIART (1834) (Fig. 4m) by its entire margins and crowded lateral veins (13–14 pairs), instead of finely dentate margins and less number of lateral veins (up to 10 pairs) in Brongniart's specimen.

The European specimens regarded as *Cladophlebis nebbensis* would be distinct from the sterile leaves described under the same specific name at least in Japan and Korea. Because most of these European pinnules have serrate or toothed margins and their lateral veins are usually forking twice. HARRIS (1937) mentioned that these European sterile leaves are similar to those of *Todites hartzi*, *T. recurvatus*, or *Osmundopsis plectrophola*.

KAWASAKI's specimens assigned by him (1925) to *Cladophlebis nebbensis* from the Upper Triassic Daedong Group of Korean Peninsula, resemble *Todites fukutomii* in the form of pinnule and venation, but in KAWASAKI's specimens the first basiscopic pinnule is distinctly specialized (rounded and shorter). and some pinnae are set remotely as seen in one of OISHI's specimens from the Nariwa Group (OISHI, 1932a, pl. 30, fig. 1).

KRYSHTOFOVICH & PRYNADA (1932) mentioned the occurrence of *Cladophlebis nebbensis* from the Upper Triassic Mongugai and the Lower Cretaceous Nikan Groups in Ussuri, and SREBRODOLSKAJA (1964) noted its occurrence from the Mongugai Group. We, however, could not compare their specimens with ours, because they did show neither its detail nor illustration.

So far as we know, from the older Mesozoic of China, sterile leaves referable to *Todites fukutomii* have not been recorded.

ZEILLER's specimens from the Upper Triassic of North Viet-Nam regarded by him (1903) as *Cladophlebis nebbensis* to which FRENGUELLI (1947) proposed a new specific name, *C. zeilleri*, are somewhat different from those of *Todites fukutomii* in that in ZEILLER's leaves two basal pinnules of each pinna are usually different in size and in mode of attachment to the pinna rachis from all other pinnules, and the pinnules have usually denticulated margins at least on the posterior and middle portions of a leaf. ZEILLER's leaves are in our opinion rather similar to those of *Cladophlebis nebbensis* known from Europe and Central Asia.

HARRIS (1931, 1937, 1961) grouped the *Todites* species into *T. princeps*, *T. williamsoni-goeppertianus* and *Cladotheca* groups. Among over 30 *Todites* species hitherto known, *T. fukutomii* belongs apparently to his *Cladotheca* group, because of its pecopterid venation and its wholly fertile leaves. Thus we here make the comparison with species belonging to the *Cladotheca* group.

Todites acutinervis originally described by KILPPER (1964) resembles *T. fukutomii* in the form of pinnules, but differs in its lateral veins strongly directed forwards. *Todites acutinerivs* may belong to HARRIS' *T. williamsoni-goeppertianus* group owing to its venation.

Todites fukutomii is safely distinguished from *T. denticulatus* (BRONGNIART) on which detailed emended diagnosis was given by HARRIS (1961), by its usually denticulated margins and slender fertile pinnules with simple lateral veins.

The fertile leaves determined by KLIPPER (1964) as *Todites haiburnensis* (LINDLEY & HUTTON) differs in their twice forked veins.

Todites hartzi described by HARRIS (1931) is distinguished from *T. fukutomii* by its sterile pinnules with acute forward pointing apices and with serrate margins, its usually specialized first basiscopic pinnules, and its smaller and narrower fertile pinnules usually with simple lateral veins.

KILPPER (1964) also described some fertile pinnae as *Todites nebbensis* (BRONGNIART). Its pinnae are very slender in habit and are distinguished from those of *T. fukutomii*.

Todites thomasi described by HARRIS (1961) is easily distinguished from *T. fukutomii* by its basally constricted pinnules.

Todites recurvatus described by HARRIS (1931) is also distinguished from *T. fukutomii* by its sterile pinnules with serrate margins in their distal part, its specialized first basiscopic pinnules, and its fertile pinnules with blunt reflexed teeth along the margins and with simple lateral veins.

E. TAKAHASHI (1950) described sterile and fertile fragments from the Hagimine Coal-Mine of the Momonoki Formation as *Todites recurvatus*. Some of his sterile fragments (his text-fig. 1) remind us of sterile *T. fukutomii*, others (his text-fig. 2) of sterile *T. yamanoiensis*. His fertile pinnules seem to us like those of *T.* cfr. *denticulatus* (KIMURA & TSUJII, 1980 MS).

Todites yamanoiensis (YOKOYAMA) KIMURA & OHANA comb. nov.

Pl. 4, fig. 1; Pl. 5, fig. 1b; Pl. 6, figs. 2–3; Figs. 5a–g

The following specimens are safely referable to *Todites yamanoiensis*.

Asplenium roesserti PRESL var. *whitbiensis* BRONGNIART (pars): YOKOYAMA, 1891, p. 241, pl. 32, figs. 3, 3a, 4 (Yamanoi Formation, Habu Group) (non pl. 32, figs. 1, 2, 5 and pl. 34, fig. 2 which are *Todites fukutomii*, see p.77–81).

Cladophlebis yamanoiensis YOKOYAMA: YOKOYAMA, 1905, p. 4 (nomenclature).

The following sterile leaves resemble those of *Todites yamanoiensis*.

Japanese specimens:

Cladophlebis haiburnensis (LINDLEY & HUTTON): OISHI, 1931, p. 237, pl. 2, figs. 2, 2a (Tsuchizawa, Kuruma Group): 1932c, p. 56 (Yamanoi and Momonoki Formations): 1940, p. 266 (pars) (general remarks): KIMURA, 1959b, p. 69, pl. 1, fig. 5; pl. 2, fig. 1 (Kotaki Coal-Field, Kuruma Group).

Korean specimens from the Daedong Group:

Cladophlebis haiburnensis (LINDLEY & HUTTON): KAWASAKI, 1925, p. 18, pl. 5, figs. 16–18, 20, 19(?); pl. 6, figs. 21, 22 (?): 1939, p. 12, pl. 2, fig. 9; pl. 3, figs. 13–14; pl. 4, figs. 15–17; text-fig. 2.

Cladophlebis haiburnensis (LINDLEY & HUTTON) forma *aquilina* KAWASAKI: KAWASAKI, 1926, p. 3, pl. 2, figs. 5–6, 4 (?); pl. 3, fig. 10.

Cladophlebis (*Todites*) *williamsoni* BRONGNIART forma *whitbiensis* KAWASAKI: KAWASAKI, 1925, p. 21, pl. 4, fig. 13.

Cladophlebis (*Todites*) *williamsoni* BRONGNIART: KAWASAKI, 1925, p. 24, pl. 36, fig. 101 (?).

Cladophlebis williamsoni BRONGNIART cfr. var. *tenuicaulis* THOMAS: KAWASAKI, 1926, p. 26, pl. 7, fig. 21 (?).

