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The fossil on the cover is *Vicarya yokoyamai* Takeyama, an Early Middle Miocene gastropod from the Kurosedani Formation at Kakehata, Yatsuo-cho, Nei-gun, Toyama Prefecture, central Japan (Collected by T. Kotaka and K. Ogasawara, IGPS No. 99075, photo by S. Ohtomo and Y. Kikuchi,  $\times 0.9$ ).

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## 867. NEW TAXA IN THE LATE TRIASSIC DAEDONG FLORA, SOUTH KOREA. PART 1\*

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**Abstract.** From the Late Triassic 'Daedong System' of non-marine origin distributed in the southern part of the Korean Peninsula, we recognized a flora consisting of 79 species belonging to 38 genera. Of these, eleven species belonging to nine genera are new to science and many plant taxa are newly found. This paper deals with the description of the following taxa recognized by us in the Daedong flora: *Annulariopsis bunkeiensis* (Kobatake), n. comb., *Dictyophyllum exile* (Brauns) Nathorst, *Hausmannia ussuriensis* Kryshstofovich, *Cladophlebis mungyeongensis*, sp. nov., *Chiropteis coreanica*, sp. nov., *Anomozamites mungyeongensis*, sp. nov. *Otozamites micrauritus*, sp. nov. and *Pterophyllum micraequale*, sp. nov. In addition taxonomic description is further refined in this paper on *Coreanophyllum variisegmentum* Kimura et Kim, a bennettitalean with bipinnate habit of leaf.

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### Foreword

Non-marine sedimentary rocks yielding abundant fossil plants are distributed in the Daedong, Kimpo (Gimpo), Yeoncheon, Chungnam, Mungyeong and Danyang Coal-Fields in the Korean Peninsula (Kimura and Kim, 1984a, 1985).

These strata are called the Daedong Group in the Daedong Coal-Field (North Korea), Kimpo Group in the Kimpo and Yeoncheon Coal-Fields, Nampo Group in the Chungnam Coal-Field and Bansong Group in the Mungyeong and Danyang Coal-Fields respectively, but these sedimentary rocks have customarily been called the collective and non-committal 'Daedong System' or 'Daedong Supergroup'.

The Nampo Group is divided into the Hajo,

Amisan, Jogyeri, Baegunsa and Seongjuri Formations and the Bansong Group in the Mungyeong Coal-Field into the Buunryeong, Bolim, Dangi, Dangog, Maseong, Bongmyeongsan and Bongmyeongri Formations in upward sequence respectively.

Unfortunately, stratigraphical correlation among the above-mentioned coal-fields has not been made precisely because of being destitute of guide fossils and appropriate key-beds.

The fossil plants of the 'Daedong System' were studied by Yabe (1922), Yabe and Oishi (1929), Kawasaki (1925, 1926, 1927, 1939), Oishi (1940), Kon'no (1944), Kobatake (1954), Kimura *et al.* (1982) and Kimura and Kim (1982).

Since 1974, we collected a number of fossil plants from the new fossil-sites of the Amisan Formation (Chungnam Coal-Field) and Bongmyeongri Formation (Mungyeong Coal-Field) and we made revision of the previous works on the basis of specimens newly collected and recognized

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79 species belonging to 38 genera (Kimura and Kim, 1984a, 1985; Kim and Kimura, 1986). We call the plant-assemblage known from the 'Daedong System' the Daedong flora for the sake of convenience.

Among them, the following taxa are new to science: *Cladophlebis mungyeongensis*, *Chiropteris coreanica*, *Anomozamites mungyeongensis*, *Otozamites micrauritus*, *Pterophyllum cheondaeriense*, *P. micraequale*, *Anthrophyopsis decurrens*, *Taeniopteris cheondaeriensis* and *T. mungyeongensis*. In addition there are *Annulariopsis bunkeiensis* (Kobatake), n. comb. and *Coreanophyllum variisegmentum* Kimura et Kim.

We described the above-mentioned new taxa in our two serial papers, together with the description of the following characteristic taxa: *Dictyophyllum exile* (Brauns) Nathorst, *Hausmannia ussuriensis* Kryshstofovich, *Drepanozamites* sp. A, *Podozamites* ex gr. *schenki* Heer, *P.* sp. A, *Cycadocarpidium* sp. cf. *C. asaense* Kon'no, *C.* sp. cf. *C. nagatoense* Kon'no and *C.* sp. A.

All plant taxa from the Chungnam, Mungyeong and Danyang Coal-Fields will be described in a separate paper by J. H. Kim and Kimura in the near future, together with a detailed comparison of the Daedong flora with coeval floras and discussion of Late Triassic phytogeography in East Asia.

It becomes evident that the geological age of the Amisan and Bongmyeongri Formations is Late Triassic on the basis of their floristic composition (Kimura and Kim, 1984b) and that of the Baegunsa Formation is considered to be also Late Triassic on the basis of the presence of *Lobatannularia*, one of the important elements of the Permian Cathaysia flora (Kim, J. H. and Kimura, 1988).

The age-determination mentioned above is supported partly by the occurrence of abundant and varied conchostracans indicating the Late Triassic age, from the Amisan Formation and Kimpo Group (e.g. Kobayashi, 1975). However, the precise ages of the Daedong Group, Seongjuri Formation in the Chungnam Coal-Field and Bansong Group in the Danyang Coal-Field are still uncertain. We are of the opinion that the geological age of the 'Daedong System' is mostly Late Triassic except for the uppermost layers in most

coal-fields, such as the Seongjuri Formation which is barren of fossils.

