

Middle Jurassic and Some Late Liassic Plants from the Toyora Group, Southwest Japan [II]

By

Tatsuaki KIMURA and Tamiko OHANA

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

(Communicated by Ikuwo OBATA)

Genus *Ctenozamites* NATHORST, 1886: 122

Ctenozamites fukutomii KIMURA et OHANA sp. nov.

Pl. 5, fig. 2; Text-fig. 24a-b

Material: Holotype; NSM-PP 8033. Other specimens; many pinna-fragments.

Stratum typicum: Utano Formation. *Locus typicus*: 063. *Derivatio nominis*: After Takayoshi FUKUTOMI who collected the holotype. *Occurrence*: Not rare.

Diagnosis: Leaf pinnate (probably bipinnate). Pinnae small-sized, more than 6 cm long and up to 2 cm wide. Pinna axis slender, 0.6 mm wide, but mostly concealed by the pinna bases. Pinnules rectangular with rounded apex, attached alternately to the upper surface of pinna axis at an angle of 50 degrees; neither contracted nor expanded at base; typically 1 cm long and 0.4 cm wide. Veins 13 in number at base; about half of them dichotomously forking in the proximal half of pinna, parallel, ending at lateral and distal margins. (Cuticle not preserved. Reproductive organs not known.)

Discussion and comparison: Although there is no remarkable feature in our leaves, they are characterized by having rather small-sized pinnae bearing rectangular pinnules with rather crowded veins. It is highly probable that our leaves belong to *Ctenozamites* redefined by HARRIS (1964), because in our leaves pinnules are attached to the upper sides of pinna axis.

Ctenozamites cycadea (BERGER) SCHENK and *C. surangei* SUKH-DEV et ZEBABANO are with similar pinnules to ours. *Ctenozamites cycadea* described in detail by HARRIS (1964) from the Middle Jurassic of Yorkshire is distinguished by its twice forked veins and its pinnules are mostly larger in size than those of ours. *Ctenozamites surangei* described by SUKH-DEV et ZEBABANO (1981) is also distinguished by its short-rectangular pinnules with small number of veins.

Ctenozamites sarrani (ZEILLER) HARRIS (e.g. KIMURA and TSUJII, 1982) has also similar pinnules to ours, but they are much larger in size and also differ in venation-pattern. Accordingly we here propose *Ctenozamites fukutomii* as a new species. Regularly dissected pinnae of *Nilssonia compta* (PHILLIPS) BRONN (e.g. HARRIS, 1964, fig. 22J) resemble those of our *Ctenozamites fukutomii*, but are distinguished by their

simple veins.

Ctenozamites ? sp.

Pl. 5, fig. 1; Pl. 7, fig. 1; Text-figs. 25a–b

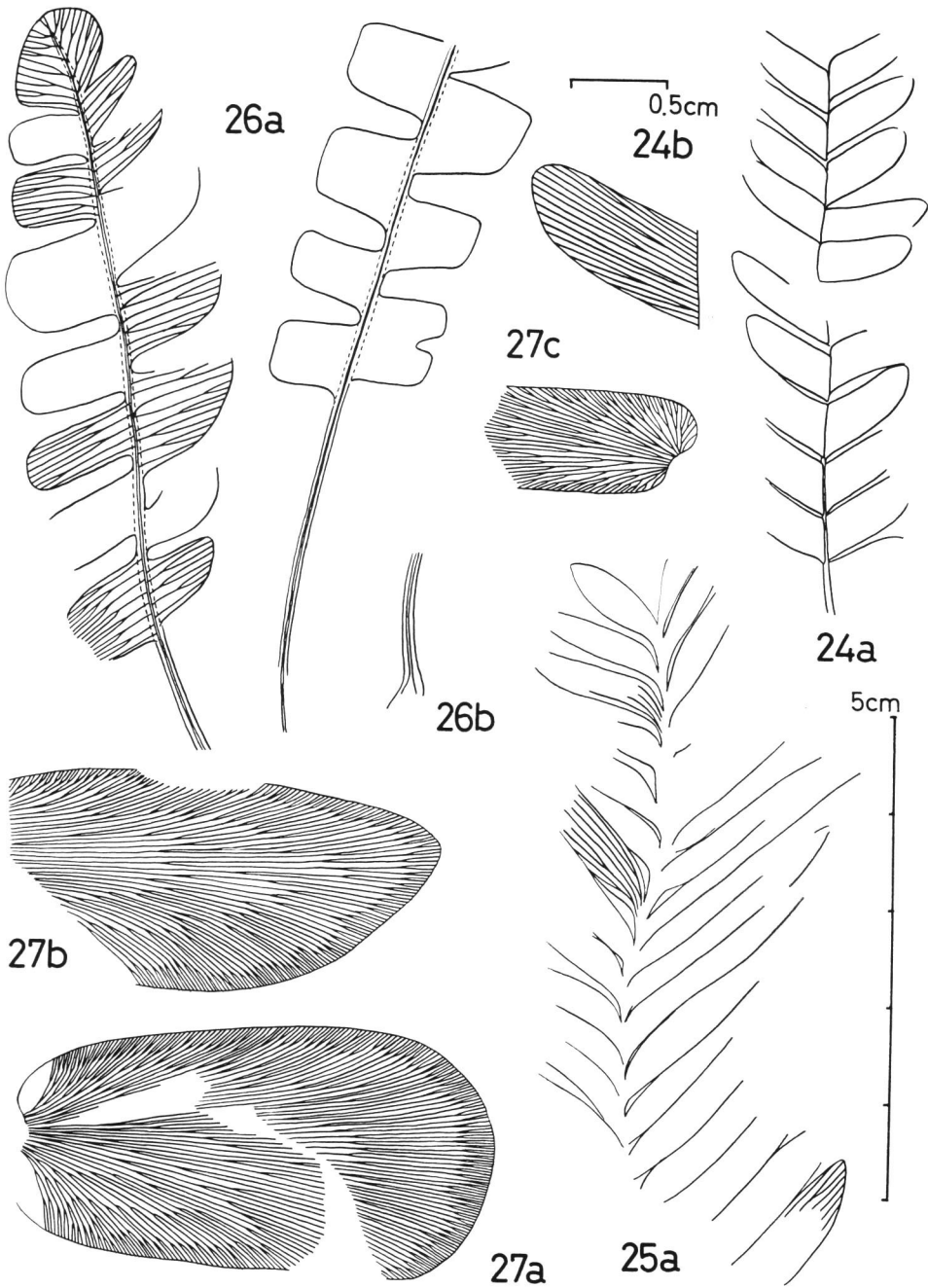
Material: NSM-PP 8034~8036. *Locality*: 068. *Occurrence*: Rare.

Description: Leaf is large-sized, bipinnate; more than 20 cm wide. Main rachis is rather slender, 2 mm wide, giving perpendicularly off closely set and elongated pinnae at interval of 3.5 cm. Pinnae are overlapping laterally, more than 10 cm long, giving alternately off closely set pinnules (segments) at an angle of 50–60 degrees. Pinnules are subulate in form with rounded acroscopic basal angle and slightly decurrent basis-copic base, and with obtusely or acutely pointed apex; typically 2.8 cm long and up to 0.7 cm wide; margins are entire, and attached to the upper surface of pinna axis and concealed the pinna axis completely. Apical pinnules are oblong or elongate-elliptical in form with obtusely pointed apex (Text-fig. 25a). No pinnule attached directly to the main rachis between pinnae is observed. Veins are partly visible, 5 in number at base; among them two or three are dichotomously forking at or near the base or occasionally near the apex; acroscopic two are radiated, ending at the acroscopic basal margin; others are nearly parallel, ending at the distal margin. Cuticle is not preserved.

Remarks: It is difficult to make further observation beyond the above mentioned description of our leaf. The general feature of our leaf reminded us of its affinity with *Ctenozamites* redefined by HARRIS (1964), leaving its affinity with *Ptilophyllum*. Our leaf is characterized by its bipinnate habit and by its subulate pinnules with entire margins and small number of veins. However, the information of our leaf is not satisfactory, so we at present regard it provisionally as *Ctenozamites* ? sp. It is distinguished from *C. fukutomii* sp. nov. here described together by its elongated pinnules with small number of veins and with obtusely or acutely pointed apex, instead of those with crowded veins and rounded apex in the latter. *Ctenozamites* ? sp. is also distinguished from the type species, *C. cycadea* (BERGER) SCHENK by its more elongated pinnules.

Text-figs. 24–27 ($\times 2/3$, unless otherwise indicated).

24. *Ctenozamites fukutomii* KIMURA et OHANA sp. nov.: Drawn from NSM-PP 8033 (holotype).
24b. Showing the venation enlarged. Loc.; 063.
- 25a. *Ctenozamites* ? sp.: Drawn from NSM-PP 8035. Loc.; 068.
26. *Anomozamites fukutomii* KIMURA et OHANA sp. nov.: Drawn from NSM-PP 8037 (holotype).
26b. Base of the petiole. Loc.; 063.
27. *Otozamites* sp. cf. *O. klipsteinii* (DUNKER) SEWARD: 27a–c. Drawn from NSM-PP 8039, 8038 and 8040 respectively. Loc.; 063.



Bennettitales

Genus *Anomozamites* SCHIMPER, 1870: 140*Anomozamites fukutomii* KIMURA et OHANA sp. nov.

Pl. 5, fig. 3; Text-fig. 26a–b

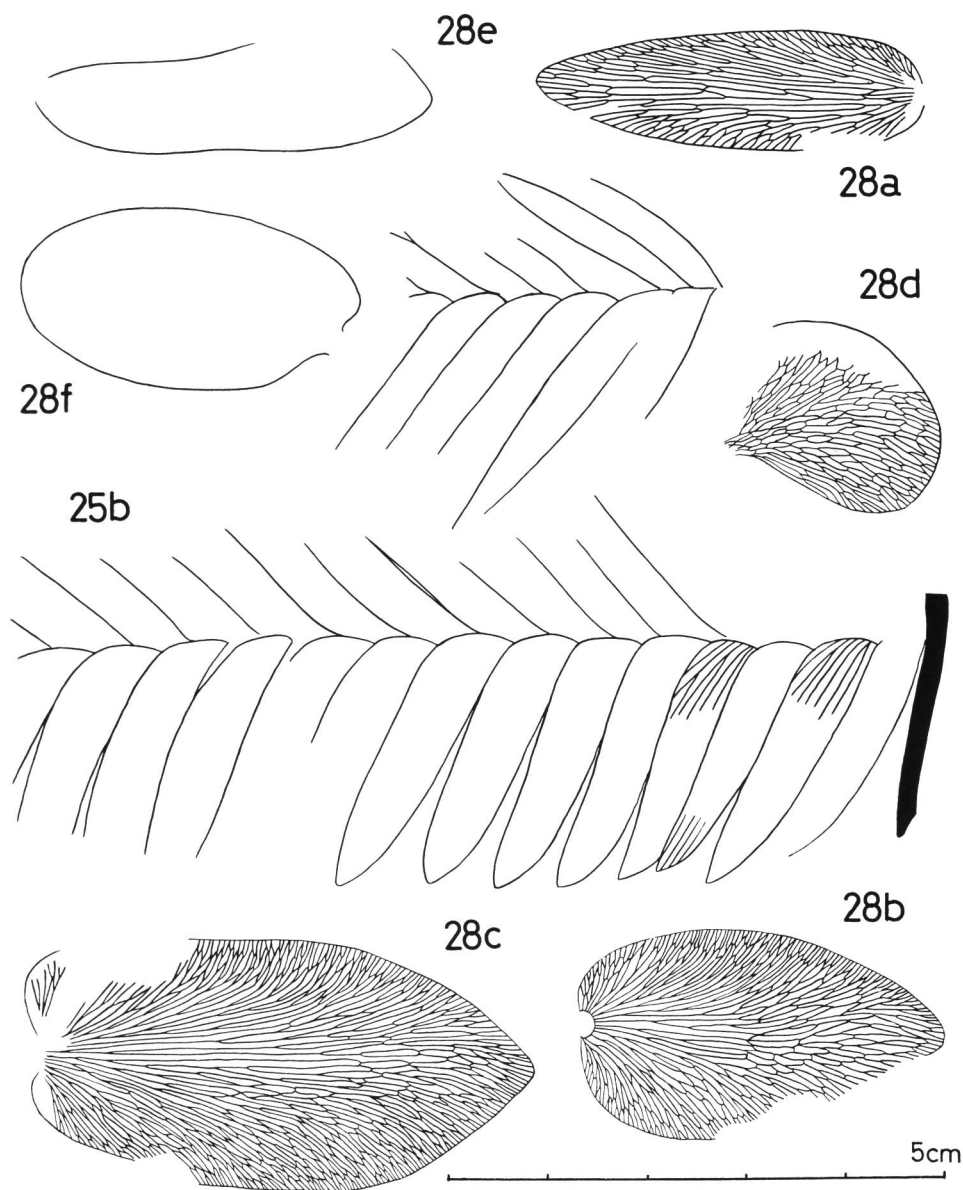
Material: NSM-PP 8037 (Holotype). *Stratum typicum*: Utano Formation. *Locus typicus*: 063. *Derivatio nominis*: After Takayoshi FUKUTOMI who collected the holotype. *Occurrence*: Rare.