Chinese specimens:

Todites williamsoni (BRONGNIART) (pars): YOKOYAMA, 1906, p. 28, pl. 8, fig. 1 (non pl. 3; pl. 5, fig. 1a; they belong possibly to *Asterotheca okafujii*; non pl. 4, fig. 4).

Cladophlebis haiburnensis (LINDLEY & HUTTON): YABE & OISHI, 1928, p. 5, pl. 1, fig. 2; pl. 3, fig. 1 (Fangtzi Coal-Field, Shan-dong): 1933, p. 208, pl. 30, fig. 12 (?); pl. 31, figs. 4, 4a, 5 (?); pl. 32, figs. 1, 2 (?) (NE-China): HE et al., 1979, p. 143, pl. 64, fig. 8; pl. 66, figs. 1, 2, 2a (Upper Triassic of Qinghai).

Cladophlebis cfr. *haiburnensis* (LINDLEY & HUTTON): CHANG, 1976, p. 188, pl. 92, fig. 3 (?)(Lower-Middle Jurassic of Neimung).

Other Asian and Middle-East specimens:

Cladophlebis haiburnensis (LINDLEY & HUTTON): KRYSHTOFOVICH, 1910, p. 6, pl. 1, figs. 2, 3 (?) (Ussuriland): SEWARD & THOMAS, 1911, p. 14, pl. 1, figs. 1–6; pl. 2, figs. 7, 8 (?); pl. 3, figs. 17–19 (text-fig. 1 is a Yorkshire specimen)(Irkutsk): SEWARD, 1912a, p. 19, pl. 2, figs. 31–35 (Afghanistan): 1907, p. 24, pl. 4, fig. P; pl. 6, figs. 35, 36, 41, 44 (pl. 2, fig. 34 is a Yorkshire specimen) (Turkestan): GENKINA, 1963, p. 26, pl. 8, figs. 1–4; pl. 9, figs. 1–6; pl. 10, fig. 1 (Middle Jurassic of Eastern Ural): 1966, p. 77, pl. 31, fig. 1; pl. 32, fig. 1 (Issyk-Kul Basin): TESLENKO, 1970, p. 126, pl. 14, fig. 1; pl. 15, figs. 1–4; pl. 16, fig. 4; pl. 50, fig. 5 (Jurassic of Western Siberia): KON'NO, 1972, p. 138, pl. 27, figs. 3–6, 7a, 8a (Upper Triassic of East Malaysia).

Cladophlebis ex gr. *haiburnensis* (LINDLEY & HUTTON): KRASSILOV & SCHOROCHOVA, 1973, p. 20, pl. 5, fig. 1; pl. 6, fig. 1 (Lower Jurassic of Primorye).

Material: Lectotype; PP7534. Paralectotypes; PP7529, 7534, 7535. Many fine sterile specimens were collected by G. OKAFUJI from the Momonoki Formation. A single YOKOYAMA's specimen (1891, pl. 32, fig. 3) is kept in the University Museum,

the University of Tokyo (Reg. no. MP6901). Other YOKOYAMA's specimens are not registered and missing.

Stratum typicum: Middle Carnic Momonoki Formation, Miné Group.

Locus typicus: Momonoki, Ominé-machi, Miné City, Yamaguchi Prefecture (Fig. 1B).

Derivatio nominis: The specific name is named after Yamanoi where the first sterile specimens were described by YOKOYAMA (1891).

Diagnosis: Sterile and fertile leaves probably separate, although they are similar in size and form. Frond large, more than 1 m long and 50 cm wide, bipinnate. Rachis 3–10 mm wide, with flat-topped ridge on the upper side, rounded below. (Petiole not known).

Pinnae alternate or rarely subopposite to the rachis at an angle of 50–90 degrees at intervals of 1.5–4 cm, more than 23 cm long, nearly parallel-sided for the most part, 3.8 cm wide, then narrowing to the obtusely rounded apex, touching each other laterally.

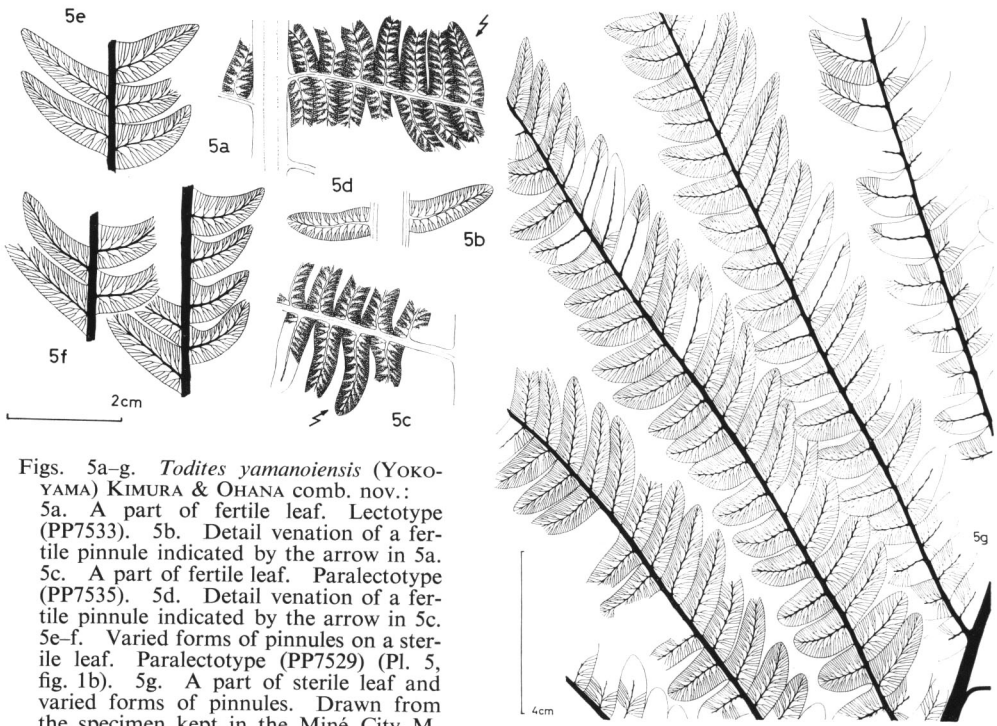
Sterile pinnules katadromic in order, varied in form; oblong-broadly deltoid (shorter ones) or elongate oblong—elongate triangular (longer ones), with obtusely pointed or broadly rounded at apex; margins entire. The first pair of pinnules not specialized. Shorter pinnules mainly on the basiscopic side of pinnae, typically 1.6 cm long (range noted 1.3–2.1 cm) and 7.8 mm wide (range noted 7–11 mm) near the base, attached to the pinna rachis by the whole base at an angle of 60–90 degrees, then bending forwards; acroscopic base expanded and basiscopic base often contracted. Longer pinnules mainly on the acroscopic side of pinnae, straight, typically 2.3 cm long (range noted 1.7–2.8 cm) and 7.5 mm wide (range noted 5–10 mm) near the base, attached to the pinna rachis at an angle of 50–90 degrees. Midrib prominent, persisting to the tip, often decurrent, arising from a little lower than the middle of base, sending off 7–8 pairs (short pinnules) or 8–11 pairs (longer pinnules) of lateral veins. Lateral veins nearly perpendicular to the midrib, usually twice forking.