The specimens here described are kept in the National Science Museum of Korea, Daejeon City. The localities of fossil plants are as follows:

Amisan Formation in the Chungnam Coal-field:

Jogaegog (or Jogaegol): Misan-myeon, Boyeaong-gun, Chungcheongnam-do (roughly 126°40'00"E, 36°18'54"N).

Dobung Coal-Mine: Ditto (roughly 126°40'00"E, 36°17'48"N).

Seongjuri: Ditto (roughly 126°38'18"E, 36°20'00"N).

Cheondaeri (Cheondaer or Yesan Coal-Mine): Changgog-myeon, Hongseong-gun, Chungcheongnam-do (roughly 126°46'00"E, 36°31'54"N).

Bongmyeongri Formation in the Mungyeong Coal-Field:

Hanaeri: Maseong-myeon, Mungyeong-gun, Chungcheongnam-do (roughly 128°05'10"E, 36°39'18"N).

We thank Dr. Kazuo Asama, National Science Museum, Tokyo, Prof. Kiyoshi Takahashi, Nagasaki University, Prof. Hisayoshi Igo, University of Tsukuba and Prof. Chang-Hi Cheong, Seoul National University, who cooperated with us in collecting fossil plants. Our thanks are extended to Miss Tamiko Ohana, Tokyo Gakugei University who made a clear line-drawing of those specimens here described. The present study was supported by the Grant-in-Aids (Overseas Scientific Research Fund) of Ministry of Education, Science and Culture; nos. 1974-7433, 1981-56041024 and 1982-57043021.

## Systematic description

### Equisetales

#### Genus *Annulariopsis* Zeiller, 1903

The relation between *Lobatannularia* Kawasaki, 1927 and *Annulariopsis* Zeiller, 1903 has been discussed by such authors as Halle (1927), Yabe and Koiwai (1928), Kawasaki (1934), Kon'no and Asama (1950) and Harris (1961). *Annulariopsis* has been defined somewhat vaguely for whorls of small

lanceolate uni-nerved leaves borne in a terminal position due probably to breaking off of a stem or bud above. According to Harris (1961), it is distinguished from *Phyllothea*, *Schizoneura* and *Lobatannularia* by having leaves which are free even at their bases. It differs from the leafy twigs of *Neocalamites* chiefly in that the *Neocalamites* shoots do not originally break just above a leafy-whorl but bear successive whorls.

However, we now think that it is close in form to *Annularia* and *Lobatannularia* because of the recent discovery of shoots bearing successive whorls as in *Annulariopsis annularioides* and *A. lobatannularioides* from the Upper Triassic Yanchang Formation (Huang and Zhou, 1980). *Annulariopsis* differs from *Annularia* in its leaves being free to their bases except for about 1 mm at the base, instead of the leaves forming a basal leaf-sheath as in *Annularia*. On the other hand, *Lobatannularia* is easily distinguished from *Annulariopsis* by its whorl consisting of markedly anisophyllous and largely fused leaves. Thus *Annulariopsis* is a valid genus and diagnosis of the genus will be emended as follows:

*Emended diagnosis* : Articulate plant. Stem slender, marked with longitudinal ridges; internodes rather long. Leaf-whorls circular or oval, often divided into two lobes, spread out in one plane, obliquely attached to the stem and persistent. Leaves equal or sometimes unequal in size. Adjacent leaves united for about 1 mm at the base, then free. Leaf linear, linear-lanceolate, or broadly spatulate in form with a round or mucronate apex, generally broadest at or near distal end and uninerved; margins entire or sinuous. Stem easy to break off at the node; thus most of the specimens showing the leaves in a terminal position on the shoot. (Fructification unknown.)

*Annulariopsis bunkeiensis* (Kobatake)  
Kimura et Kim, comb. nov.

Figures 1a—b

*Pseudolobatannularia* ? *bunkeiensis* Kobatake : 1954, p. 73, figs. 5—6.

*Annulariopsis inopinata* Zeiller : Kawasaki, 1939, p. 8, pl. 1, fig. 1.

*Material* : Lectotype : Reg. no. 81-303 (Jogaegog). Paralectotype : Reg. no. 81-089 (Dobung Coal-Mine). Other specimens : A number of specimens were collected from Jogaegog and Dobung Coal-Mine. *Locus typicus* : Jogaegog. *Stratum typicum* : Lowest Member of the Amisan Formation. *Derivatio nominis* : Bunkei—originally adopted by Kobatake in Japanese means Mungyeong in Korean.

*Emended diagnosis* : Stems slender, 1.5 mm wide, its surface-ornamentation indistinct. Internode more than 2 cm long. Leaf-whorl oval, not divided into two lobes, spread out in one plane, obliquely attached to the stem and persistent; smaller whorl, 1.2 cm (major) and 0.8 cm (minor), and larger one more than 2.6 cm (major) and 2.0 cm (minor) in diameter. Uninerved leaves more than 10 in a whorl, unequal in size, broadly spatulate in outline with mucronate apex and broadest near the distal end; largest one 2.5 cm long and 0.8 cm wide; margins entire or faintly undulated. Leaves mostly free but adjacent ones united for about 1 mm at the base. Midnerve thick, persisting to the tip.

*Distribution and occurrence* : *Annulariopsis bunkeiensis* is quite abundant but fragmented in the lowest Member of Amisan Formation at Jogaegog and Dobung Coal-Mine, where its broken leafy stems coexist with several species of conchostracans and rhizomes of *Neocalamites carrerei* (Kimura *et al.*, 1982). This species has been recorded by Kawasaki (1939) as *Annulariopsis inopinata* from the Bansong Group at Yeonhari (Danyang Coal-Field) and by Kobatake (1954) as *Pseudolobatannularia* ? *bunkeiensis* from the Dangi Formation at Gujeomri (Mungyeong Coal-Field). However, their precise locality is uncertain.