Diagnosis: Leaves probably originating on the top of supposed short shoot. Leaf oblanceolate or elongate-rectangular in outline with rather long petiole, 8.5 cm long and up to 2.3 cm wide; petiole expanded at base. Lamina attached to the upper edge of a slender rachis, dissected into at least 8 alternate pairs of segments. Segments varied in form; rectangular, trapezoid, orbiculate with rounded or truncated distal margin; sinuses wider, reaching to the rachis, but occasionally very shallow; distal segments semi-circular in form not notched at apex. Veins sparse, simple or dichotomously forking once or twice at all levels, parallel, not converging at apex; the first dichotomy sometimes occurring at base; 10 per cm basally and 20 per cm distally in density. (Cuticle not preserved.)

Discussion and comparison: Our leaves are characterized by its multiformed segments with sparse veins. The lamina is not completely covering the upper surface of rachis, leaving a ridge throughout. We now think our leaves fall under the category of *Anomozamites* because of their shorter segments. In multi-formed segments our leaves resemble *Anomozamites loczyi* first described by SCHENK (1884) from the Upper Triassic Xujiahe Formation, Sichuan, China, but the former species is distinguished by its segments with crowded veins most of which are forking dichotomously at their origin.

BOSE and BANERJI (1981) described the following *Anomozamites* species from India: *A. crenata* (McCLELLAND), *A. amarjolense* SHARMA, SURANA et SINGH, *A. fissus* FEISTMANTEL, *A. hasnapurensis* BOSE et BANERJI and *A. haburensis* BOSE et BANERJI. Except the last one, these species are characterized by multi-formed segments and indeed some resemble our segments in form. However, *Anomozamites amarjolense* is distinguished from ours by its irregularly segmented lamina with rather thick rachis, *A. fissus* by its segments mostly with distal margin crested once-thrice, and *A. hasnapurensis* by its rather regularly segmented lamina and small number of simple or once forked veins in each segment. Among these Indian species, *Anomozamites crenata* is most close to ours in leaf-form, but is distinguished by its mostly simple veins. Under the circumstances, we here propose *Anomozamites fukutomii* sp. nov. to accommodate our characteristic leaves. It is worth mentioning that such *Anomozamites* species with multiformed segments as mentioned above are common in occurrence between the Jurassic India and of Japan.

Judging from the occurrence of our leaves as shown in Pl. 5, fig. 3 (Text-fig. 26a–b), it is highly probable that our leaves originate spirally at the top of supposed short shoot

Text-figs. 25b and 28 ($\times 2/3$).

25b. *Ctenozamites* ? sp.: Drawn from NSM-PP 8034. Loc.; 068.

28. *Dictyozamites naitoi* KIMURA et OHANA sp. nov.: 28a-f. Drawn from NSM-PP 8043 (paratype), 8042 (paratype), 8041 (holotype), 8045, 8047 and 8048 respectively. Loc.; 063.

with very short internodes like those of *Nilssoniocladus nipponensis* (YOKOYAMA) (KIMURA and SEKIDO, 1975).

Genus *Otozamites* BRAUN, 1842

Otozamites sp. cf. *O. klipsteinii* (DUNKER) SEWARD

Pl. 6, figs. 1–2; Text-figs. 27a–c

Otozamites beani (LINDLEY et HUTTON) BRONGNIART: OISHI, 1940, p. 328, pl. 29, figs. 7, 8a (Takaji; Loc. no. probably 061).

Otozamites klipsteinii (DUNKER) SEWARD: OISHI, 1940, p. 331, pl. 29, fig. 8b; pl. 30, fig. 6; pl. 31, fig. 2 (Takaji; Loc. no. probably 061).

Material: NSM-PP 8038~8040. *Localities*: 063 and probably 061.

Occurrence: Locally common.

Description: Several detached pinnae of various size and form were examined. The ordinary pinnae are oblong in form, with broadly rounded apex. The pinna base is asymmetrical and its acroscopic side is more or less auriculated, and attached to the rachis by its middle part. Veins of the median part of pinna are straight, but those of lateral sides are radiated, all veins are dichotomously forking at all levels and are further forking near the margin. Vein-density is 22 per cm at the middle part of pinna and 32–36 at the distal margin.

Text-fig. 27a shows the largest pinna in our hand, about 5 cm long and 2.5 cm wide at the middle and its venation is well preserved. Text-fig. 27b shows a broken pinna of which apical part is deltoid in form and Text-fig. 27c shows a small-sized pinna of which auricle is rather well developed. Fructification is not known. Cuticle is not preserved.

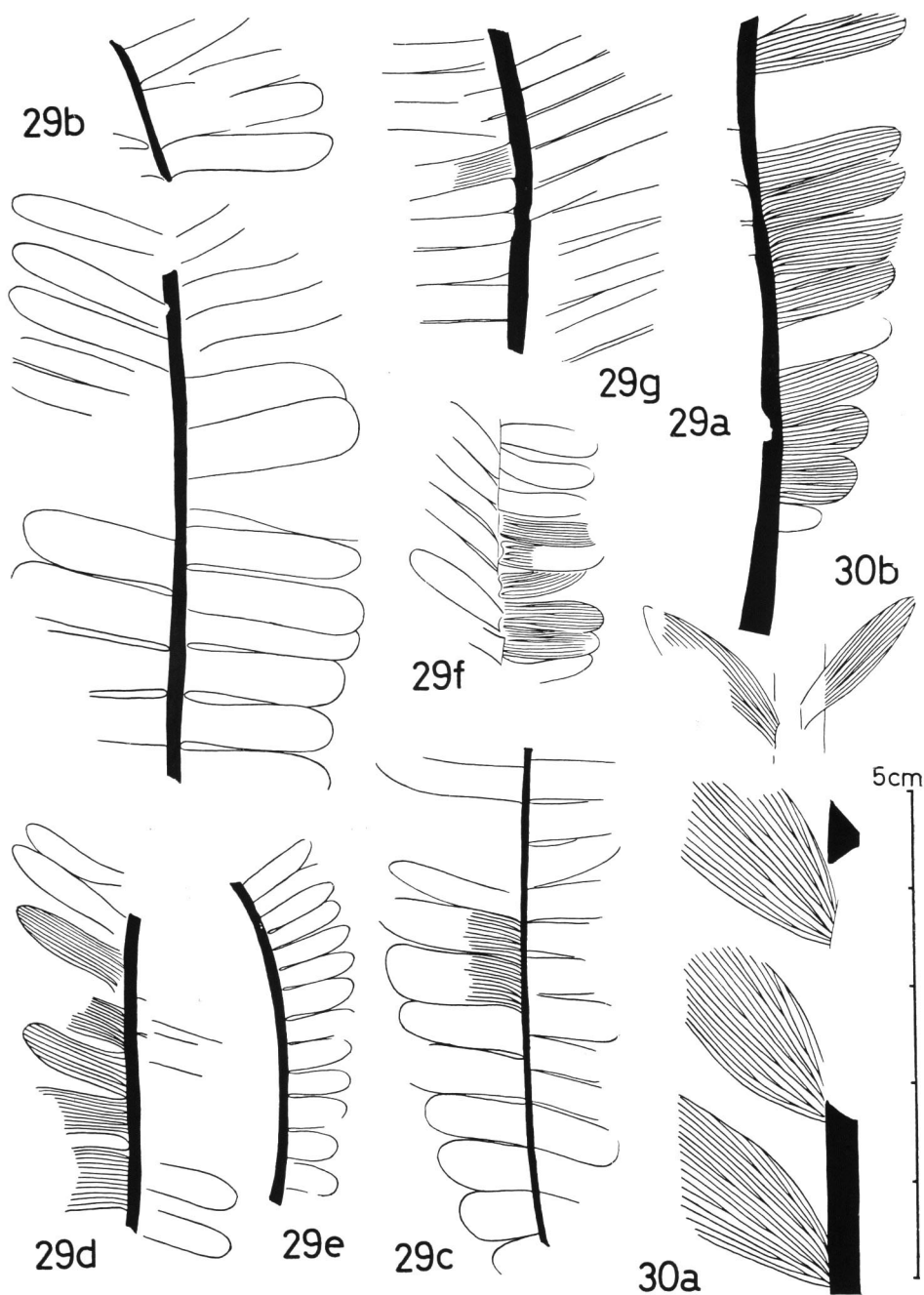
Remarks: The present pinnae are characterized by their oblong form with more or less developed auricle and the venation, especially regularly forked veins near the margin.

OISHI (1940) illustrated three detached pinnae under the name of *Otozamites klipsteinii*, collected from Takaji (Loc. no. probably 061). Their form and venation are so similar to those of our pinnae that it is obvious that all of them belong to the same species. In addition, OISHI (1940) illustrated three detached small-sized pinnae collected also from Takaji under the name of *Otozamites beani* (LINDLEY et HUTTON) BRONGNIART. We are of the opinion that these small-sized and deltoid pinnae would represent proximal ones of the same leaves as those with large-sized and oblong pinnae as mentioned above. Because in OISHI's figure (his pl. 29, fig. 8), one oblong pinna is in close association with two deltoid pinnae in occurrence and their venation is similar

Text-figs. 29–30a, b ($\times 2/3$).

29. *Pterophyllum heterosegmentum* KIMURA et OHANA sp. nov.: 29a–f. Drawn from NSM-PP 8056 (holotype), 8058, 8065, 8066, 8060, 8057 (paratype), and 8061 respectively. Loc.: 063.

30a–b. *Zamites varius* KIMURA et OHANA sp. nov.: 30a–b. Drawn from NSM-PP 8070 (paratype) and 8071 (paratype).



one another.

In an *Otozamites* leaf, it is very usual that its pinnae differ in form according to its position, especially in its proximal part. Thus we here regard such oblong and deltoid pinnae as those of the *Otozamites* leaves belonging to a single species. Indeed our oblong pinnae closely resemble in form those of *Otozamites klipsteinii* (DUNKER) illustrated in detail by SEWARD (1895, 1917) from the Wealden of England. But in SEWARD's illustrations we could not find such deltoid pinnae as illustrated by OISHI and such usual vein-forking near the pinna margin as observed in our pinnae.

Accordingly, it would be quite probable that the Japanese *Otozamites* species here discussed is distinct from *O. klipsteinii*. However, at present we would like to reserve to give these Japanese pinnae a new specific name and regard them as *O. sp. cf. O. klipsteinii*, because the Japanese pinnae are all detached and the whole leaf has not been known.

Our *Otozamites sp. cf. O. klipsteinii* seems to be different in venation from *Cyclopteris klipsteinii* originally described by DUNKER (1846, p. 11, pl. 9, figs. 6–7) and *Aneimidium klipsteinii* SCHIMPER by SCHENK (1871, p. 213, pl. 31, fig. 6) both from the Wealden of Germany.