Fertile pinnules similar in all features to sterile ones but convex above. Sporangia ovoid, 0.3 mm in diameter, whole apical third of wall composed of thickened cells, borne in a single file along each vein. (Spores unknown).

Distribution and *occurrence*: Fertile specimens of *Todites yamanoiensis* are occasional at the Momonoki Formation but not known at the Yamanoi Formation and the Kuruma Group. Sterile specimens are abundant with the fertile ones at the Momonoki Formation and less abundant in the Kuruma Group. Similar sterile leaves have been described from Upper Triassic to Middle Jurassic of Primorye, Korea, China, Southern Siberia, East Malaysia, Middle East and the Eastern border of Ukraine.

Discussion and *comparison*: Our fertile and sterile leaves belong to the same plant. Because the fertile leaves agree in all features with the sterile ones, and the fertile leaves occur in close association with the sterile ones in the Momonoki Formation.

The sterile leaves were first described by YOKOYAMA (1891) as *Asplenium roesserti* var. *whitbiensis* (pars), then the name was changed by him (1905) to *Cladophlebis*



Figs. 5a–g. *Todites yamanoiensis* (YOKOYAMA) KIMURA & OHANA comb. nov.: 5a. A part of fertile leaf. Lectotype (PP7533). 5b. Detail venation of a fertile pinnule indicated by the arrow in 5a. 5c. A part of fertile leaf. Paralectotype (PP7535). 5d. Detail venation of a fertile pinnule indicated by the arrow in 5c. 5e–f. Varied forms of pinnules on a sterile leaf. Paralectotype (PP7529) (Pl. 5, fig. 1b). 5g. A part of sterile leaf and varied forms of pinnules. Drawn from the specimen kept in the Miné City Museum of History and Folk-Custom.

yamanoiensis. Thus YOKOYAMA's specific name has the priority to the leaves here described. Nevertheless the later authors identified the similar sterile leaves with the Yorkshire species, *Cladophlebis haiburnensis*.

Our sterile leaves, however, differ in several respects from *Cladophlebis haiburnensis* to which useful emended diagnosis and detailed comparison were given by HARRIS (1961). Differences are: In *Cladophlebis haiburnensis*: All rachises are slender. Pinnae are usually opposite. Margins of larger pinnules are divided into rounded lobes; lower lobe on basiscopic side of large pinnule is occasionally forming a spur with a midrib of its own. In *Todites yamanoiensis*: Main rachis is fairly thick, some reaching 1 cm across. Pinnae are alternate or subopposite. Margins of pinnules are usually entire; not specialized at base.

Cladophlebis aktashensis TURUTANOVA-KETOVA resembles the sterile leaves of *Todites yamanoiensis*. But it differs in several respects from ours. Differences are: In *Cladophlebis aktashensis*: Rachises are not channelled but showing obscure longitudinal ridges and cellular striae on the surface. Pinna rachis is stout, typically 2 mm wide. Pinnules on the two sides of a pinna are equal. Largest pinnule is 3.4 cm long and 10 mm wide. Number of lateral veins is 12–15 pairs or more. In *Todites yamanoiensis* (from the type locality): Rachis has a flat-topped ridge on the upper

side. Pinna rachis rather slender up to 1 mm wide. Pinnules on the two sides of a pinna are often unequal. Largest pinnule is 2.8 cm long and 1 cm wide. Number of lateral veins is 7–11 pairs.

We consider good specimens of sterile leaves of *Todites yamanoiensis* distinct from those of *Cladophlebis haiburnensis* and *C. aktashensis*, but small sterile fragments may be indistinguishable.

The following specimens referred to *Cladophlebis haiburnensis* are either distinct from *Todites yamanoiensis* or else indeterminable. Some of them are, as HARRIS (1961) pointed out, referable to *Cladophlebis atkashensis*.

Japanese specimens: YABE, 1922, p. 16, pl. 2, figs. 10–11; text-figs. 15, 16 (Shitaka Group of uncertain age); having about 14 pairs of lateral veins, more like *C. aktashensis*. OISHI, 1932a, p. 281, pl. 6, figs. 1–3; pl. 8, figs. 1–2 (Nariwa Group); more than 12 pairs of lateral veins, referable to *C. aktashensis*. OISHI, 1932b, p. 6, pl. 1, fig. 6; pl. 2, fig. 2 (Shitaka Group); more like *C. aktashensis*, although the number of lateral veins is uncertain. KIMURA, 1959a, p. 16, pl. 4, fig. 8; pl. 6, figs. 3, 5, 7; text-fig. 10 (Iwamuro Formation); misidentified, at present referable to *Todites fastuosus* (KIMURA & TSUJII, 1980 MS).

Korean specimens from the Daedong Group: YABE, 1922, p. 16, pl. 2, fig. 9; text-figs. 13–14; having 14–15 pairs of lateral veins, more like *C. aktashensis*.

Chinese specimens: YABE, 1922, p. 16, text-fig. 12 (exact locality uncertain); indeterminable, veins not illustrated.

Other Asian specimens: SEWARD, 1912b, p. 26, pl. 1, fig. 7, 7a; pl. 2, fig. 10, 10a (Amurland); distinct, pinnules are smaller, with 6–7 pairs of lateral veins. KRYSHTOFOVICH & PRYNADA, 1932, p. 365 (Ussuriland): not illustrated.

Accordingly at present there is no specimen referable to *Cladophlebis haiburnensis* in Japan and adjacent lands. We suspect that *Cladophlebis haiburnensis* is not cosmopolitan species but local one.

Todites yamanoiensis is distinguished in several respects from *T. haiburnensis* (LINDLEY & HUTTON) with polymorphous pinnules, originally described by KILPPER (1964) from the Liassic of North Iran. Differences are: In *T. haiburnensis*: Pinnae are opposite or subopposite. Shorter pinnules represent rather neuropterid venation as shown in his pl. 9, figs. 1–3, 5. Margins of some longer pinnules are roundly lobed as shown in his pl. 8, fig. 4. Some pinnules are narrowly elongated as shown in his text-fig. 25 (on the right pinna) which strongly remind us of those of *Cladophlebis aktashensis*. In *T. yamanoiensis*: Pinnae are usually alternate or rarely subopposite. Venation is unexceptionally of pecopterid-type. Margins of pinnules are entire. Pinnules are not so narrowly elongated.