*Discussion and comparison* : Many specimens were present at these localities but none of them were complete. We could not show any photographs of them, because they were all preserved as faint impressions in a black shale.

This species was originally described by Kobatake (1954) as *Pseudolobatannularia* ? *bunkeiensis* as mentioned above. But his concept of the genus *Pseudolobatannularia* on the basis of detached leaf-whorls from the Norian Nariwa

Group, Japan is said to be characterized by its leaf-whorl consisting of more than 30 uninerved leaves usually united with each other for most of their length. Thus, his *Pseudolobatannularia* ? *bunkeiensis* belongs to *Annulariopsis* of which a leaf-whorl consists usually of 10 uninerved leaves united with each other only at their bases.

Our leafy-stems, detached leaf-whorls and a single leaf-whorl described by Kawasaki (1939) as *Annulariopsis inopinata* agree well with Kobatake's leaf-whorls in all the features. Thus, we propose *Annulariopsis bunkeiensis* (Kobatake) as a newly combined name herein.

Since Zeiller (1902-3) established *Annulariopsis* and described *A. inopinata* from the Upper Triassic of Hongay Coal-Field, several species have been described mainly from older Mesozoic rocks of Eurasia.

*Annulariopsis inopinata* is distinguished from *A. bunkeiensis* by its rather large-sized leaf-whorl with linear or elongate-oblancoolate leaves. Among our collection, there is no such a leaf-whorl referable to Zeiller's species.

Oishi (1930, 1932a, 1940) and Oishi and Takahasi (1936) described three imperfect leaf-whorls as *Annulariopsis inopinata* ? from the Nariwa Group and a single imperfect leaf-whorl from the Carnian Momonoki Formation. Unfortunately, they are insufficient for definite determination.

*Annulariopsis inopinata* described by Kiritchkova (1969) from the Upper Triassic of the Cheliabinsk Basin, East Ural is also distinguished from our specimens by its leafy stem bearing rather large-size leaf-whorls with linear leaves.

*Annulariopsis inopinata* described by Yabe (1922) from the Upper Permian Gobangsan Formation, Korea is now regarded as *Lobatannularia ensifolia* Halle (Kon'no and Asama, 1950).

*Annulariopsis simpsoni* (Phillips) Harris known from the Middle Jurassic of Yorkshire (Harris, 1947, 1961) and Middle Asia (Sixel *et al.*, 1971) is distinguished from the present species by its markedly sinuous leaf-margins. However, the leaf-whorls described by Jacob *et al.* (1955) as *Annulariopsis simpsoni* from the Jurassic of Afghanistan are rather similar in form to the pre-

sent species because of their entire leaves.

*Annulariopsis annularioides* and *A. lobatannularioides* originally described by Huang and Zhou (1980) are similar in form and size to the present species, but they are distinguished by the leaf-whorls consisting of eight leaves with an acutely pointed apex and by those divided into two lobes, respectively.

*Neocalamites annularioides* originally described by Sze (1956a) from the Upper Triassic in the Junggaer (Dzungaria) Basin is similar in form and size to the present species, but it is difficult to make a precise comparison by its published characters.

*Hexaphyllum sinensis* originally described by Ngo (1956) from the Upper Triassic Xiaoping Formation and later regarded as *Annulariopsis* ? *sinensis* (Ngo) by Lee (in Sze *et al.*, 1963) is easily distinguished by its much larger leaf-whorls.

*Annulariopsis oishii*, the youngest recorded genus, described by Kimura and Hirata (1975) from the Lower Cretaceous Ryoseki Formation, Japan differs from the present species in the leaves bearing deeply sinuous or entire margins and an acutely pointed apex.

## Filicales

### Family Dipteridaceae

Genus *Dictyophyllum* Lindley et Hutton, 1834

*Dictyophyllum exile* (Brauns) Nathorst

Figures 2a—h

*Dictyophyllum exile* (Brauns) Nathorst, 1878b, p. 39, pl. 5, fig. 7; Nathorst, 1906, p. 7, pls. 4—5, pl. 6, figs. 1—22, pl. 7, figs. 2—11, text-figs. 1—3; Harris, 1926, p. 64, pl. 1, figs. 1—2, text-fig. 7B; Harris, 1931, p. 80, pl. 13, figs. 15—16; Genkina, 1966, p. 62, pl. 10, fig. 7, pl. 11, figs. 1—5, pl. 12, figs. 1—3; Zhou, 1978, p. 102, pl. 18, figs. 2—3; Hsü *et al.*, 1979, p. 23, pl. 27, figs. 2—6, pl. 28. For further references, see Nathorst, 1906 and Harris, 1931.

*Material*: Examined specimens; Reg. no. A-5019 and 12 other specimens (Seongjuri) and Reg. no. T-024 and eight other specimens (Cheondaeri).

*Description*: The petioles are represented only by their distal part each with two arms leaving

between both an oval space (Fig. 2b). They are preserved presumably as their original state ; both distal and proximal ends of each arm are missing. Each arm bears more than 17 crowded pinnae (e.g. Fig. 2a), more than 17.5 cm long. The pinnae are slender, linear or linear-oblongate in outline, pinnatifid into triangular segments (or pinnules) which are directed forwards, with a pointed apex and with straight or shallowly undulated margins; the incision is shallow and does not reach to a half of the length of segments. The pinna rachis is rather thick, 2 mm wide, and gradually narrows proximally into a long and slender basal part with an extremely narrow sterile lamina, 1—2 mm wide and 1—1.5 cm long, nearly entire at margin; the web of the basal lamina of the adjacent pinnae is narrow and sterile (Figs. 2c and 2e). There are a considerable number of isolated pinnae, varying in size and form; the widest one is 4.5 cm (Fig. 2d). The venation is of the typical *Dictyophyllum*-type. The midnerve of each segment is strong, straight, persists to the tip and gives off secondaries at an angle of about 60° in proximal part and at about a right angle near distal end. They bifurcate twice or thrice in typical manner of sympodial ramification and form polygonal meshes, with one row of especially large-sized primary meshes on each side of midnerve.