According to OISHI (1940), *Otozamites* leaves referable to *O. klipsteinii* were said to be known from the Lower Cretaceous Oguchi Formation, Itoshiro Group, Yuasa and Ryoseki Formations, but they were neither illustrated nor described. *Otozamites sp.* described by KIMURA and MATSUKAWA (1979) from the Lower Cretaceous Ishido Formation differs in pinna form and venation from *O. sp. cf. O. klipsteinii*.

KRASSILOV (1967) illustrated a leaf-fragment with several small-sized oblong pinnae and two detached pinnae under the name of *Otozamites klipsteinii* from the Lower Cretaceous of Southern Primorye. So far as his illustrations are concerned, they differ in venation from our *O. sp. cf. O. klipsteinii*. A single detached pinna illustrated by SZE (1945) as *Otozamites sp. cf. O. klipsteinii* from the Lower Cretaceous Bantou Formation, South China is also different in venation from our *O. sp. cf. O. klipsteinii*.

Genus *Dictyozamites* OLDHAM et MORRIS, 1863: 37

Dictyozamites naitoi KIMURA et OHANA sp. nov.

Pl. 6, figs. 3–4; Text-figs. 28a–f

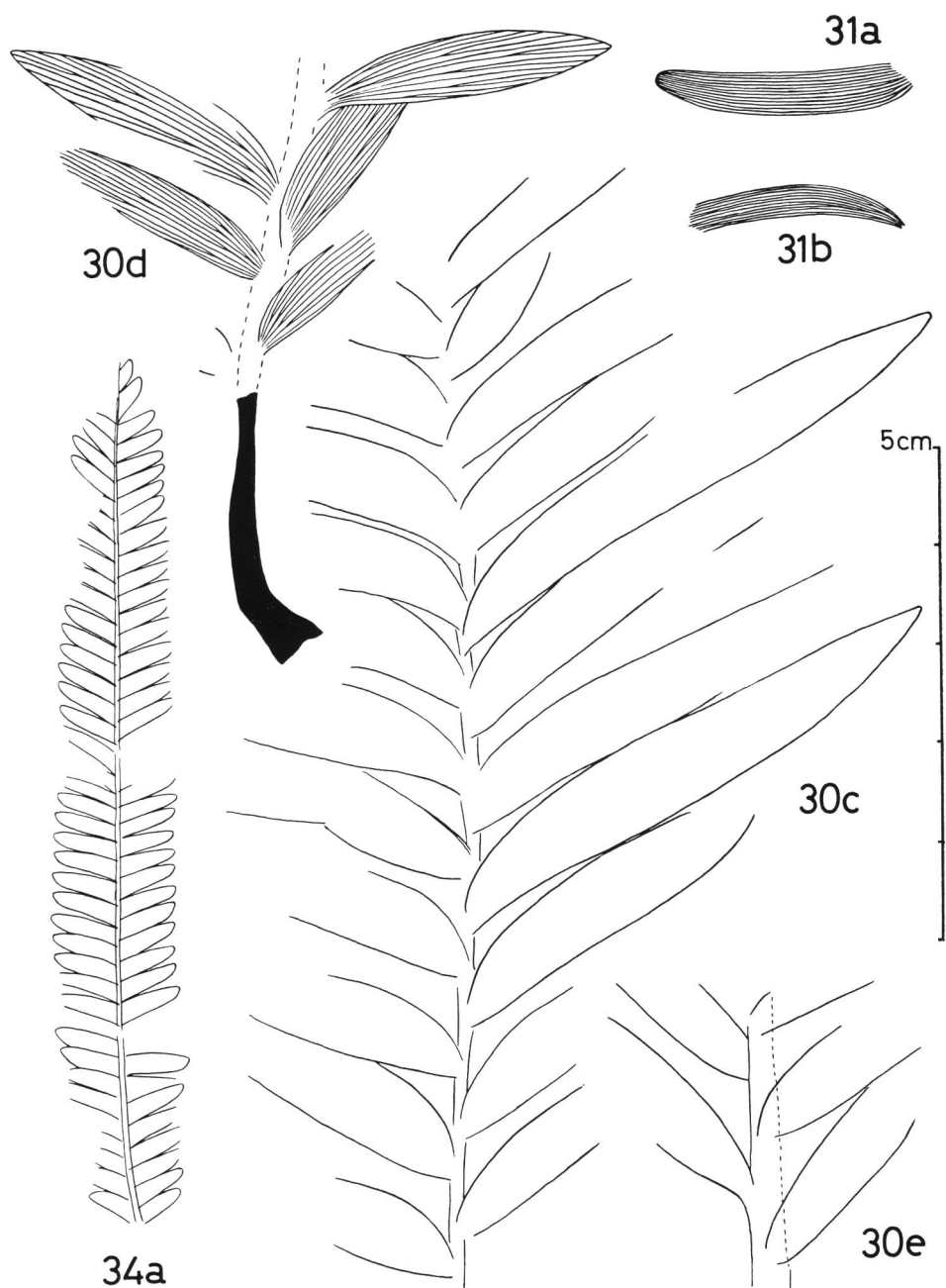
Material: Holotype; NSM-PP 8041. Paratypes; NSM-PP 8042, 8043. Other specimens; NSM-PP 8044~8055 and other 55 specimens. *Stratum typicum*: Utano Formation. *Locus typicus*: 063 (Several specimens from Loc. no. 065). *Derivatio nominis*: After Gentaro NAITO. *Occurrence*: Locally abundant in Loc. no. 063.

Text-figs. 30c–e, 31 and 34a ($\times 2/3$).

30c–e. *Zamites varius* KIMURA et OHANA sp. nov.: Drawn from NSM-PP 8068 (holotype), 8069 (paratype) and 8075 respectively. Loc.; 063.

31. *Zamites* ? sp. A: 31a–b. Drawn from NSM-PP 8087. Loc.; 065.

34a. *Ptilophyllum sp. cf. P. cutchense* MORRIS: Drawn from NSM-PP 8090. Loc.; 063.



Diagnosis: Pinnae varied in size and form; elliptic to elongate-oblong, 2.2–5.0 cm long and 1.0–2.5 cm wide, attached to the upper sides of rachis by a small circular area of middle part of symmetrically or asymmetrically rotund, obtuse or cordate pinna base; apex obtusely pointed or occasionally broadly rounded; margins entire. Veins crowded, originated from the small area of basal attachment of pinna, then radiated except those of median region of pinna, forking dichotomously and connected each other to form meshes. Meshes along the median region of basal two-thirds of pinna markedly elongated, but those along the margins of pinna becoming shorter and at nearly right angle to the margin. (Reproductive organs not known. Cuticle not preserved.)

Discussion and comparison: Our pinnae are characterized by their varied forms and venation as mentioned above. We are of the opinion that our pinnae, although most of them are detached, belong to the same population and to the same species, because they are crowded in occurrence on the same bedding plane.

KIMURA and SEKIDO (1976a) originally described *Dictyozamites auriculatus*, *D. ishikawaensis*, *D. tetoriensis*, *D. yamazakii* and *D. sp.* from the Lower Cretaceous Ogu-chi Formation in the Inner Zone of Japan and reviewed and reillustrated such species hitherto known as *D. areolatus* ARCHANGELSKY, *D. asseretoi* BARNARD, *D. bagjoriensis* JACOB, *D. cazaubonii* ARCHANGELSKY et BALDONI, *D. cordatus* (KRYSHTOFOVICH) PRYNADA, *D. crassinervis* MENÉNDEZ, *D. crusinensis* KON'NO, *D. falcatus* (MORRIS), *D. grossinervis* YOKOYAMA, *D. hallei* SAHNI et RAO, *D. imamurae* OISHI, *D. indicus* FEISTMANTEL, *D. johnstrupi* NATHORST, *D. kawasakii* TATEIWA, *D. latifolius* MENÉNDEZ, *D. minusculus* MENÉNDEZ, *D. obliquus* SAMYLINA, *D. reniformis* OISHI and *D. tateiwaiae* OISHI.

BOSE and ZEBABANO (1978) reviewed the Indian species of *Dictyozamites* including *D. sahnii* GUPTA et SHARMA and originally described *D. feistmantelii* and *D. sp.* Recently in their monograph of the African megaflores, ANDERSON and ANDERSON (1985) originally described *Dictyozamites mukuziensis* together with *D. crassinervis* MENÉNDEZ and *D. minusculus* MENÉNDEZ.

In China *Dictyozamites baitianbaensis* LI and *D. zhonghuaensis* YANG were recorded by CHEN, Y. et al. (1978) and *D. sp.* by ZHANG, W. et al. (1980). Of these none of pinnae of them is referable to our pinnae, especially in venation. Thus we here propose *Dictyozamites naitoi* as a new species. Most close to our *Dictyozamites naitoi* are *D. kawasakii* and *D. crassinervis* in pinna form and venation respectively, but *D. naitoi* differs in venation from *D. kawasakii* and in vein-density from *D. crassinervis*. *Dictyozamites mukuziensis* is also close in venation to *D. naitoi*, but differs in pinna form. Text-figs. 28a–f show varied pinna forms of *Dictyozamites naitoi*.

Genus *Pterophyllum* BRONGNIART, 1828: 25*Pterophyllum heterosegmentum* KIMURA et OHANA sp. nov.

Pl. 5, fig. 4; Pl. 6, figs. 5–9; Text-figs. 29a–f

Material: Holotype; NSM-PP 8056. Paratype; NSM-PP 8057. Other specimens: NSM-PP 8058~8067 and other 10 specimens. *Stratum typicum*: Utano Formation. *Locus typicus*: 063. *Derivatio nominis*: According to varied form of segments (or pinnae). *Occurrence*: Locally abundant at Loc. no. 063.

Diagnosis: Leaf elongate-obovate in outline, with stout petiole, variable in size; about 10 cm long and up to 3.5 cm wide. Pinnae varied in size and form according to the position of a leaf, attached to the lateral sides of rachis at a wide angle or nearly perpendicular. Pinnae on the apical part of a leaf long and narrow, nearly parallel-sided or elongate-spathulate in form, those on the middle part of a leaf elongate-rectangular and those on the proximal part of a leaf small-sized, short-rectangular or semi-circular. (Apex of leaf unknown.) Pinna base often slightly expanded and pinna apex mostly broadly rounded. Veins parallel, simple or forking dichotomously near the base or sometimes at all levels; density mostly 10 per cm but 14 per cm in the proximal pinnae. (Peproductive organs not known. Cuticle not preserved.)

Discussion and comparison: *Pterophyllum heterosegmentum* is characterized by its varied pinnae in a leaf. The leaves of *Pterophyllum heterosegmentum* resemble those described by KIMURA and TSUJII (1982) as *P. ex gr. propinquum* GOEPPERT from the Upper Liassic Kuruma Group and Iwamuro Formation in the Inner Zone of Japan, but are distinguished by its pinnae mostly with broadly rounded apex, instead of those mostly with truncated apex in the latter; no pinna with truncated apex has been found in *P. heterosegmentum*.

Pterophyllum portali originally described by ZEILLER (1902–3) from the Upper Triassic of North Vietnam resembles in pinna form *P. heterosegmentum*, but is distinguished by its leaves about twice as large as those of the latter; no spathulate pinna is found in ZEILLER's illustrations of *P. portali*.

Pterophyllum nathorsti SCHENK (SCHENK, 1883) or *Tyrmia nathorsti* (SCHENK) YE (in WU, S. Q. et al., 1980) described from the Upper Liassic Xiangxi Formation, China also resembles in pinna form and size *P. heterosegmentum*, but in the former pinna form is not varied but rather constant; so far as their illustrations are concerned no spathulate pinna is found in *P. nathorsti*.

Pterophyllum sp.

Ptilophyllum pachyrachis OISHI: TAKAHASI et al., 1965, pl. 3, fig. 5 (Toriyama; Utano Formation).