Todites yamanoiensis is distinguished from *T. katoi* described by KON'NO (1972) from the Upper Triassic of East Malaysia by its more crowded lateral veins making a wide angle to the midrib, instead of less number of sphenopterid lateral veins (6 pairs) making a narrow angle to the midrib in *T. katoi*.

Cladophlebis asiatica CHOW & YEH (in SZE, LI et al., 1963) from the Early to Middle Jurassic of China resembles the sterile leaves of *Todites yamanoiensis*.

Todites yamanoiensis apparently belongs to HARRIS' *Cladotheca* group owing to its pecopterid venation, and is distinguished from other species belonging to this

group formerly mentioned in this paper.

Unclassified fern

Form-genus *Cladophlebis* BRONGNIART, 1849: 105

Cladophlebis bitchuensis OISHI

Pl. 6, fig. 4; Fig. 6

Cladophlebis bitchuensis OISHI: OISHI, 1932a, p. 284, pl. 25, fig. 1 (Nariwa Group): 1940, p. 253 (general remarks).

Material: PP7536 (collected from the Momonoki Formation).

Emended diagnosis: Frond large and bipinnate. (Whole leaf unknown). Rachis comparatively slender, 5 mm wide with longitudinal striations on its surface. Pinnae long and narrow, nearly parallel-sided for the most part, being 4 cm wide near the base, set closely, at intervals of 4–6 cm, touching each other laterally, attached subopositely or alternately to the rachis at an angle of 70–80 degrees, often perpendicular. (Pinna apex unknown).

Pinnules katadromic in order, elongate-oblong or broadly linear in form, typically 1.9–2.2 cm long and 0.8–1.1 cm wide near the base, attached to the slender pinna axis at a wide angle, often perpendicular by their whole bases; apex rounded or obtusely pointed; margins entire. Midrib distinct, persisting to the tip, sending off typically 7–8 pairs of lateral veins at a wide angle basally and at a narrow angle apically. Basal

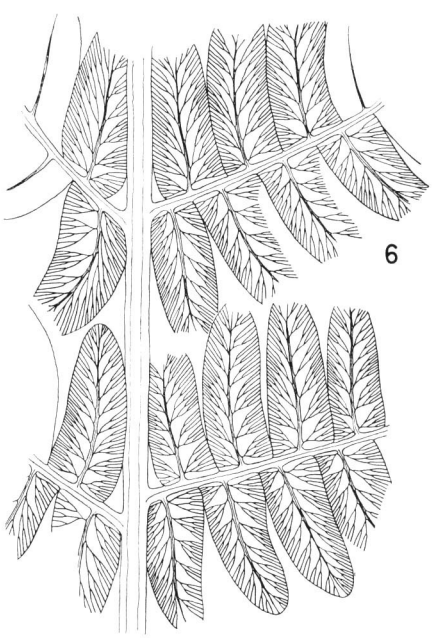


Fig. 6. *Cladophlebis bitchuensis* OISHI: Showing the detailed venation; surface view. (PP7536).

3–4 pairs of lateral veins thrice forking, first close to the midrib, secondly midway and lastly near the margin, thus making a bundle of nervelets. Apical 3–4 pairs of lateral veins twice forking.

The first pinnules not so specialized, but their basal basiscopic margins are usually contracted. (Fructification unknown).

Discussion and *comparison*: OISHI (1932a) first described this species based on a single specimens from the Nariwa Group. *Cladophlebis bitchuensis* is characterized by its large-sized and entire pinnules with rounded or obtusely pointed apex and thrice forking basal 3–4 pairs of lateral veins.

Cladophlebis bitchuensis is of the type of *Todites yamanoiensis* here described together. But it is distinct from *T. yamanoiensis*, because we have not so far found the pinnules with thrice forking lateral veins together on the large numbers of *Todites yamanoiensis* leaves collected from the Momonoki Formation.

Cladophlebis bitchuensis resembles *C. gigantea* originally described by OISHI (1932a) based probably on a single specimen from the Nariwa Group. But it is distinguished from *C. gigantea* by its rather slender rachis and the pinnules with entire margins instead of thick rachis (7 mm wide) and the pinnules with shallowly crenulated or lobed margins in *C. gigantea*.

P'AN (1936) mentioned that *Cladophlebis bitchuensis* was most probably not specifically distinct from *C. gigantea*, and SZE (1956) suspected this. But we now consider that the discovery of more specimens from the Nariwa or the Miné Groups may compel us to recognize more definitely the close agreement between the two forms.

Cladophlebis fukiensis originally described by SZE (1933) from Fukien of China resembles *C. bitchuensis* on possessing also thrice forking lateral veins. It looks similar.

Sterile leaf-fragments described by KON'NO (1972) from the Upper Triassic of East Malaysia as *Cladophlebis* cfr. *haiburnensis*, have the pinnules with thrice forking lateral veins, but KON'NO's specimens are distinguished from *C. bitchuensis* by its large-sized and elongated pinnules with acutely pointed apex.

Specimens here described are kept in the National Science Museum, Tokyo (PP-7529–7536) and the Miné City Museum of History and Folk-Custom (MMHF200001–200003).

References

BRONGNIART, A., 1828–1834. Histoire des végétaux fossiles ou recherches botaniques et géologiques sur les végétaux renfermés dans les diverses couches du globe. 488+72 pp., 166+29 pls. Paris.

CHANG, C. C., 1976. Palaeontological Atlas of North China. Volume of Inner Mongolia, Part 2. Division of plants. 179–213, pls. 86–120. Peking, Di-Zhi-Chu-Ban-She (in Chinese).

DE LA SOTA, E. R. & S. ARCHANGELSKY, 1962. Dos nuevas especies de *Asterotheca* de la Serie Triásica 'El Tranquilo', Prov. de Santa Cruz. *Ameghiniana*, **2** (7): 113–118, pl. 1.

FENG, S. N., F. S. MENG, G. X. CHEN, Y. H. XI, C. F. ZHANG, & Y. A. LIU, 1977. Palaeontological

Atlas of Middle-South China. Part 3: Mesozoic-Cenozoic. 195–262, pls. 70–107. Peking, Di-Zhi-Chu-Ban-She (in Chinese).

FONTAINE, W. M., 1883. Contributions to the knowledge of the older Mesozoic flora of Virginia. 1–144 pp., 54 pls., Washington, U. S. Geol. Surv.

FRENGUELLI, J., 1943. Contribuciones al conocimiento de la flora del Gondwana superior de la Argentina. XIV. *Asterotheca truempyi* sp. nov. *Notas Mus. La Plata*, **8**(60): 421–430, pls. 1–4.