The fertile pinnae are similar in size and form to sterile ones ; their laminae appear to be thicker than sterile ones. The sporangia are about 400—500  $\mu\text{m}$  in diameter, with 5—7 grouped into a definitely uniseriate sorus, 1—1.5 mm in diameter (Fig. 2f) ; crowded sori are distributed over the whole under surface of the lamina (Fig. 2d).

*Distribution and occurrence* : Locally abundant in the Chungnam and Mungyeong Coal-Fields. This is the first occurrence of *Dictyophyllum* in the Daedong flora.

*Remarks* : All the specimens collected from various localities and horizons in the surveyed area, are common in almost every important character, thus they belong to the same species and are identified to *Dictyophyllum exile*.

The present species is characterized by crowded sori distributed over whole under surface of the

pinna consisting of 5—7 sporangia and narrow web of basal lamina of the adjacent pinnae.

The isolated pinnae of this species resemble those of *Dictyophyllum nilssoni*, *D. nathorsti*, *D. falcatum* and *Camptopteris japonica*.

*Dictyophyllum nilssoni* (Brongniart) Goeppert is similar to pinna form to the present species, but is distinguished by the shorter arms and the sporangia not arranged in sorus (Harris, 1931). *Dictyophyllum nathorsti* Zeiller is also similar in pinna form and soral character to the present species but differs in its basal web of the pinnae which are conrescent for a length of 5—8 cm, instead of nearly free as in the present species.

*Dictyophyllum falcatus* Naito (Kon'no, 1968) is also similar in pinna form and soral character to the present species, but it differs in its shorter and small-sized arms.

*Camptopteris japonica* (Yokoyama) Kon'no (Kon'no, 1968) formerly defined as *Dictyophyllum japonicum*, is similar in pinna form and soral character to this species, but it differs essentially in its spirally twisted arms.

#### Genus *Hausmannia* Dunker, 1846

#### *Hausmannia (Protorhipis) ussuriensis* Kryshtofovich

Figures 3a—b

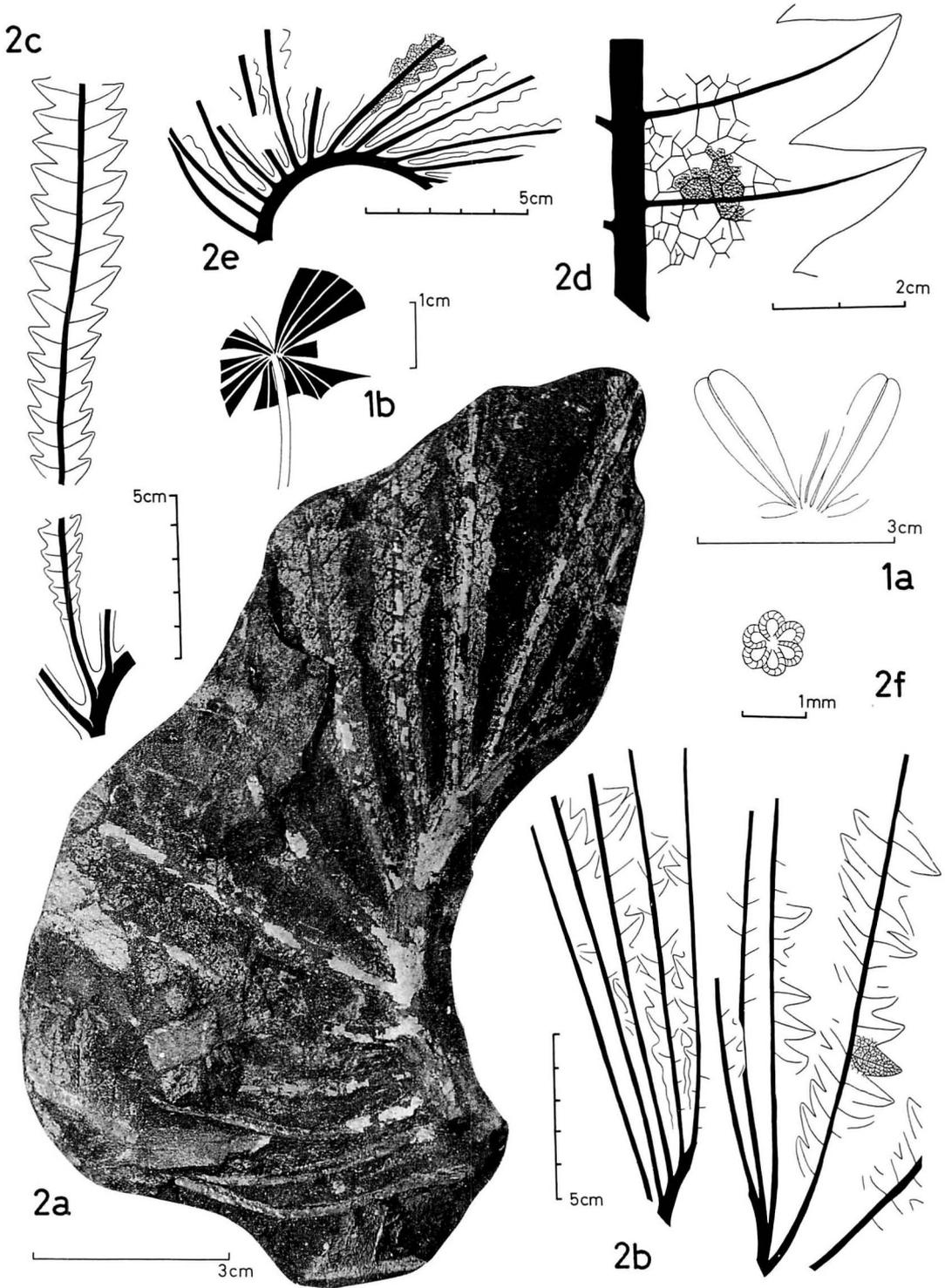
*Hausmannia ussuriensis* Kryshtofovich, 1923, p. 295, fig. 4: Kryshtofovich and Prynada, 1932, p. 367, pl. 2, figs. 4—5: Sze *et al.*, 1963, p. 89, pl. 26, figs. 3—4, pl. 28, fig. 1.