Material: TAKAHASI et al., 1965, pl. 3, fig. 5. *Occurrence*: Uncertain.

Remarks: OISHI (1940) originally described *Ptilophyllum pachyrachis* from Mochiana-locality, Fukui Prefecture (now under the dam-water; Upper Jurassic Kuzuryu Group, in the Inner Zone of Japan) and KIMURA (1959) also described it based on

many specimens collected from the same locality.

At present, we are of the opinion that OISHI's species should be placed in the genus *Pterophyllum*, because there is no positive reason that Oishi's original leaves should be regarded as belonging to *Ptilophyllum*. Indeed, in OISHI's species, the pinnae are attached to the upper surface of the rachis and the bases of pinnae on both sides of the rachis generally meet at the longitudinal median line of the rachis proximally; they are separated by a zone of a part of the surface of the rachis as mentioned by OISHI (1940). However, such feature was already shown by HARRIS (1969) in his *Pterophyllum thomasi* HARRIS and *P. cycadites* HARRIS et REST. Thus in *Pterophyllum* species, pinnae are not always attached to the lateral sides of rachis. Accordingly, we regard OISHI's *Ptilophyllum pachyrachis* as *Pterophyllum pachyrachis* (OISHI) KIMURA et OHANA comb. nov.

In the meantime, judging from the illustration made by TAKAHASI *et al.* (1965, pl. 3, fig. 5), their *Ptilophyllum pachyrachis* is referable possibly to *Pterophyllum*, but is not identical with *Pterophyllum pachyrachis* in pinna form and size of leaf. Accordingly we at present regard it as *Pterophyllum* sp.

Genus *Zamites* BRONGNIART, 1828

Zamites varius KIMURA et OHANA sp. nov.

Pl. 7, fig. 2; Pl. 8, figs. 1-2; Pl. 10, fig. 1; Text-figs. 30a-e

Cf. *Pseudoctenis brevipennis* OISHI: TAKAHASI, 1951b, p. 191, fig. 1 (Takaji; Loc. no. possibly 061); TAKAHASI *et al.*, 1965, pl. 2, fig. 6 (Ono; Loc. no. possibly 063).

Material: Holotype; NSM-PP 8068. Paratypes; NSM-PP 8069, 8070, 8071. Other specimens; NSM-PP 8072~8086 and other 103 specimens. *Stratum typicum*: Utano Formation. *Locus typicus*: 063. *Derivatio nominis*: According to varied forms of pinnae. *Occurrence*: Locally abundant at Loc. no. 063.

Diagnosis: Leaf simply pinnate, oblanceolate in outline, more than 15 cm long with rather thick rachis, 0.5 mm wide above, 0.55 cm below and expanded at base. Pinnae variable in form, according to the position of a leaf, attached alternately to the upper edge of rachis by the nearly symmetrically contracted base at an angle of about 50 degrees; in some pinnae acroscopic basal margin rounded and basiscopic base contracted then slightly decurrent; margins entire and apex acute. Distal pinnae elongated, nearly parallel-sided for the most part, narrowing gradually towards the apex; typically 5.8 cm long and up to 0.9 cm wide. Proximal pinnae elliptical or oblanceolate in outline, smaller in size than distal ones; the smallest 1.8 cm long and up to 4 mm wide, with obtusely pointed apex. Four-five veins originated at base, then repeatedly forking dichotomously, radiated and ending both lateral margins and apex, typically 10 per cm in density at the middle of pinna. (Reproductive organs not known. Cuticle not preserved.)

Discussion and comparison: Over 100 specimens were obtained, but all of them were fragmental. Our leaves resemble in pinna form and venation such *Pseudoctenis*

leaves as of *P. locusta* HARRIS (HARRIS, 1949, '64; DOLUDENKO and ORLOVSKAJA, 1976). But in *Pseudoctenis*, pinnae are attached to the lateral sides of rachis (HARRIS, 1964).

As our pinnae are obviously attached to the upper sides of rachis, it would be appropriate to place them in the genus *Zamites*. So far as we know, about 200 *Zamites* species were described. Accordingly it is difficult to make thorough comparison of our leaves with all of them. However, as it is true that in the Mesozoic of East and Southeast Asia no leaves referable to ours have so far been described, we here propose *Zamites varius* as a new species to accommodate our leaves.

Zamites varius somewhat resembles *Z. recta* (TATE) SEWARD known from the Middle Jurassic of South America (BONETTI, 1963) and Lower Cretaceous of South Africa (ANDERSON and ANDERSON, 1985) in size and form of pinna, but is distinguished by its less crowded venation. *Zamites toyoraensis* originally described by OISHI (1935) from the Upper Liassic Nishinakayama Formation differs from *Z. varius* in pinna form and venation.

Zamites ? sp. A

Text-figs. 31a-b

Material: NSM-PP 8087. *Locality*: 065. *Occurrence*: Rare.

Description: Obtained are several detached pinna-fragments. Pinnae are elongate-rectangular, narrowing abruptly to the rounded apex and gradually to the narrow base, about 2.8 cm long and 0.4 cm wide at middle. Four veins are originated at base, forking dichotomously near the base, then running in parallel with margins and not converging but ending at the apex; density is 32 per cm at the middle of pinna. Cuticle is not preserved.

Remarks: Our pinnae are distinguished from those of *Zamites varius* described in this paper by their rounded apices and not radiated veins. Owing to the incompleteness of our pinnae, we provisionally place them as *Zamites* ? sp. A.

Zamites ? sp. B

Pl. 8, fig. 3; Text-fig. 32

Material: NSM-PP 8088. *Locality*: 063. *Occurrence*: Rare.

Description: Obtained is a single apical region of a leaf with thin rachis, 1.5 mm wide below. Pinnae are pinnate, elongated, nearly parallel-sided, directed forwards, gradually narrowing towards the base and abruptly narrowing towards the obtusely pointed apex, and attached alternately to the upper edge of rachis; pinna base is not decurrent; the longest pinna is 7 cm long and 0.5 cm wide at the middle. Veins are mostly invisible, but are possibly parallel each other, at places, counted are 11-12 in each pinna. Cuticle is not preserved.

Remarks: The present leaf reminds us of *Zamites yabei* originally described by

OISHI (1940) and Cf. *Zamiophyllum buchianum* (ETTINGSHAUSEN) NATHORST by YABE (1922) from the Nishinakayama Formation, and *Z. yabei* illustrated by TAKAHASI *et al.* (1965) from Ono (Loc. no. possibly 063) and Toriyama.

But at present it is difficult to make full comparison of our leaf with the above-mentioned leaves, because of ill-preservation of our leaf. Accordingly we provisionally regard the present leaf as *Zamites* ? sp. B. It is highly probable that the isolated pinnae regarded by us as *Zamites* ? sp. A in this paper are proximal ones of the same leaf as *Z.*? sp. B.

Zamites ? sp. C

Pl. 9, fig. 1; Text-fig. 33

Material: NSM-PP 8089. *Locality*: 063. *Occurrence*: Rare.

Description: Obtained is a single leaf-fragment with pinnate pinnae. Pinnae are elongate-oblong or lanceolate in form and with obtusely pointed apex, but their bases are hidden by the thick rachis, 0.5 cm wide; possibly 2.5 cm long or more above and 2.2 cm long below, and up 0.7 cm wide. Veins are parallel, mostly simple but a few forking dichotomously, ending both lateral margins; about 24 per cm in density. Cuticle is not preserved.

Remarks: Owing to the hidden pinna bases of our leaf, it is difficult to make its generic identity, but we now suppose that our leaf-fragment may represent a proximal portion of some *Zamites* leaf, such as that of *Z. toyoraensis* OISHI. Under the circumstances, we at present regard our leaf-fragment as *Zamites* ? sp. C.

Genus *Ptilophyllum* MORRIS, 1840: 327

Ptilophyllum sp. cf. *P. cutchense* MORRIS

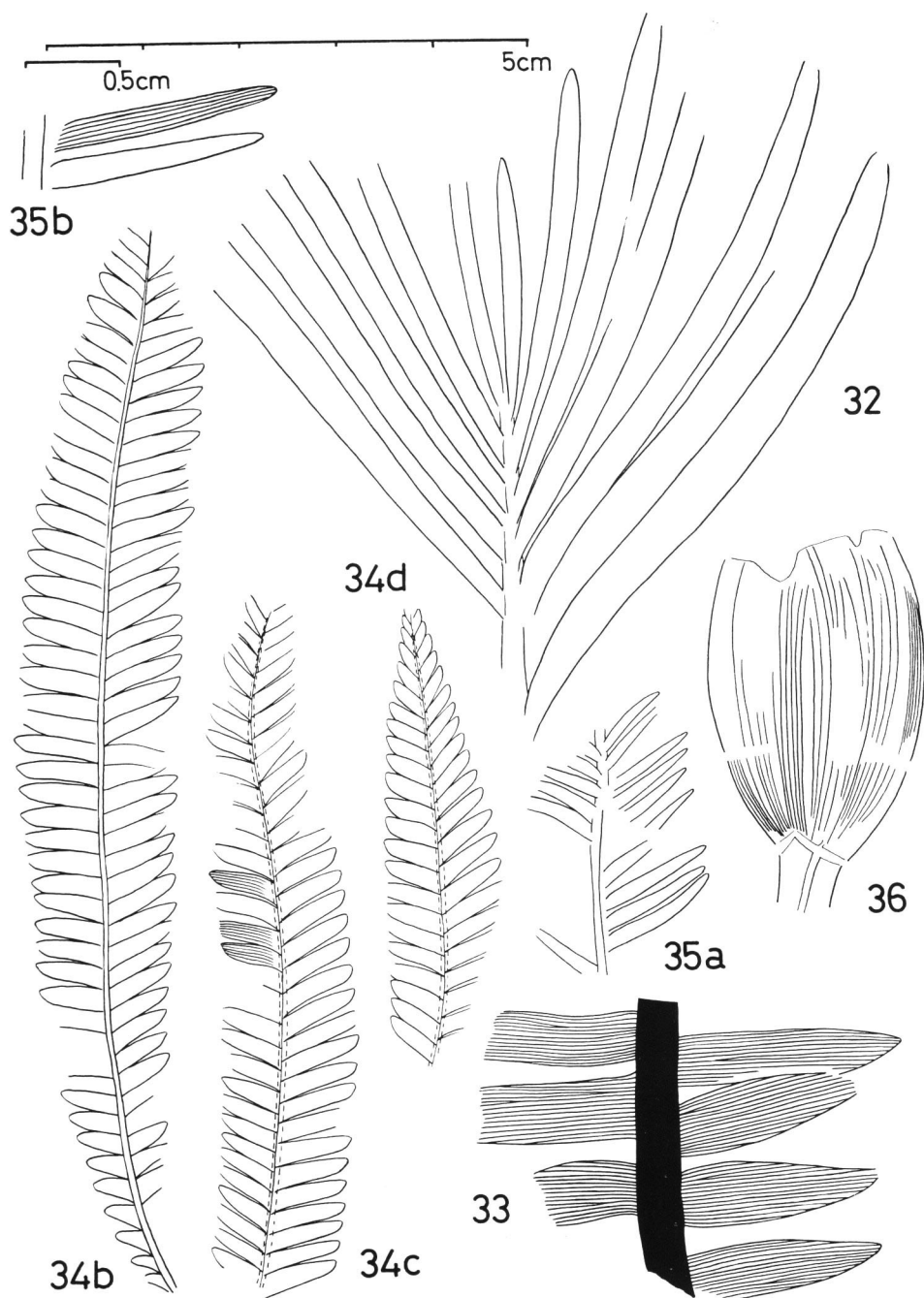
Pl. 5, fig. 5; Pl. 7, figs. 3–4; Pl. 9, fig. 2; Text-figs. 34a–d

Ptilophyllum pecten (PHILLIPS) MORRIS: OISHI, 1940, p. 348, pl. 32, fig. 4 (Outi and Takaji; Loc. nos. possibly 065 and 061 respectively).