———, 1947. El género '*Cladophlebis*' y sus representantes en la Argentina. *An Mus. La Plata (N.S.), Paleont., sec. B*, **2**: 1–74. pls. 1–12.

GENKINA, R. Z., 1963. Fossil flora of the Mesozoic coal-bearing deposits of the East Ural-field of Orsk Coal Basin. 115 pp., 51 pls. Moscow, Acad. Sci. USSR (in Russian).

———, 1966. Fossil flora and stratigraphy of the Lower Mesozoic deposits of the Issyk-kul Basin (Northern Kirghizia). 148 pp., 61 pls. Moscow, Nauka (in Russian).

HARRIS, T. M., 1931. The fossil flora of Scoreby Sound East Greenland. *Medd. om Grønland*, **85**: (2): 1–104, pls. 1–18.

———, 1937. Ditto. Part 5: Stratigraphic relations of the plant beds. *ibid.*, **112**: (2): 1–114, pl. 1.

———, 1961. The Yorkshire Jurassic flora I. Thallophyta-Pteridophyta. ix+212 pp. London, British Museum (Nat. Hist.).

HE, Y. L., S. Y. WU, S. W. WU, P. C. LI, H. M. LI & S. X. KUO, 1979. Palaeontological Atlas of Northwest China. Volume of Qinghai. Part 2. 129–167, pls. 50–82. Peking, Di-Zhi-Chu-Ban-She (in Chinese).

HSÜ, J., J. N. ZHU, Y. CHEN, S. Y. DUAN, Y. F. HU & W. Q. ZHU, 1979. Late Triassic Baoding flora of China. 130 pp., 75 pls. Peking, Ke-Xue-Chu-Ban-She (in Chinese).

KAWASAKI, S., 1925. Some older Mesozoic plants in Korea. *Bull. Geol. Surv. Chosen (Korea)*, **4**(1): 1–71, pls. 1–47.

———, 1926. Addition to the older Mesozoic plants in Korea. *Ibid.*, **2**: 1–35, pls. 1–11.

———, 1939. Second addition to the older Mesozoic plants in Korea. *Ibid.*, **3**: 1–69, pls. 1–16.

KILPPER, K., 1964. Über eine rät/lias Flora aus dem nödlichen Abfall des Alburs-Gebirges in Nordiran. Teil 1: Bryophyta und Pteridophyta. *Palaeontographica, B*, **114**: 1–78, pls. 1–15.

KIMURA, T., 1959a. Mesozoic plants from the Iwamuro Formation (Liassic), Tone-gun, Gumma Prefecture, Japan. *Bull. Sen. High Sch., Tokyo Univ. Educ.*, **3**: 1–59, incl. pls. 1–12.

———, 1959b. Mesozoic plants from the Kotaki Coal-Field, the Kuruma Group, Central Honshu, Japan. *Ibid.*, **3**: 61–83, incl. pls. 1–2.

——— & M. TSUJII, 1980 MS. Early Jurassic plants in Japan. Part 2. *Trans. Proc. Palaeont. Soc. Japan. N. S.*

KON'NO, E., 1972. Some late Triassic plants from the southwestern border of Sarawak, East Malaysia. *Geol. Palaeont. SE-Asia*, **10**: 125–178, pls. 24–32.

KRASSILOV, V. A. & S. A. SCHOROCHOVA, 1973. Early Jurassic flora from the Petrovka River (Primorye). In 'Fossil floras and phytostratigraphy of the Far East'. Vladivostok, Far East Geol. Inst., Far East Sci. Centre, Acad. Sci. USSR 13–27, pls. 3–12 (in Russian).

KRYSHTOFOVICH, A. N., 1910. Jurassic plants from Ussuriland. *Mém. Com. Géol., St.-Pétersb., N. S.*, **56**: 1–23, pls. 1–3 (in Russian).

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

KURTZ, F., 1921. Atlas de plantas fosiles de la Republica Argentina. *Actas Acad. Nac. C. Cordoba*, **7**: 129–153, pls. 1–27.

LEUTHARDT, F., 1904. Die Keuperflora von Neuwelt bei Basel. Teil 2. Kryptogamen. *Abhandl. d. Schweiz. Paläont. Gesell.*, **31**: 25–48, pls. 11–21.

MENÉNDEZ, C. A., 1957. *Asterotheca hilariensis* sp. nov. del Triasico Superior de Hilario, San Juan. *Ameghiniana*, **1** (1–2): 25–30, pls. 1–2.

OISHI, S., 1931. Mesozoic plants from Kita-Otari, Prov. Shinano, Japan. *Journ. Fac. Sci., Hokkaido*

Imp. Univ., (4), **1** (2): 223–255, pls. 16–18.

———, 1932a. The Rhaetic plants from the Nariwa District, Prov. Bitchu (Okayama Prefecture), Japan. *Ibid.*, **1** (3–4): 257–380, pls. 19–53.

———, 1932b. The Jurassic plants from Shitaka (the Maizuru Coal-Field), Prov. Tango (Kyoto Prefecture). Japan. *Ibid.*, **2** (1): 1–13, pls. 1–3.

———, 1932c. Rhaetic plants from Province Nagato (Yamaguchi Prefecture), Japan. *Ibid.* **2** (1): 51–67, pls. 9–10.

———, 1939. Notes on some fossil ferns from the Naktong Series of Korea. *Ibid.*, **4** (3–4): 307–312, pl. 35.

———, 1940. The Mesozoic floras of Japan. *Ibid.*, **5** (2–4): 123–480, pls. 1–48.

——— & K. Huzioka, 1938. Fossil plants from Nariwa. A supplement. *Ibid.*, **4** (1–2): 69–101, pls. 7–12.

——— & E. Takahashi, 1936. The Rhaetic plants from Province Nagato. A supplement. *Ibid.*, **3** (2): 113–133, pl. 10.

P'an, C. H., 1936. Older Mesozoic plants from North Shensi. *Palaeont. Sinica, ser. A.* **4** (2): 1–49, pls. 1–15.

Seward, A. C., 1907. Jurassic plants from Caucasia and Turkestan. *Mem. Com. Géol., St.-Pétersb., N. S.*, **38**: 1–48, pls. 1–8.

———, 1912a. Mesozoic plants from Afghanistan and Afghan-Turkistan. *Mem. Geol. Surv. India, Palaeont. Indica, N. S.*, **4** (4): 1–57, pls. 1–7.

———, 1912b. Jurassic plants from Amurland. *Mém. Com. Géol., St.-Pétersb., N. S.*, **81**: 17–34, pls. 1–3.

——— & H. H. Thomas, 1911. Jurassic plants from the Balagansk District, Government of Irkutsk. *Ibid.*, 73: 1–23, pls. 1–3.

Srebrodolskaja, I. N., 1964. The late Triassic (Mongugai) flora of the Primorye and stages of her development. *Tr. VSES. N.-Journ. Geol. Inst., N. S.*, **107**: 54–61 (in Russian).