*Hausmannia* cf. *ussuriensis* Kryshtofovich: Sze, 1933c, p. 66, pl. 9, figs. 1—6.

*Hausmannia nariwaensis* Oishi, 1930, p. 52, pl. 7, figs. 2, 2a: Oishi, 1932a, p. 303, pl. 38, figs. 1—10 : Oishi and Yamasita, 1936, p. 163: Oishi, 1940, p. 220, pl. 5, figs. 2—3.

*Material* : Examined specimens ; Reg. no. TA-7 (Seongjuri) and T-0105A-C (Cheondaeri).

*Description* : Four sterile leaf-fragments were obtained. Two of them are petiolate ; the petiole is very slender, 1 mm wide, but its length is unknown. The lamina is broadly reniform in outline and varies in diameter from 2.5 to 7.5 cm. At the base, the lamina makes a deep and narrow sinus reaching to the centre. Both edges of the sinus



are convex outwards and overlap with each other. Primary nerves are 12 in number, radiate through the lamina from the top of petiole, branched dichotomously 2—4 times, and reach to the margin of lamina. The finer nerves originate nearly at a right angle or sometimes at narrower angles from the primary nerves, and are subdivided and united to form small square or polygonal meshes. The margin of lamina is irregularly, broadly and shallowly undulated.

*Distribution and occurrence* : The present species is rare and is only known from the Amisan Formation. This is the first occurrence in the Daedong flora.

*Remarks* : Although Kryshstofovich's original specimens were roughly drawn, we consider that *Hausmannia ussuriensis* and *H. nariwaensis* belong to the same species as already mentioned by Sze (1933c). The former name has priority. The present leaves are close to those of *Hausmannia nariwaensis* described by Oishi (1930, 1932a, 1940) from the Nariwa Group.

*Hausmannia ussuriensis* resembles the following species in outline of lamina, but it is distinguished by various reasons as briefly mentioned below:

*Hausmannia crenata* (Nathorst) Moeller, 1902, p. 50, pl. 5, figs. 5—6: Lamina is semicircular with a deep median sinus. Similar lamina was reported from the Liassic Fuxian Formation (Ordos Basin) as *Hausmannia papilionaceae* Liu (in Huang and Zhou, 1980).

*Hausmannia dentata* Oishi, 1932a, p. 306, pl. 21, figs. 1—4, 5A, pl. 35, figs. 2—3, text-fig. 2: A lamina with strongly sinuate-dentate margin characterizes this species.

*Hausmannia leeiana* Sze, 1933b, p. 7, pl. 2, figs. 8—9: A large-sized lamina (18—19 cm wide) is a characteristic of this species.

#### Unclassified fern

Form-genus *Cladophlebis* Brongniart, 1849

*Cladophlebis mungyeongensis* Kimura et Kim,  
sp. nov.