Material: NSM-PP 8090~8111. *Locality*: 063. *Occurrence*: Locally common at Loc. no. 063.

Description: Among many specimens collected, several nearly completely preserved leaves were found. The leaf shown in Text-fig. 34b is elongate-oblongate or linear or linear lanceolate in outline, about 11 cm long and up to 1.7 cm wide, sending suboppositely off about 50 pairs of closely set pinnae at a wide angle. Pinna is typically 0.9 cm long and 2 mm wide, attached on upper surface of rachis by its entire base and as a whole linear, rhomboidal, subulate or ovate with entire and straight margins; pinna apex is obtusely pointed or rounded; pinna base is neither contracted nor decurrent. Veins are typically five in number at base, running parallel and ending at the distal margin. Reproductive organs are not known. Cuticle is not preserved.

Remarks: Many leaf-fragments occurred at Loc. no. 063 in crowd. Judging

Text-figs. 32-36 ($\times 2/3$, unless otherwise indicated).32. *Zamites* ? sp. B: Drawn from NSM-PP 8088. Loc.; 063.33. *Zamites* ? sp. C: Drawn from NSM-PP 8089. Loc.; 063.34b-d. *Ptilophyllum* sp. cf. *P. cutchense* MORRIS: Drawn from NSM-PP 8091, 8092 and 8093 respectively, Loc.; 063.35. *Ptilophyllum* sp.: Drawn from NSM-PP 8112. 35b. Showing venation enlarged. Loc.; 063.36. *Williamsonia* sp.: Drawn from NSM-PP 8113. Loc.; 063.

from the occurrence they belong to a single population and to a single species. We know a number of *Ptilophyllum* species hitherto described from the Mesozoic plant-beds in both Hemispheres. Of these externally our leaves are most close to those of *Ptilophyllum cutchense* MORRIS redescribed by BOSE and KASAT (1972) and BOSE and BANERJI (1984) from the Middle Jurassic-Lower Cretaceous of India based on leaf-impressions.

But we here reserve to make full identity of our leaves to *Ptilophyllum cutchense*, because in *P. cutchense* some leaves are supposed by BOSE and KASAT (1972) to attain 30 cm in length, and such long leaf has not been found in our collection.

OISHI (1940) described *Ptilophyllum pecten* (PHILLIPS) MORRIS from Outi (Ouchi) and Takaji. But we are of the opinion that his leaf illustrated is not similar in pinna form to those of *Ptilophyllum pecten* redescribed by HARRIS (1969) but close to our leaves. The leaf-fragments described as *Ptilophyllum* cf. *cutchense* by KIMURA and TSUJII (1982) from the Upper Liassic Negoya Formation, Kuruma Group are externally indistinguishable from our present leaves.

Ptilophyllum sp.

Pl. 7, fig. 5; Text-fig. 35a-b

Material: NSM-PP 8112. *Locality*: 063. *Occurrence*: Rare.

Description: Obtained is a single and small-sized leaf-fragment with rachis, 1 mm wide sending alternately off elongated pinnae. Its lower pinnae are 1.3 cm long and upper ones 0.8 cm long and up to 1.5 mm wide, attached to the upper edge of rachis at a wide angle; pinna bases are mostly straight but some are slightly contracted; apex is obtusely pointed. Veins are simple, parallel and not converging at apex; 5 in number in each pinna. Cuticle is not preserved.

Remarks: The present leaf-fragment does not agree with *Ptilophyllum* sp. cf. *P. cutchense* described in this paper, because of its elongated pinnae. The present elongated pinnae remind us of those of *Ptilophyllum elongatum* KIMURA et OHANA (non DOUGLAS) described from the Lower Cretaceous Choshi Group (KIMURA and OHANA, 1984), but are distinguished by their small number of veins, instead of 11 in number in the latter. Unavoidably at present we provisionally regard our leaf-fragment as *Ptilophyllum* sp.

Genus *Williamsonia* CARRUTHERS, 1870

Williamsonia sp.

Pl. 6, fig. 10; Text-fig. 36

Material: NSM-PP 8113 and 8114 (counterpart). *Locality*: 063.

Occurrence: Rare.

Description: Obtained is a single impressed flower-like organ; ovate in form, more than 2.8 cm long and up to 2.2 cm wide, with a thick receptacle, 0.5 cm wide and

more than 0.8 cm long. Preserved are only outer bracts, each with 5 longitudinal striations; apex is unknown and hairs are not recognized. Cuticle is not preserved.

Remarks: Judging from the form of perianth consisting of bracts, it is highly probable that our specimen belongs to *Williamsonia*. But it is hopeless to make its specific identity because of its ill-preservation, although similar perianths have been recorded such as by TURTANOVA-KETOVA (1963).

Cycadales (or Nilssoniales)

Genus *Nilssonia* BRONGNIART, 1825: 200

Nilssonia sp. cf. *N. densinervis* (FONTAINE) BERRY

Pl. 9, fig. 3; Text-figs. 37a-b

Nilssonia densinerve (FONTAINE) BERRY: OISHI, 1940, p. 300, pl. 24, fig. 2 (Outi; Loc. no. possibly 065).

Material: NSM-PP 8032, 8115~8118, and other 43 specimens. *Localities:* 063 and 065. *Occurrence:* Locally common at Loc. no. 063.

Description: The leaves are elliptical or belt-like, more than 8 cm long and the broadest one, 2.8 cm wide. Lamina is almost covering the upper surface of rather stout rachis, entire or irregularly divided into rectagnular segments. Veins are numerous, simple and delicate, nearly perpendicular to the rachis; 24-40 per cm in density. Cuticle is not preserved.

Remarks: Our leaves resemble in form and vein-density those of *Nilssonia densinervis*, but do not agree fully with its original specimens illustrated by FONTAINE (1889) and BERRY (1911), especially in leaf-size. According to BERRY (1911), the leaves of *Nilssonia densinervis* are said to reach 70 cm long and 15-18 cm wide. Thus at present we regard our leaves as *Nilssonia* sp. cf. *N. densinervis*, as there is no such large-sized leaf in our collection.

OISHI (1940) described a broken leaf as *Nilssonia densinerve* from Outi (Ouchi), of which preserved length is 14 cm and 9 cm wide, and with less crowded veins, 18-22 per cm in density. OISHI (1940) mentioned that his leaf from Outi represented a striking agreement in all respects with those of the Potomac Group. But OISHI's leaf is far smaller in size than those of the Potomac Group. However, we are of the opinion that OISHI's leaf from Outi may belong to the same species as ours, although its veins are less crowded than ours.

In such *Nilssonia* species as *N. japonica* (KIMURA and TSUJII, 1983), vein-density is variable, 10-30 per cm according to the leaves. The leaves regarded as *Nilssonia densinervis* (or *N. densinerve*) from the Lower Cretaceous plant-beds in the Outer Zone of Japan (OISHI, 1940; KIMURA and KANSHA, 1978) are unexceptionally small-sized. *Nilssonia densinervis* described by KRASSILOV (1967) from the Lower Cretaceous of Southern Primorye is also represented by rather small-sized leaves. *Nilssonia japonica* is easily distinguished from *N. sp. cf. N. densinervis* in its leaf-size reaching 50 cm long and 9-10 cm wide and in its lamina mostly dividing into segments. The original

leaves of *Nilssonia orientalis* HEER (HEER, 1878) are all small-sized. They are also distinguished from our leaves in their leaves with entire or irregularly undulated margins.

Our leaves are mostly represented by their lower side, so in this case alone, it is difficult to identify them with *Nilssonia*. But a few leaves are represented by their upper side, and in this case their laminae are mostly covered the upper surface of rachis. We are of the opinion that they belong to a single fossil population, because they are preserved in crowds at the Loc. no. 063.

Nilssonia sp.

Pl. 7, figs. 6–7; Text-figs. 38a–c

Nilssonia nipponensis YOKOYAMA: OISHI, 1940, p. 306 (pars), pl. 27, figs. 3–4 (Takaji; Loc. no. possibly 061).

Material: NSM-PP 8119~8121. *Localities*: 061, 065 and 063. *Occurrence*: Rather rare.

Description: Obtained are all smaller leaf-fragments. One of them is shown in Text-fig. 38b in which only five deeply ditsected segments are preserved in one rows; segments are more than 2.8 cm long and 0.4–0.7 cm wide at the middle, falcate and expanded at base; entirely covering the upper surface of slender rachis. Veins are rather crowded, parallel, 28 per cm in density; mostly simple but a few forking dichotomously at the proximal half of pinna. Cuticle is not preserved.

Remarks: It is difficult to make specific identity to our leaves because of their ill-preservation. However, our leaves do not agree with *Nilssonia nipponensis* YOKOYAMA because the segments of *N. nipponensis* do not elongate like those of our leaves. Our leaves are externally close to those described by GOTHAN (1914) and OISHI (1932) as *Nilssonia acuminata*, but they do not fully agree with those of *N. acuminata* in form of segments and in small number of veins (18 per cm). Occasional leaves of *Nilssonia grossinervis* PRYNADA (e.g. SAMYLINA, 1964) and *N. mediana* (LECKENBY et BEAN) FOX-STRANGWAYS (e.g. GENKINA, 1963) are similar in leaf-form and venation to ours.

Unclassified cycadophyte

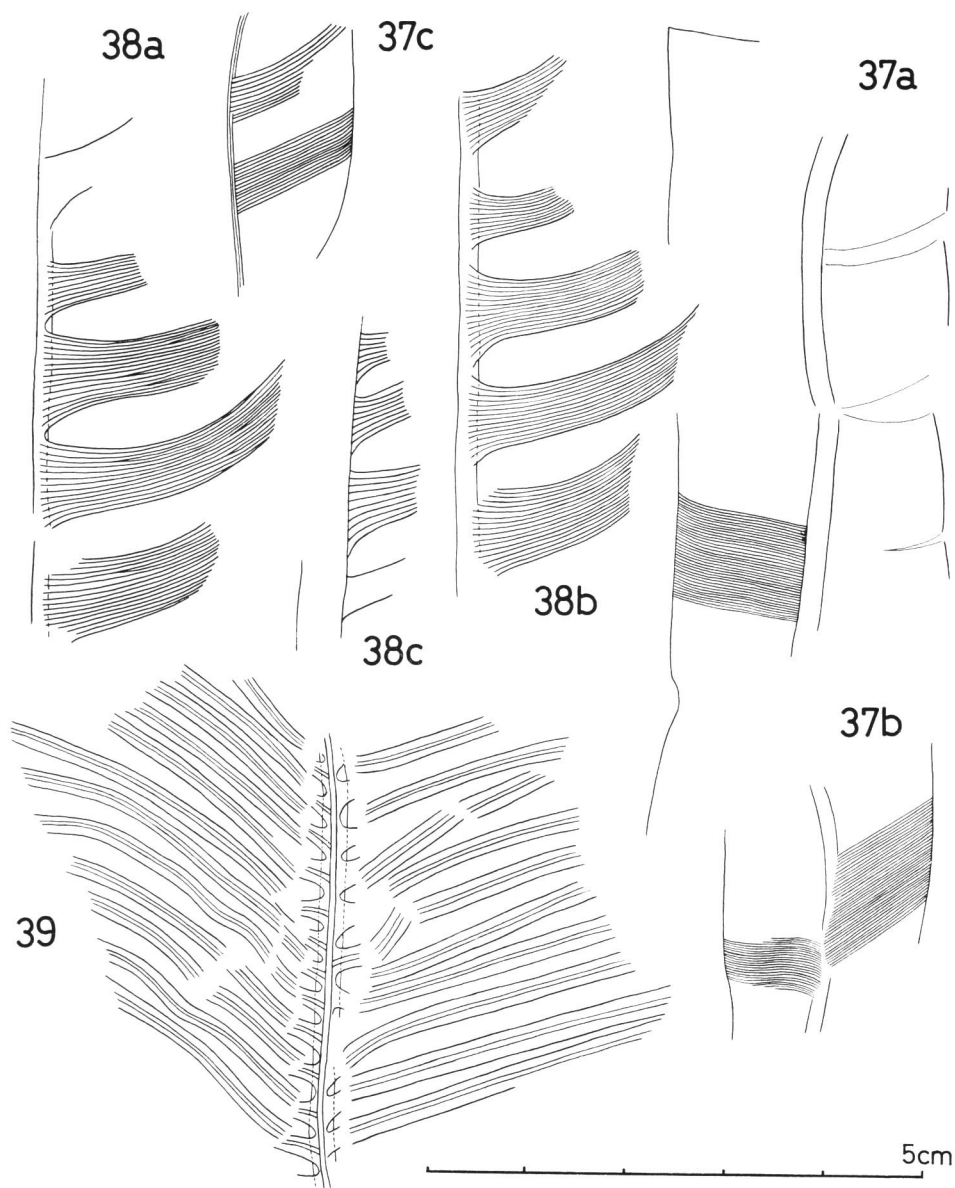
Form-genus *Cycadites* STERNBERG, 1825: 32

Cycadites sp.