Stur, D. R. J., 1885. Die obertriadische Flora der Lunzer-Schichten und des bituminösen Shiefers van Raibl. *K. Akad. Wiss. Sitzungsber.*, Vienna, **91** (1): 93–103.

Sze, H. C., 1933. Beiträge zur meszoischen Flora von China. *Palaeont. Sinica, ser. A*, **4** (1): 1–68, pls. 1–12.

———, 1956. Older Mesozoic plants from the Yenchang Formation, Northern Shensi. *Ibid., N. S., ser. A*, **5**: 1–111 (Chinese part), 110–217 (English part), pls. 1–56.

———, X. X. Li, T. Y. Chow, S. C. Wu, P. C. Li, M. N. Ye & G. L. Shen, 1963: Fossil plants of China. Vol. 2. Mesozoic plants of China. iv+429 pp., 118 pls. Peking, Ke-Xue-Chu-Ban-She (in Chinese).

Takahashi, E., 1950. Two species of *Todites* from the Triassic Miné Series, Prov. Nagato (Yamaguchi Prefecture). *Journ. Geol. Soc. Japan.* **58** (660): 439–440.

——— & T. Mikami, 1975. Triassic System in Yamaguchi Prefecture. *In* 'Geology of Yamaguchi Prefecture' 93–108. Yamaguchi Museum, Yamaguchi. (in Japanese).

Teslenko, Y. V., 1970. Jurassic stratigraphy and flora of Western and Southern Siberia and Tuva. *Bull. Siber. Sci. Stud., Inst. Geol. Geophys. Min. Res., ser. Palaeont. Stratigr.*, **42**: 1–216, pls. 1–52 (in Russian).

Thomas, H. H., 1911. The Jurassic flora of Kamenka in the district of Isium. *Mém. Com. Géol., St.-Pétersb., N. S.*, **71**: 1–95, pls. 1–8.

Townrow, J. A., 1957. On *Dicroidium*, probably a Pteridospermous leaf, and other leaves now removed from this genus. *Trans. Geol. Soc, South Africa*, **60**: 21–56, pls. 1–3 (with discussions, 57–60).

Walkom, A. B., 1917. Mesozoic floras of Queensland. Part 1. The flora of the Ipswich and Walloon Series. *Queensl. Geol. Surv.*, **259**: 7–48, incl. pls. 1–9.

———, 1928. Fossil plants from the Esk District, Queensland. *Proc. Linn. Soc. N. S. W.*, **53** (4):

458–468, pls. 26–28.

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

YABE, H. & S. OISHI, 1928. Jurassic plants from the Fang-tzu Coal-Field, Shantung. *Jap. Journ. Geol. Geogr.*, **6** (1–2): 1–14, pls. 1–4.

——— & ———, 1933. Mesozoic plants from Manchuria. *Sci. Rep., Tohoku Imp. Univ., sec. ser.*, **12** (2B): 195–238, pls. 30–35.

YANG, X. H., 1978. Palaeontological Atlas of Southwest China. Volume of Sichuan. Part **2**. 469–484, pls. 155–190. Peking, Di-Zhi-Chu-Ban-She (in Chinese).

YOKOYAMA, M., 1891. On some fossil plants from the coal-bearing series of Nagato. *Journ. Coll. Sci., Imp. Univ. Japan*, **4** (2): 239–247, pls. 32–34.

———, 1905. Mesozoic plants from Nagato and Bitchu. *Ibid.*, **20** (5): 1–13, pls. 1–3.

———, 1906. Mesozoic plants from China. *Ibid.*, **21** (9): 1–39, pls. 1–12.

ZEILLER, R. 1875. Note sur les plantes de La Ternera (Chili). *Bull. Soc. Geol. France*, (3), **3**: 572–574, pl. 1.

———, 1903. Etudes des gîtes minéraux de la France, flora fossile des gîtes de Charbon du Tonkin. 320 pp., 56 pls. Paris.

ZHOU, T. S., 1978. On the Mesozoic coal-bearing strata and fossil plants from Fujian Province. *Prof. Pap. Stratigr. Palaeont.* **4**: 88–134, pls. 15–30. (in Chinese).

Explanation of plates

Plate 1

Fig. 1. *Asterotheca okafujii* KIMURA & OHANA sp. nov.: Upper part of a bipinnate leaf, with fertile pinnules on the proximal part of each pinna on the lower three pairs of pinnae in this figure. Holotype, MMHF-200002, collected by G. OKAFUJI from Loc. A (Fig. 1), kept in the Miné City Museum of History and Folk-Custom.

Plate 2

Fig. 1. *Asterotheca okafujii* KIMURA & OHANA sp. nov.: Middle part of a bipinnate leaf, with fertile pinnules on the proximal part of basal two pinnae in this figure.
Paratype, MMHF-200001, collected by G. OKAFUJI from Loc. A (Fig. 1), kept in the Miné City Museum of History and Folk-Custom.

Fig. 2. *Asterotheca okafujii* KIMURA & OHANA sp. nov.: A part of leaf, with sterile pinnules, having been regarded by the previous authors as *Cladophlebis raciborskii* ZEILLER forma *integra* OISHI & TAKAHASHI. Paratype, MMHF-200003, collected by G. OKAFUJI from Loc. A (Fig. 1), kept in the Miné City Museum of History and Folk-Custom.

Plate 3

Fig. 1. *Todites fukutomii* KIMURA & OHANA sp. nov.: A part of leaf, with fertile pinnules on the proximal part of each pinna on the lower two pairs of pinnae in this figure. Holotype, PP7530, collected by T. FUKUTOMI from Loc. B (Fig. 1), kept in the National Science Museum, Tokyo.

Fig. 2. *Todites fukutomii* KIMURA & OHANA sp. nov.: A pair of opposite pinnae, enlarged from Fig. 1 (holotype)(the second pair from the bottom).

Fig. 3. *Asterotheca okafujii* KIMURA & OHANA sp. nov.: Middle part of leaf, with fertile pinnules on the proximal part of pinnae. Paratype, MMHF-200003, collected by G. OKAFUJI from Loc. A (Fig. 1), kept in the Miné City Museum of History and Folk-Custom.

Plate 4

Fig. 1. *Todites yamanoiensis* (YOKOYAMA) KIMURA & OHANA comb. nov.: A part of bipinnate leaf, with fertile pinnules. Enlarged from the lectotype, PP7533, collected by Y. KURIHARA from Loc. B (Fig. 1), kept in the National Science Museum, Tokyo.

Fig. 2. *Todites fukutomii* KIMURA & OHANA sp. nov.: A part of leaf, with fertile pinnules on the proximal portion of each pinna. Paratype, PP7531, collected by T. FUKUTOMI from Loc. B (Fig. 1), kept in the National Science Museum, Tokyo.