Figure 4a—d

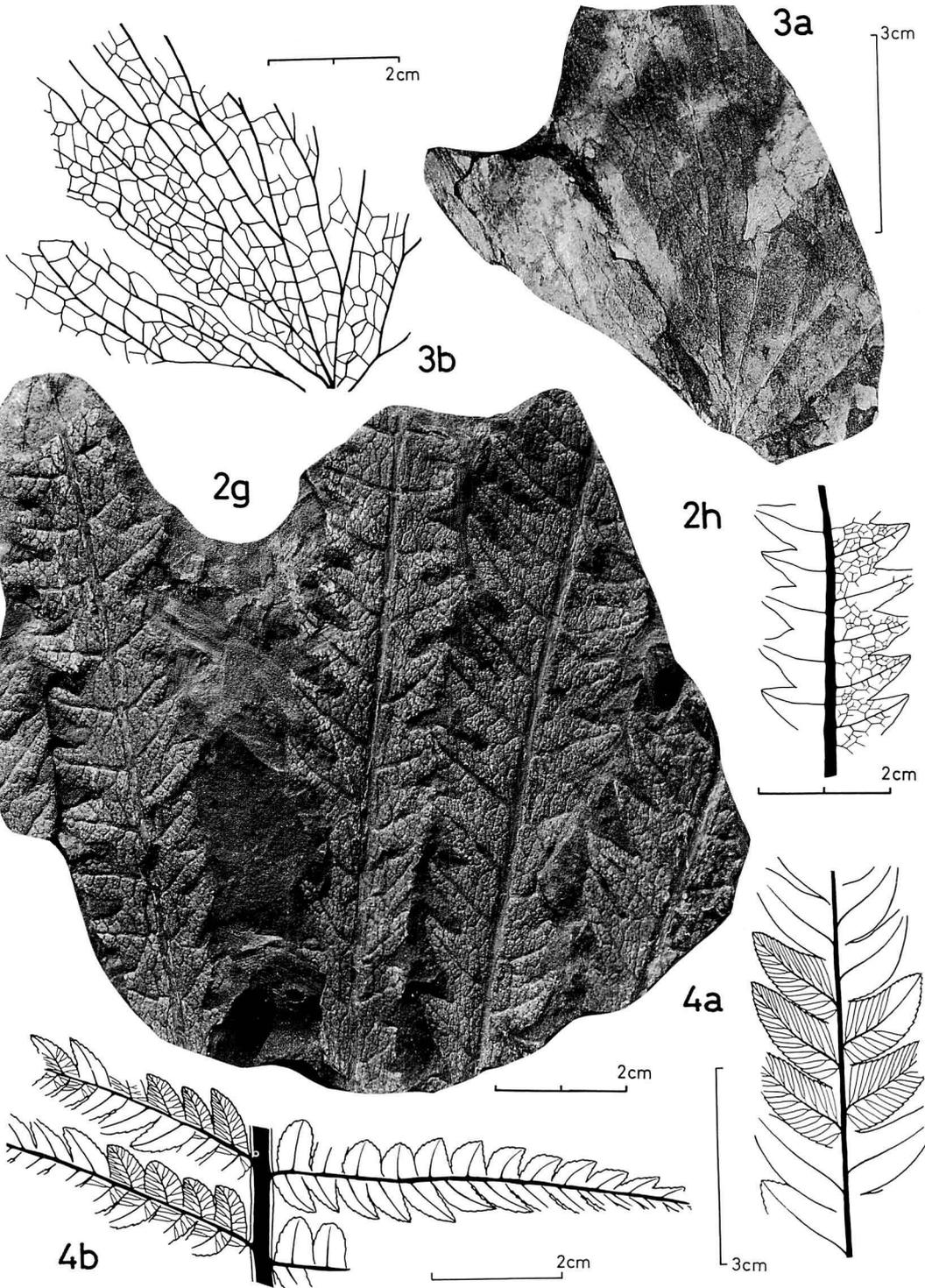
*Cladophlebis nebbensis* Brongniart: Kawasaki, 1939, p. 19, pl. 5, figs. 18—19, pl. 6, fig. 20a, text-fig. 3a.

*Material* : Holotype ; Reg. no. 81-021 (A—D) (Hanaeri). Paratypes ; Reg. nos. 81-040 and 093 (Hanaeri). *Stratum typicum* : Bongmyeongri Formation. *Locus typicus* : Hanaeri (west-side). *Derivatio nominis* : After Mungyeong Coal-Field where the holotype was collected.

*Diagnosis* : Frond bipinnate, medium-sized, 50 cm long, lanceolate in outline and up to 20 cm wide. Rachis up to 2 mm wide with wings, 0.5 mm wide along its lateral sides. Pinnae set closely, alternate, mostly perpendicular or sometimes obliquely at an angle of 45° to the rachis and nearly parallel-sided for the most part; apex acuminate. The longest pinnae on the middle portion of a frond 10 cm long and 1.5 cm wide at an interval of 1.5 cm, overlapping each other laterally and bearing 16 pairs of katadromically arranged pinnules. Both distal and proximal pinnae set rather remotely at an interval of 1.7—1.8 cm, directed forwards and backwards, respectively and bearing a reduced number of pairs of pinnules. Pinnules set closely, typically deltoid in form, sometimes falcate and attached to the pinna axis by their whole base at an angle of from 35° to 90°; margins finely serrate; apex acute or sometimes rounded. Basicopic basal pinnule not specialized but slightly reduced in size and originating from the angle between rachis and

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← **Figures 1 (a—b) and 2 (a—f).** 1. *Annulariopsis bunkeiensis* (Kobatake) Kimura et Kim, comb. nov.: 1a. An incompletely preserved leaf-whorl consisting of uninerved, unequal-sized and broadly spatulate leaves, each of which possessing a macronate apex (Lectotype, Reg. no. 81-303). Loc. Jogaegog. 1b. A leaf-whorl and successive stem (paralectotype, Reg. no. 81-089). Loc. Dobung Coal-Mine. 2. *Dictyophyllum exile* (Brauns) Nathorst: 2a. A bending arm; the web of the basal lamina of adjacent pinnae being sterile and narrow (Reg. no. B-7011). Loc. Seongjuri. 2b. Distal part of two arms (Reg. no. T-0009). Loc. Cheondaeri. 2c. A pinna most of which is fertile (Reg. no. A-5020). Loc. Seongjuri. 2d. A large-sized fertile pinna (Reg. no. A-5040). Loc. Seongjuri. 2e. Drawn from 2a. 2f. A sorus enlarged, but details of it uncertain, drawn from 2d.



pinna axis. Midnerve distinct, persisting to the tip and typically sending off 6—7 pairs of once forked lateral veins; each serration receiving a set of lateral vein. (Petiole and fructification not known).

*Distribution and occurrence*: The present species is locally common in the Mungyeong Coal-Field.

*Discussion and comparison*: The holotype represented by almost whole leaf except its petiole is characterized by its main rachis with narrow lateral wings and by deltoid pinnules with finely serrate margins and typically with 6—7 pairs of once forked lateral veins.

*Cladophlebis nebbensis* described by Kawasaki (1939) from the Mungyeong Coal-Field is referable to the present species in its form and venation of pinnules.

The present species resembles *Todites fukutomii* described in detail by Kimura and Ohana (1980), but it is distinguished by pinnules having serrated margins instead of the entire margins of the latter.