Pl. 9, figs. 4–5; Text-fig. 39

Material: NSM-PP 8123, 8124 (collected by T. FUKUTOMI) and 8125.
Locality: 063. *Occurrence*: Rare.

Description: The leaf is pinnate with a rather thick rachis, 3 mm wide, sending suboppositely off long and narrow pinnae from the upper edge of rachis at an angle of about 60 degrees. Pinnae are more than 7 cm long, with a strong median vein, and nearly parallel-sided, 2–3 mm wide for the most part; upper surface is convex and

Text-figs. 37-39 ($\times 2/3$).

37. *Nilssonia* sp. cf. *N. densinervis* (FONTAINE) BERRY: 37a-c. Drawn from NSM-PP 8115, 8116 and 8117 respectively. Loc.; 063.

38. *Nilssonia* sp.: 38a-c. Drawn from NSM-PP 8120. Loc.; 061.

39. *Cycadites* sp.: Drawn from NSM-PP 8123. Loc.; 063.

lateral margins are reflexed; apices are all missing. Cuticle is not preserved.

Remarks: Obtained are only three broken leaves and we at present place them in the non-committal genus *Cycadites*. *Pseudocycas* sp. illustrated by TAKAHASI *et al.* (1965, pl. 3, fig. 4) from Ono (Loc. no. possibly our 063) is thought to be the same plant as ours.

Ginkgoales

Genus *Ginkgoites* SEWARD, 1919: 10

Ginkgoites ex gr. *sibiricus* (HEER) SEWARD

Ginkgoites sibirica (HEER) SEWARD: OISHI, 1940, p. 380, pl. 38, fig. 11 (Takaji; Loc. no. possibly 061).

Material: OISHI, 1940, pl. 38, fig. 11 (a single leaf-impression). *Occurrence:* Very rare.

Remarks: A single leaf described by OISHI (1940) as mentioned above is nothing else than a ginkgoalean leaf, and we regard it as *Ginkgoites* ex gr. *sibiricus*. Accordingly it is true that the Utano flora includes such a ginkgoalean species, though it is very rare in occurrence and no such leaf is found in our huge collection.

TAKAHASI (1973b) listed *Ginkgoites digitata* (BRONGNIART) and *G.* cf. *sibiricus* (HEER) from the Utano Formation, but he did make neither illustrations nor descriptions of them.

Czekanowskiales

Genus *Czekanowskia* HEER, 1876: 65

Czekanowskia ex gr. *rigida* HEER

Czekanowskia rigida HEER: OISHI, 1940, p. 384, pl. 39, figs. 6–7 (Takaji; Loc. no. possibly 061).

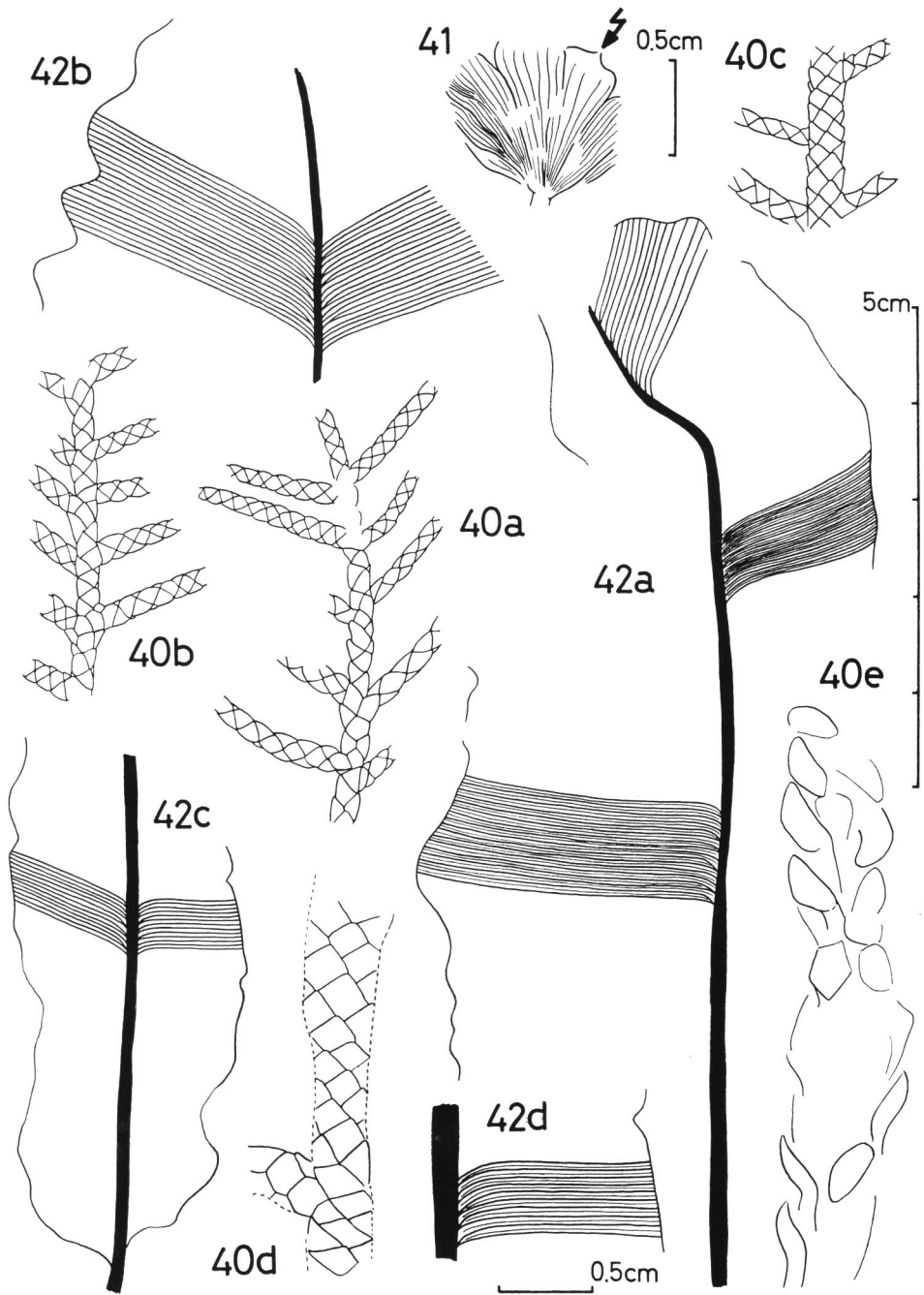
Material: OISHI's 8614 (1940, pl. 39, figs. 6–7) (Three bundles of leaves; impression). *Occurrence:* Very rare.

Remarks: At least a specimen figured by OISHI (1940, pl. 39, fig. 6) is referable not to *Acrostichopteris* but to *Czekanowskia*, though it is concerned about the OISHI's description of the venation that each leaf (segment) seems to carry one or two forking veins. Because in *Czekanowskia* it is the way that each segment carries a single vein. At any rate, it is true that the Utano flora contains czekanowskialean species, though its occurrence is very rare and no czekanowskialean leaf is found in our collection.

It is difficult to make specific identity in such impressions of leaves as mentioned above, and accordingly we regard OISHI's specimens as *Czekanowskia* ex gr. *rigida*.

Text-figs. 40–42 ($\times 2/3$, unless otherwise indicated).

40. *Brachyphyllum* ex gr. *expansum* (STERNBERG) SEWARD: 40a–e. Drawn from NSM-PP 8127, 8130, 8126, 8132 and 8129 respectively. Loc.; 063.
41. *Araucarites* sp. cf. *A. cutchensis* FEISTMANTEL: Drawn from NSM-PP 8133. Loc.; 068.
42. *Taeniopteris* sp.: 42a–c. Drawn from NSM-PP 8138, 8134 and 8135 respectively. 42d. Showing *venuli recurrentes* (interstitials) drawn partly from NSM-PP 8135 (Text-fig. 42c).



Coniferales

Form-genus *Brachyphyllum* LINDLEY et HUTTON,

1836: 188 ex BRONGNIART, 1828

Brachyphyllum ex gr. *expansum* (STERNBERG) SEWARD

Pl. 5, figs. 6–8; Pl. 6, fig. 11; Pl. 8, figs. 4–5; Text-figs. 40a–e

Brachyphyllum expansum (STERNBERG) SEWARD: OISHI, 1940, p. 391, pl. 39, figs. 10–11; pl. 40, fig. 9 (Takaji; Loc. no. possibly 061).

Material: NSM-PP 8126~8132 and other 55 specimens. *Localities*: 063, 061 and 068. *Occurrence*: Locally abundant at Loc. no. 063.

Description: Obtained are all sterile and pinnately branched shoots with spirally arranged and appressed scale-leaves. The thickest one is 1.3 cm wide. The leaves are rhomboidal in form and with subacutely pointed apex. Cuticle is not preserved.

Remarks: As mentioned before by KIMURA, NAITO and OHANA (1986), in the case of such branching shoots without cuticle and reproductive organs as ours, it is difficult to make precise specific identity.

Our sterile branching shoots agree in form with those described by OISHI (1940) as *Brachyphyllum expansum* from Takaji in all respects. But there is no positive proof that our shoots are referable to *Brachyphyllum expansum* or other *Brachyphyllum* species because of lacking cuticle and reproductive organs. Accordingly we at present regard our shoots as *Brachyphyllum* ex gr. *expansum*.

TAKAHASI (1951a) originally described *Brachyphyllum toyoraensis* based on sterile branching shoots and a single detached cone with spirally arranged cone-scales. TAKAHASI (1951a) mentioned that the cone-scale was rhomboidal in surface view, 0.6–1 cm in diameter, ornamented with an escutcheon of rhomboidal or rectangular upheaval or tri-edged solid angle and that his cone was different from the cones of *Brachyphyllum expansum* discussed by KENDALL (1949) from the Upper Jurassic of England because of having convex surface in KENDALL's cone-scales. If TAKAHASI's cone is that of *Brachyphyllum* ex gr. *expansum*, our branching shoots do not belong to the Cheirolepidiaceae but possibly to the other coniferous group, because so far as we know female cone-scales of cheirolepidiaceous conifers are quite different in form from those of TAKAHASI.

Genus *Araucarites* PRESL, 1838*Araucarites* sp. cf. *A. cutchensis* FEISTMANTEL

Text-fig. 41

Araucarites cutchensis FEISTMANTEL: OISHI, 1940, p. 387, pl. 39, figs. 8–9 (Takaji; Loc. no. possibly 061).

Material: NSM-PP 8133. *Localities*: 068 and 061. *Occurrence*: Rare at Loc. no. 068. But according to OISHI (1940) detached cone-scales are locally common at Takaji (Loc. no. possibly 061).