Fig. 3. *Todites fukutomii* KIMURA & OHANA sp. nov.: A pair of opposite pinnae, enlarged from the holotype (Pl. 3, fig. 1)(the 3rd pair from the bottom).

Plate 5

Fig. 1a. *Asterotheca okafujii* KIMURA & OHANA sp. nov.: A part of apical part of leaf, with sterile pinnules; rachis is buried in the matrix. Paratype, PP7529, collected by G. OKAFUJI from Loc. A (Fig. 1), kept in the National Science Museum, Tokyo.

Fig. 1b. *Todites yamanoiensis* (YOKOYAMA) KIMURA & OHANA comb. nov.: A part of leaf, with sterile pinnules. Paralectotype.

Plate 6

Fig. 1. *Todites fukutomii* KIMURA & OHANA sp. nov.: A pair of opposite pinnae, enlarged from the holotype (Pl. 3, fig. 1)(bottom pair).

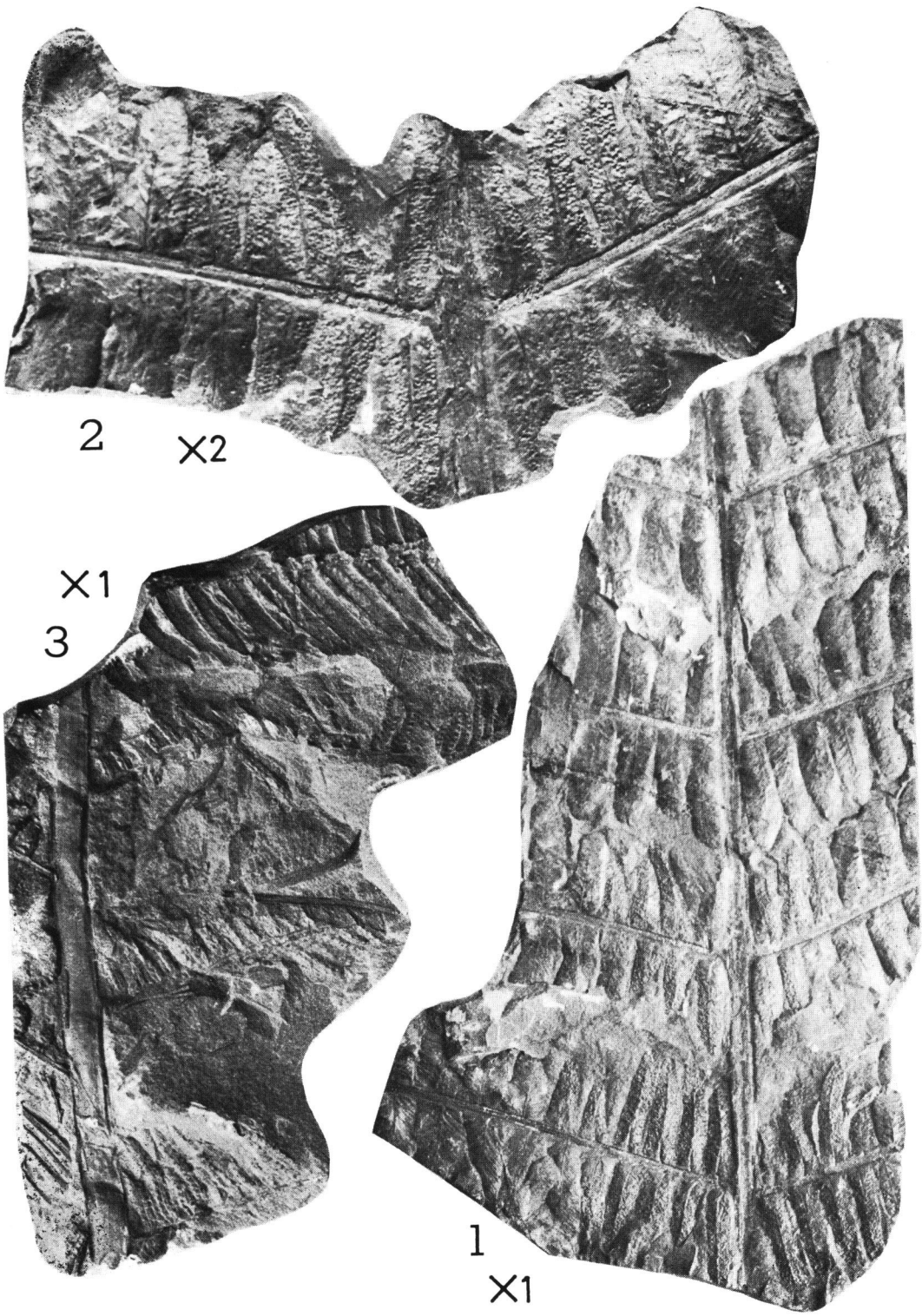
Fig. 2. *Todites yamanoiensis* (YOKOYAMA) KIMURA & OHANA comb. nov.: Pinna with fully fertile pinnules. Paratype, PP7535, collected by Y. KURIHARA from Loc. B (Fig. 1), kept in the National Science Museum, Tokyo.

Fig. 3. *Todites yamanoiensis* (YOKOYAMA) KIMURA & OHANA comb. nov.: A part of sterile pinnae, showing the venation of pinnules. Paralectotype, PP7534, collected by G. OKAFUJI from Loc. A (Fig. 1), kept in the National Science Museum, Tokyo.

Fig. 4. *Cladophlebis bitchuensis* OISHI: Leaf with sterile pinnules with thrice forked lateral veins. PP7536, collected by G. OKAFUJI from Loc. A (Fig. 1), kept in the National Science Museum, Tokyo.