The present species is also distinguished from *Todites denticulatus* (or *Cladophlebis denticulata*) by its wholly deltoid pinnules.

#### Pteridospermales

#### Genus *Chiropteris* Kurr, 1845

*Chiropteris coreanica* Kimura et Kim, sp. nov.

Figures 5a—i

*Material*: Holotype; Reg. no. 81-009Ta (Cheondaeri). Paratypes; Reg. nos. T-0029b, d, 81-017Te, g (Cheondaeri). Examined specimens: Reg. nos. 81-007T, 009Tf, 022Te, 032T, 035T, T-0082 (Cheondaeri), 81-149, 242 (Hanaeri). *Stratum typicum*: Amisan Formation. *Locus typicus*: Cheondaeri (Cheondae Coal-Mine). *Derivatio nominis*: After Korea.

*Diagnosis*: Leaf petiolate; petiole long and narrow, more than 2 cm long and up to 2 mm

wide, consisting of a centrally projected and cylindrical part and flat lateral filmy fringes of about 0.5 mm wide. Lamina obdeltoid in form with broadly rounded apical margin; basal angle 50°—90°; lateral margin entire but apical margin shallowly undulated. Leaves varying in size; laminae typically 2.5 cm high; the largest one 3 cm high and the smallest one 0.5 cm high. Veins very fine, radiating from the top of petiole, repeatedly forking dichotomously at all levels, and reticulated into polygonal or rhomboidal meshes; meshes rare in occurrence near the base of lamina, elongated at the middle region, 1.3 cm long and 0.5 mm wide, but becoming shorter towards the apical margin, where 2.5 mm long and 0.5 mm wide. (Cuticle not preserved and fructification not known.)

*Distribution and occurrence*: The present species is locally common at the Cheondae Coal-Mine and Hanaeri.

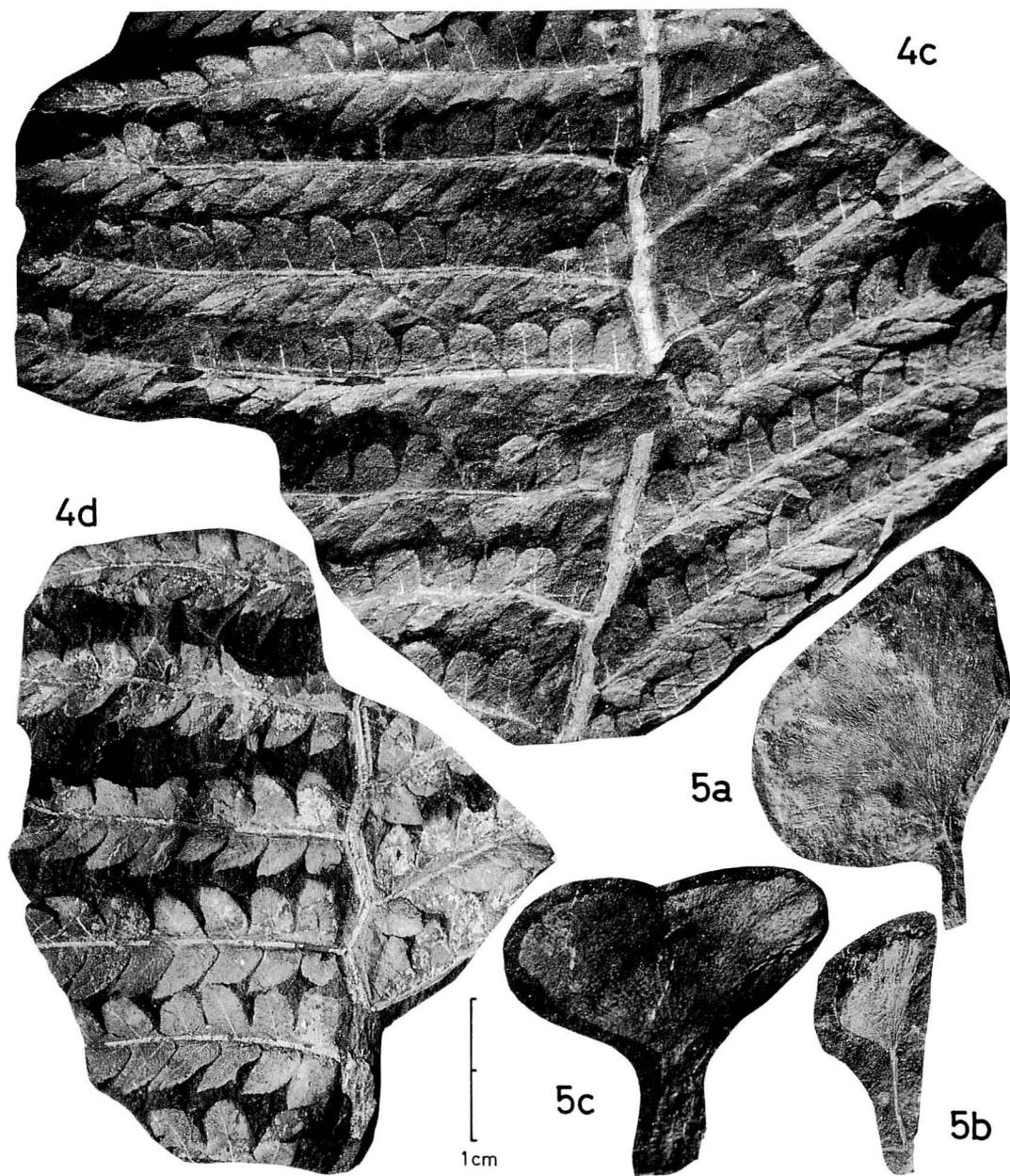
*Discussion and comparison*: Since Lilienstern (1931, 1932) reviewed ten species of the genus *Chiropteris* known at that time, so far as we know, eight additional species have been described under this genus from Mesozoic plant-beds.