Description: A single cone-fragment obliquely and dorsally crushed was obtained. Seven cone-scales are preserved. Cone-scale is typically wedge-shaped, 0.8 cm long and up to 0.4 cm wide at apex with a trace of spinous distal appendage (indicated by an arrow in Text-fig. 41); its dorsal surface is ornamented by 6–7 longitudinal striations except near the apex.

Remarks: It is highly probable that the present cone-fragment is with araucarian affinity. Its cone-scales, though only dorsal-side is represented, resemble those of *Araucarites*.

A cone-scale with a single seed illustrated by OISHI (1940, pl. 39, fig. 8) is obviously that of *Araucarites* (or *Araucaria*) because of its narrow and spinous distal appendage. According to OISHI (1940), such cone-scales are common at Takaji. But we could not find them in our collection. We are of the opinion that the present cone should be regarded as *Araucarites* sp. cf. *A. cutchensis*, because recently we know many records of cones and cone-scales belonging to other araucarian species (e.g. BOSE and BANERJI, 1984).

Unclassified plant

Form-genus *Taeniopteris* BRONGNIART, 1828: 31

Taeniopteris sp.

Pl. 9, fig. 6; Pl. 10, figs. 2–5; Text-figs. 42a–d

Material: NSM-PP 8134–8138 and many other leaf-fragments. *Locality:* 063. *Occurrence:* Locally common.

Description: The leaves are variable in size, with rather thick rachis but whole leaf is unknown. Lamina is attached to the lateral sides of rachis; margins are irregularly undulated, but not segmented. Veins are originated at a narrow angle near base then bending outwards, making an angle of 60–70 degrees or more to the rachis, simple or dichotomously forking at base; weak *venuli recurrentes* are often recognized; density is 20 per cm at the margin.

Text-fig. 42b shows the largest leaf-fragment in our collection, representing the distal part of a leaf, the widest part preserved is 6.1 cm. Text-fig. 42a shows the longest leaf-fragment, more than 10.7 cm. Cuticle is not preserved.

Remarks: The present *Taeniopteris* sp. is characterized by its leaves of varied size and with irregularly undulated margins and by representing *venuli recurrentes*.

TAKAHASI (1973b) described two leaf-fragments as *Taeniopteris* cf. *richthofeni* (SCHENK) from Ono (Loc. no. possibly 063). According to TAKAHASI, veins of his leaves bend acutely upwards distally and the density is 12 per cm. Accordingly we at present regard his leaves as distinct from our leaves.

In *Taeniopteris* sp. A described by KIMURA and TSUJII (1983) from the Upper Liassic Negoya Formation, Kuruma Group and Iwamuro Formation based on three broken leaves, it represents marked *venuli recurrentes*, but we are of the opinion that it may represent sterile pinnae of *Marattia asiatica* (KAWASAKI) HARRIS.

Seeds

Several kinds of isolated seed-impressions were obtained. At present it is difficult to classify them depending only on their external morphology.

References

- ANDERSON, J. M. & ANDERSON, H. M., 1985. Palaeoflora of Southern Africa. Prodrum of South African megaflores. Devonian to Lower Cretaceous. 423 pp., incl. 226 pls. Balkema, Rotterdam.
- BARNARD, P. D. W. & MILLER, J. C., 1976. Flora of the Shemshak Formation (Elburg, Iran). Part 3: Middle Jurassic (Dogger) plants from Katumbargah, Vasek Gah and Imam Manak. *Palaeontographica*, B, **155**, 31–117, pls. 1–15.
- BELL, W. A., 1956. Lower Cretaceous floras of Western Canada. Geol. Surv. Canada, Mem. 285, 331 pp., 85 pls.
- BERRY, E. W., 1911. Section on fossil plants. In: Maryland Geol. Surv., Lower Cretaceous. 99–172, 213–508, pls. 22–97.
- BONETTI, M. I. R., 1963. Florula Mesojurassica de la zona de Taquetren (Canadon del Zaino) Chubut. *Rev. Mus. Arg. Cienc. Nat., Paleont.*, **1** (2), 23–43, pls. 1–7.
- BOSE, M. N. & BANERJI, J., 1981. Cycadophytic leaves from Jurassic-Lower Cretaceous rocks of India. *Palaeobotanist*, **28–29**, 218–300, incl. pls. 1–14.
- & ——— 1984. The fossil floras of Kachchh. I. *Ibid.*, **33**, 1–189, incl. pls. 1–55.
- & KASAT, M. L., 1972. The genus *Ptilophyllum* in India. *Ibid.*, **19**, 115–145, pls. 1–14.
- & ZEBABANO, 1978. The genus *Dictyozyamites* OLDHAM from India. *Ibid.*, **25**, 79–99, incl. pls. 1–8.
- CHEN, P. J., 1985. An outline of Jurassic paleogeography. In: The Jurassic System of China (Stratigraphy of China, no. 11). 330–332, 341–342. Geol. Publ. House, Beijing (in Chinese).
- CHEN, Y., DUAN, S. Y., YANG, X. H. & GUO, S. X., 1978. Plant. In: Fossil Atlas of Southwest China Sichuan Volume II. 460–537, pls. 153–191. Ditto (in Chinese).
- DOLUDENKO, M. P. & ORLOVSKAJA, E. R., 1976. Jurassic flora of the Karatau. Acad. Sci. USSR, TRANS., vol. 284, 1–262, incl. pls. 1–89 (in Russian).
- DUNKER, W., 1846. Monographie der norddeutschen Wealdenbildungen. Ein Beitrag zur Geognosie und Naturgeschichte der Vorwelt. 83 pp., 21 pls. Braunschweig.
- FONTAINE, W. M., 1889. The Potomac or younger Mesozoic flora. Monograph of the USGS, vol. 15. Text (Part I), 377 pp.; Plates (Part II), 180 pls.
- FONTAINE, W. M. in WARD, L. F., 1905. Status of the Mesozoic floras of the United States. Monograph of the USGS, vol. 48. Part I: Text, 616 pp. Part II: Plates, 119 pls.
- 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. Inst. Geol. & Exploit. foss. fuel, Acad. Sci. USSR. Nauka, Moscow (in Russian).
- GEYLER, T., 1877. Ueber fossil Pflanzen aus der Juraformation Japans. *Palaeontographica*, **24**, 221–232, pls. 30–34.
- GOTHAN, W., 1914. Die inter-liassische (rhätische) Flora der Umegegend von Nürnberg. *Abh. naturh. Ges. Nürnberg*, **19**, 91–186.
- HARRIS, T. M., 1949. Notes on the Jurassic flora of Yorkshire. 43–45. *Ann. Mag., Nat. Hist.*, (12) **2**, 561–585.
- , 1961. The Yorkshire Jurassic flora, I. 212 pp. Brit. Mus. (Nat. Hist.).
- , 1964. Ditto, II. 191 pp., 7 pls. *Ibid.*
- , 1969. Ditto, III. 186 pp., 7 pls. *Ibid.*
- , 1979. Ditto, V. 166 pp., 7 pls. *Ibid.*
- , MILLINGTON, W. & MILLER, J., 1974. Ditto, IV. 150 pp., 8 pls. *Ibid.*

- HEER, O., 1876. Beiträge zur Jura-Flora Ostsibiriens und des Amurlandes. Flora fossilis arctica, Bd. 4. *Acad. imp. sci. St.-Petersburg, Mém.*, **22**, 1–122, pls. 1–31.
- , 1878. Beiträge zur fossilen Flora Sibiriens und des Amurlandes. Flora fossilis arctica, Bd. 5. *Ibid.*, **25** (6), 1–58, pls. 1–15.
- HIRANO, H., 1971. Biostratigraphic study of the Jurassic Toyora Group, Part I. *Mem. Fac. Sci., Kyushu Univ.*, ser. D, **21**, 93–128, pls. 14–20.
- , 1973. Ditto, Part III. *Trans. Proc. Palaeont. Soc. Japan, N.S.*, no. 90, 45–71, pls. 9–10.
- KENDALL, M. W., 1949. On *Brachyphyllum expansum* (STERNBERG) SEWARD and its cone. *Ann. Mag. Nat. Hist.*, (12) **2**, 308–320.
- KIMURA, T., 1958. On the Tetori flora (Part 1). Mesozoic plants from the Kuzuryu Subgroup, Tetori Group, Japan. *Bull. sen. high sch., Tokyo Univ. Educ.*, no. 2–2, 1–47, pls. 1–4.
- , 1959. On the Tetori flora (Part 2). Addition to the Mesozoic plants from the Kuzuryu Subgroup, Tetori Group, Japan. *Ibid.*, no. 3, 104–121, pls. 1–2.
- , 1975. Middle-late Early Cretaceous plants newly found from the upper course of the Kuzuryu River area, Fukui Prefecture, Japan. *Trans. Proc. Palaeont. Soc. Japan, N.S.*, no. 98, 55–93, pls. 5–8.
- , 1976. Mesozoic plants from the Yatsushiro Formation (Albian), Kumamoto Prefecture, Kyushu, Southwest Japan. *Bull. Natn. Sci. Mus. Tokyo*, ser. C, **2** (4), 179–208, pls. 1–6.
- , 1980. The present status of the Mesozoic land floras of Japan. Prof. Saburo KANNO Mem. Vol., Tsukuba Univ., 379–413.
- , 1984. Mesozoic floras of East and Southeast Asia, with a short note on the Cenozoic floras of Southeast Asia and China. *Geol. Paleont. SE-Asia*, vol. 25, 325–350. Tokyo Univ. Press.
- , 1987. Geographical distribution of Palaeozoic and Mesozoic plants in East and Southeast Asia. In: Historical biogeography and plate tectonic evolution of Japan and Eastern Asia. 143–208. Terra Sci. Publ. Co., Tokyo (in press).
- & AIBA, H., 1986. *Onychiopsis yokoyamai* (YABE) comb. nov. from the Lower Cretaceous plant-beds in the Outer Zone of Japan. *Bull. Natn. Sci. Mus. (Tokyo)*, ser. C, **12** (2), 41–52, incl. pls. 1–2.
- & KANSHA, Y., 1978. Early Cretaceous plants from the Yuasa District and the Aridagawa Valley, Wakayama Prefecture, in the Outer Zone of Japan. Part 1. *Ibid.*, **4** (3), 99–116, pls. 1–4.
- & MATSUKAWA, M., 1979. Mesozoic plants from the Kwanto Mountainland, Gumma Prefecture, in the Outer Zone of Japan. *Ibid.*, **5** (3), 89–112, pls. 1–6.
- , NAITO, G. & OHANA, T., 1986. Early Jurassic plants in Japan. Part 7. Fossil plants from the Nishinakayama Formation, Toyora Group, Yamaguchi Prefecture, Southwest Japan. *Trans. Proc. Palaeont. Soc. Japan, N. S.*, no. 144, 528–540, pls. 99–100.
- & OHANA, T., 1984. *Ptilophyllum elongatum* sp. nov., from the Lower Barremian Kimigahama Formation, the Choshi Group, in the Outer Zone of Japan. *Proc. Japan Acad.*, **60B**, 381–384.
- & ———, 1987. Some Early Cretaceous plants from the Outer Zone of Japan. *Bull. Natn. Sci. Mus. (Tokyo)*, ser. C, **13**(1), 13–27, incl. pls. 1–2.
- , OHANA, T., KURIHARA, Y. & KOMORI, K. (1986). Middle Jurassic Utano flora and its significance for biostratigraphy and palaeophytogeography in East Asia (abstract). *Proc. Japan Acad.*, **62B**, 341–344.
- & SEKIDO, S., 1975. *Nilssoniocladus* n.g. (Nilssoniaceae n. fam.), newly found from the early Lower Cretaceous of Japan. *Palaeontographica*, B, **153**, 111–118, pls. 1–2.
- & ———, 1976a. *Dictyozamites* and some other cycadophytes from the early Lower Cretaceous Oguchi Formation, the Itoshiro Group, Central Honshu, Japan. *Trans. Proc. Palaeont. Soc. Japan, N.S.*, no. 101, 291–312, pls. 30–32.
- & ———, 1976b. Mesozoic plants from the Akaiwa Formation (Upper Neocomian), the Itoshiro Group, Central Honshu, Japan. *Ibid.*, no. 103, 343–378, pls. 36–39.