1
×1


1
×1
×1
2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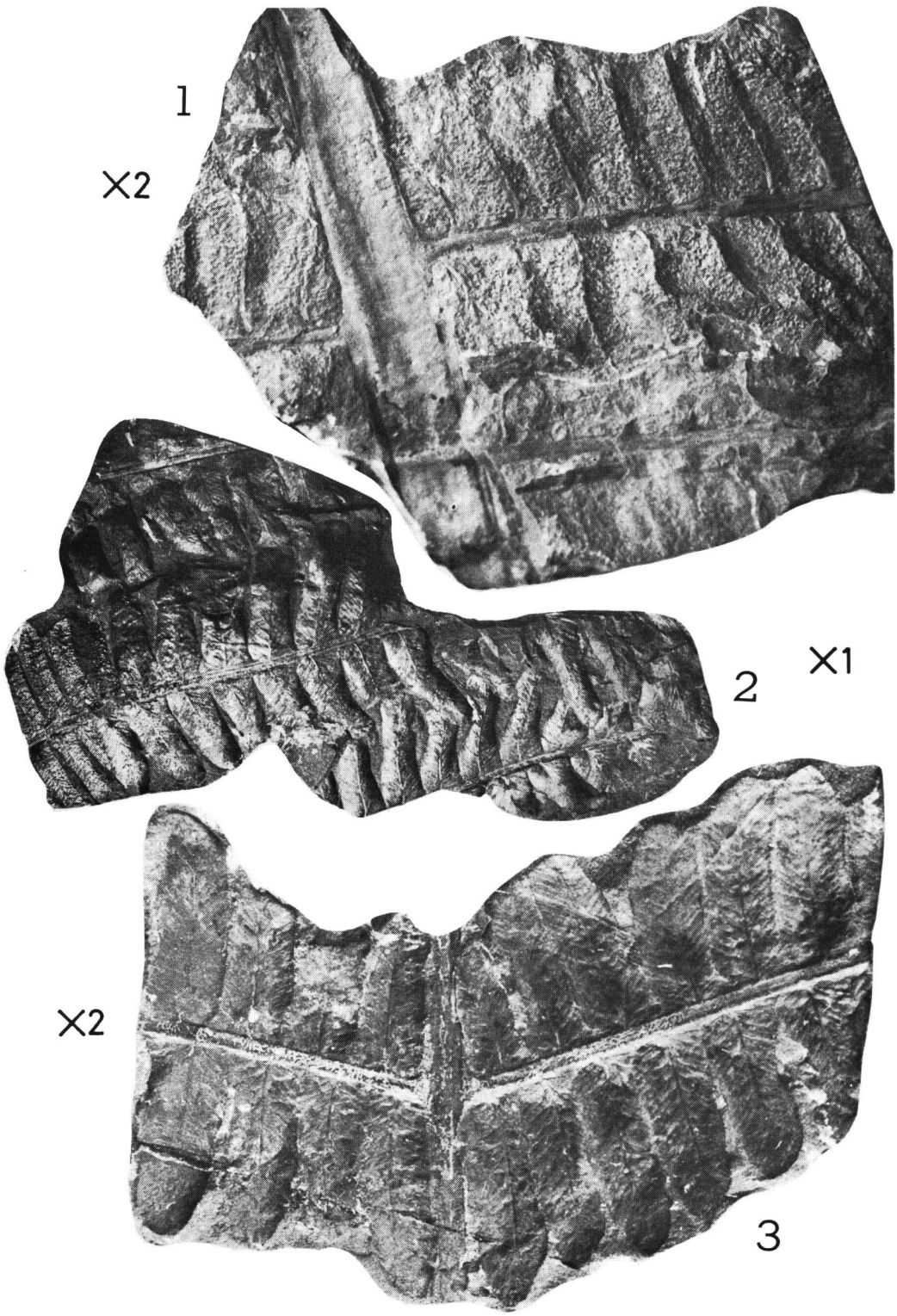
×2
×1
3
1
×1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×2
2
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3


1b
1a
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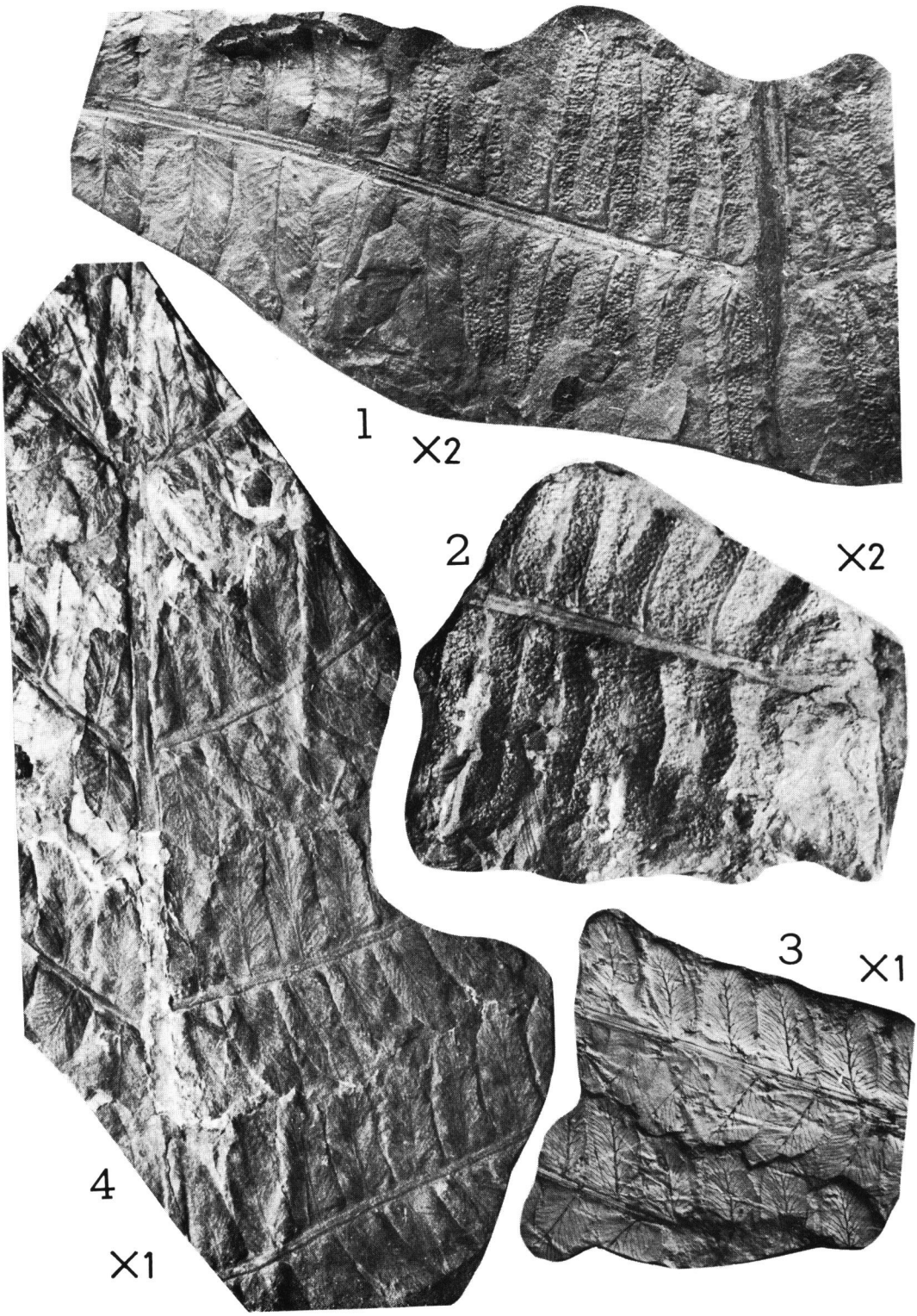
1 ×2
2 ×2
3 ×1
4 ×1