- & TSUJII, M., 1980a. Early Jurassic plants in Japan. Part 1. *Ibid.*, no. 119, 339–358, pls. 38–40.
- & ———, 1980b. Ditto. Part 2. *Ibid.*, no. 120, 449–465, pls. 54–56.
- & ———, 1981. Ditto. Part 3. *Ibid.*, no. 124, 187–207, pls. 30–32.
- & ———, 1982. Ditto. Part 4. *Ibid.*, no. 125, 259–276, pls. 41–43.
- & ———, 1983. Ditto. Part 5. *Ibid.*, no. 129, 35–57, pls. 12–14.
- & ———, 1984. Ditto. Part 6. *Ibid.*, no. 133, 265–287, pls. 54–56.
- KON'NO, E., 1962. Some species of *Neocalamites* and *Equisetites* in Japan and Korea. *Sci. Rep., Tohoku Univ.*, sec. ser., spec. vol., no. 5, 21–47, pls. 9–18.
- KRASSILOV, V. A., 1967. Early Cretaceous flora of Southern Primorye and its significance for stratigraphy. *Sib. Br., Far East Geol. Inst., Acad. Sci. USSR.* 364 pp., 93 pls. (in Russian).
- LORCH, J., 1967. A Jurassic flora of Makhtesh Ramon, Israel. *Israel Journ. Bot.*, **16**, 131–165, pls. 1–14.
- NATHORST, A. G., 1890. Beiträge zur mesozoischen Flora Japans. *Denks. Math.-Nat. Cl. Kaiser. Akad. Wiss. Wien*, **57**, 4–60, pls. 1–6.
- OISHI, S., 1932. The Rhaetic plants from the Nariwa District, Prov. Bitchu (Okayama Prefecture), Japan. *Journ. Fac. Sci., Hokkaido Imp. Univ.*, ser. 4, **1** (3–4), 257–380, pls. 19–53.
- , 1935. A new species of *Zamites* from the Nishi-Nakayama bed, Yamaguchi Prefecture. *Ibid.*, **3** (1), 97–100.
- , 1940. The Mesozoic floras of Japan. *Ibid.*, **5** (2–4), 123–480, pls. 1–48.
- PERSON, C. P. & DELEVORYAS, T., 1982. The Middle Jurassic flora of Oaxaca Mexico. *Palaeontographica*, **B, 180**, 82–119, pls. 1–10.
- PROSVIRIAKOVA, Z. P., 1966. Jurassic flora from Mangwishlak and its significance for stratigraphy. 172 pp., 35 pls. VSEGEI, Acad. Sci. USSR. Nauka, Moscow (in Russian).
- SAMYLINA, V. A., 1964. The Mesozoic flora of the area to the west of the Kolyma River (The Zyrianka Coal-Basin). I. In: *Palaeobotanika V. Komarov Bot. Inst., Acad. Sci. USSR, Acta*, ser. 8, 39–79, pls. 1–18 (in Russian).
- SCHENK, A., 1871. Beiträge zur Flora der Vorwelt. IV. *Palaeontographica*, **19**, 203–267, pls. 22–43.
- , 1883. Pflanzen aus der Steinkohlen Formation. In: *Richthofen, F. von: China*, vol. 4. 211–244, pls. 30–45.
- , 1884. Die während der Reise des Grafen Bela Szechenyi in China gessammelten fossilen Pflanzen. *Palaeontographica*, **31**, 164–181, pls. 13–15.
- SEWARD, A. C., 1895. Catalogue of the Mesozoic plants in the British Museum (Natural History). Part II. 259 pp., 20 pls. *Brit. Mus. (Nat. Hist.)*.
- , 1917. Fossil plants, vol. 3. 656 pp. Cambridge.
- SUKH-DEV & ZEBI-BANO, 1981. Some fossil gymnosperms from the Satpura Basin, Madhya Pradesh, India. *Palaeobotanist*, **27** (1), 1–11, incl. pls. 1–3.
- SZE, H. C., 1945. The Cretaceous flora from the Pantou Series in Yungan, Fukien. *Journ. Palaeont.*, **11** (1), 45–59.
- TAKAHASI, E., 1951a. Descriptive notes on some Mesozoic plants from Province Nagato. *Journ. Geol. Soc. Japan*, **57** (664), 29–33.
- , 1951b. Some cycadophyta from the Jurassic Toyora Series, Prov. Nagato (Yamaguchi Pref.), Japan. *Ibid.*, (668), 191–193.
- , 1973a. Some Triassic and Jurassic plants from Prov. Nagato (Yamaguchi Pref.), Japan. *Sci. Rep., Yamaguchi Univ.*, **20**, 7–13, incl. pls. 1–2.
- , 1973b. Stratigraphic distribution of the Mine-type and the Toyora-type floras. *Ibid.*, 15–28 (in Japanese).
- , UTO, S., MIHARA, A. & TAKAHASHI, H., 1965. Palaeozoic and Mesozoic formations of the Eastern and the Southern parts of the Tabe Basin, Yamaguchi Prefecture. *Ibid.*, **15**, 33–49 (in Japanese with English abstract).

- TATEIWA, I., 1929. Geological atlas of Chosen (Korea). no. 10. Geol. Surv. Chosen (Korea).
- TEIXEIRA, C., 1948. Flora Mesozoica Portuguesa. 1 Parte. 119 pp., 35 pls. Servicos Geol. Portugal, Lisboa.
- TURTANOVA-KETOVA, A. I., 1963. Williamsoniaceae of the USSR. *In*: Palaeobotanika, IV. Komarov Bot. Inst., Acad. Sci. USSR. Acta, ser. 8, 5-55, pls. 1-7 (in Russian).
- VAKHRAMEEV, V. A., 1966. Jurassic floras of the USSR. *Palaeobotanist*, **14** (1-3), 119-123.
- VASSILEVSKAJA N. D., 1967. Early Cretaceous ferns from the Lena-Olenek District, Lena Basin. *Sci. Rep., Palaeont. Biostratigr., NIIGA*, **17**, 58-78, pls. 1-8 (in Russian).
- WATANABE, K., MATSUO, H., KIMURA, T., KANNO, S. and SEKIDO, S., 1978. Science report on the siliceous wood remains of the Tetori Supergroup distributed along the Tetori River. 301 pp., 117 pls. Ishikawa Prefecture (in Japanese).
- WU, S. Q., YE, M. N. & LI, B. X., 1980. Upper Triassic and Lower and Middle Jurassic plants from the Hsiangchi Group, Western Hubei. *Mem. Nanjing Inst. Geol. Palaeont., Acad. Sinica*, no. 14, 63-139, pls. 1-39 (in Chinese).
- YABE, H., 1905. Mesozoic plants from Korea. *Journ. Coll. Sci., Imp. Univ. Tokyo*, **20** (8), 1-59, pls. 1-4.
- , 1913. Mesozoischen Pflanzen von Omoto. *Sci. Rep., Tohoku Imp. Univ.*, sec. ser., **1** (4), 57-64, pl. 10.
- , 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. *Ibid.*, **7** (1), 1-28, pls. 1-4.
- YOKOYAMA, M., 1889. Jurassic plants from Kaga, Hida, and Echizen. *Journ. Coll. Sci., Imp. Univ. Japan*, **3** (1), 1-66, pls. 1-14.
- , 1894. Mesozoic plants from Kozuke, Kii, Awa, and Tosa, *Ibid.*, **7** (3), 201-231, pls. 20-28.
- ZEILLER, M. R., 1902-3. Flore fossile des gîtes de Charbon du Tonkin (Études de gîtes minéraux de la France). 328 pp., 56 pls. Paris.
- ZHANG, W., ZHANG, Z. C. & ZHENG, S. L., 1980. Plant. *In*: Palaeontological atlas of Northeast China. (2) Mesozoic and Cenozoic volume. 222-339, pls. 103-210. Geol. Publ. House, Beijing (in Chinese).
- ZHANG, Z. C., 1985. Jurassic plants. *In*: The Jurassic System of China (Stratigraphy of China, no. 11). 290-320. Geol. Publ. House, Beijing (in Chinese).
- ZHOU, Z. Y., 1983. Early Liassic plants from Southwest Hunan, China. *Palaeont. Sinica*, N. S. A, no. 7 (whole no. 165). 91 pp., 34 pls. Sci. Press, Beijing (in Chinese with English abstract and description of a new genus).

Explanation of plates

(All natural size)

Plate 5

1. *Ctenozamites* ? sp.: NSM-PP 8034. Loc.; 068.
2. *Ctenozamites fukutomii* KIMURA et OHANA sp. nov.: NSM-PP 8033 (holotype). Loc.; 063.
3. *Anomozamites fukutomii* KIMURA et OHANA sp. nov.: NSM-PP 8037 (holotype). Loc.; 063.
4. *Pterophyllum heterosegmentum* KIMURA et OHANA sp. nov.: NSM-PP 8058. Loc.; 063.
5. *Ptilophyllum* sp. cf. *P. cutchense* MORRIS: NSM-PP 8093. Loc.; 063.
- 6–8. *Brachyphyllum* ex gr. *expansum* (STERNBERG) SEWARD: NSM-PP 8129, 8132 and 8126. Loc.; 063.

Plate 6

- 1–2. *Otozamites* sp. cf. *O. klipsteinii* (DUNKER) SEWARD: NSM-PP 8038 and 8039. Loc.; 063.
- 3–4. *Dictyozamites naitoi* KIMURA et OHANA sp. nov.: NSM-PP 8042 (paratype) (an arrow indicates a slender rachis) and 8043 (paratype). Loc.; 063.
- 5–9. *Pterophyllum heterosegmentum* KIMURA et OHANA sp. nov.: NSM-PP 8061, 8056 (paratype), 8060, 8065 and 8057 (paratype). Loc.; 063.
10. *Williamsonia* sp.: NSM-PP 8113. Loc.; 063.
11. *Brachyphyllum* ex gr. *expansum* (STERNBERG) SEWARD: NSM-PP 8128. Loc.; 063.

Plate 7

1. *Ctenozamites* ? sp.: NSM-PP 8035. Loc.; 068.
2. *Zamites varius* KIMURA et OHANA sp. nov.: NSM-PP 8068 (holotype). Loc. 063.
- 3–4. *Ptilophyllum* sp. cf. *P. cutchense* MORRIS: NSM-PP 8109 and 8092. Loc.; 063.
5. *Ptilophyllum* sp.: NSM-PP 8112. Loc.; 063.
- 6–7. *Nilssonsonia* sp.: NSM-PP 8120 and 8121. Loc.; 065 and 063.

Plate 8

- 1–2. *Zamites varius* KIMURA et OHANA sp. nov.: NSM-PP 8076 and 8078. Loc.; 063.
3. *Zamites* ? sp. B: NSM-PP 8088. Loc.; 065.
- 4–5. *Brachyphyllum* ex gr. *expansum* (STERNBERG) SEWARD: NSM-PP 8127 and 8130. Loc.; 063.

Plate 9

1. *Zamites* ? sp. C: NSM-PP 8089. Loc.; 063.
2. *Ptilophyllum* sp. cf. *P. cutchense* MORRIS: NSM-PP 8091. Loc.; 063.
3. *Nilssonsonia* sp. cf. *N. densinervis* (FONTAINE) BERRY: NSM-PP 8115. Loc.; 063.
- 4–5. *Cycadites* sp.: NSM-PP 8123 and 8124. Loc.; 063.
6. *Taeniopteris* sp.: NSM-PP 8138. Loc.; 063.

Plate 10

1. *Zamites varius* KIMURA et OHANA sp. nov.: NSM-PP 8086. Loc.; 063.
- 2–5. *Taeniopteris* sp.: NSM-PP 8138, 8137, 8132 and 8135. Loc.; 063.