Most *Chiropteris* species hitherto known are represented by digitate leaves in agreeing with the important diagnostic character of this genus given by Schenk (1864) and Schimper (1869).

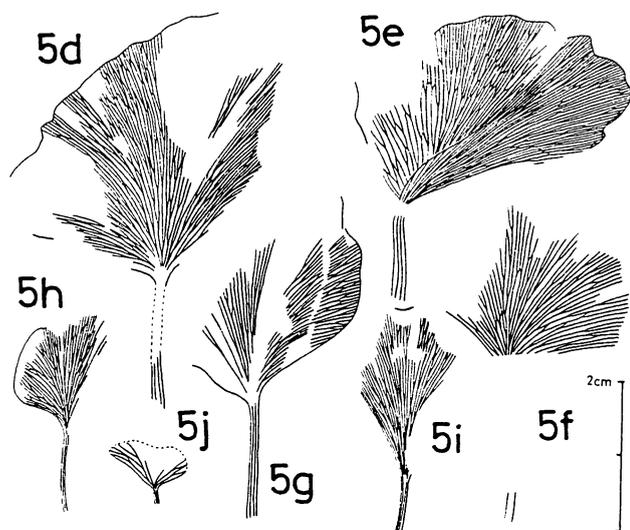
However, *Chiropteris coreanica* is characterized by rather small-sized and fan-shaped leaves with entire or shallowly and irregularly undulated apical margin, and fine and equidistant veins. Accordingly, *Chiropteris* species with digitate leaves are easily distinguishable from the present species.

The following *Chiropteris* species would be comparable with the present species in their entire or shallowly undulated margin of leaf: *Chiropteris barrealensis* Frenguelli, 1942, *C. cuneata* (Carruthers) Seward, 1903, *C. kawasaki* Kon'no, 1938, *C. manasiensis* Gu et Hu, 1979, *C. reni-*

← **Figures 2 (g—h)—4(a—b)**. **2**. *Dictyophyllum exile* (Brauns) Nathorst: **2g**. A fertile branch (proximal part missing) (Reg. no. T-024). Loc. Cheondaeri. **2h**. Main part of a sterile pinna (Reg. no. TA-T-001). Loc. Cheondaeri. **3**. *Hausmannia (Protorhipis) ussuriensis* Kryshstofovich: **3a**. A broken sterile lamina (surface view) (Reg. no. T-0105A). Loc. Cheondaeri. **3b**. Drawn from **3a**, showing the venation. **4**. *Cladophlebis mungyeongensis* Kimura et Kim, sp. nov.: **4a**. A pinna with large-sized pinnules (paratype; Reg. no. T-0116). Loc. Cheondaeri. **4b**. Middle portion of a leaf, drawn from **4c**.



**Figures 4 (c—d)—5(a—c)** (All natural size). **4.** *Cladophlebis mungyeongensis* Kimura et Kim, sp. nov.: **4c—d.** A single sterile leaf (**4d** shows an upper part of **4c** in organic connection) (Holotype; Reg. no. 81-093). Loc. Hanaeri. **5.** *Chiropteris coreanica* Kimura et Kim, sp. nov.: **5a.** A typical petiolate leaf (Holotype; Reg. no. 81-009Ta). Loc. Cheondaeri. **5b.** A small-sized leaf (paratype; Reg. no. 81-017Te). Loc. Cheondaeri. **5c.** A laterally expanded leaf (Reg. no. T-0082). Loc. Cheondaeri.



**Figures 5 (d—j):** *Chiropteris coreanica* Kimura et Kim, sp. nov.: All from Cheondaeri. **5d.** Drawn from **5a**. **5e.** Lateral lamina (right-side) is partly folded (paratype; Reg. no. T-0029b). **5f.** (Reg. no. 81-022T). **5g.** (paratype; Reg. no. T-0029d). **5h.** Drawn from **5b**. **5i** (Reg. no. 81-009Tf). **5j.** An exceptionally small-sized leaf (paratype; Reg. no. 81-017Tg).

*formis* Kawasaki, 1925 and *C. ? yuani* Sze, 1956a.

*Chiropteris barrealensis* known from the Upper Triassic of Argentina (Frenguelli, 1942) is easily distinguishable by its longitudinally elongate leaf with markedly auriculate base. *Chiropteris reniformis* known from the Upper Permian Gobangsan Formation, Korea (Kawasaki, 1925, 1931, 1934) and the Permian of China [Upper Permian Shihezi (Shihhotse) Formation, Shanxi (Halle, 1927) and its equivalents in Hebei, Anhui and Jiangxi, and Lower Permian Lower Shihezi Formation (Gu and Zhi, 1974)], resembles the present species in leaf-form and venation, but it is distinguished by its large-sized leaves (some exceeding 12 cm wide) and reniform laminae with deeply cordate base (Kawasaki, 1931, pl. 72, fig. 201). In the present leaves, all the laminae bear an acute or wedge-shaped base and no lamina with cordate base is known. *Chiropteris ? yuani* from the Upper Triassic Keramayi Formation, Xinjiang (Sze, 1956b) resembles the present species in leaf-form and size, but it is distinguished by having longer and wider vein-meshes.

*Chiropteris manasiensis* from the Keramayi Formation (Gu and Hu, 1979) is similar to *C. ? yuani* in leaf-form, size and venation, and it is also distinguished from the present species by having coarser venation (up to 10 per cm at the middle portion of lamina).

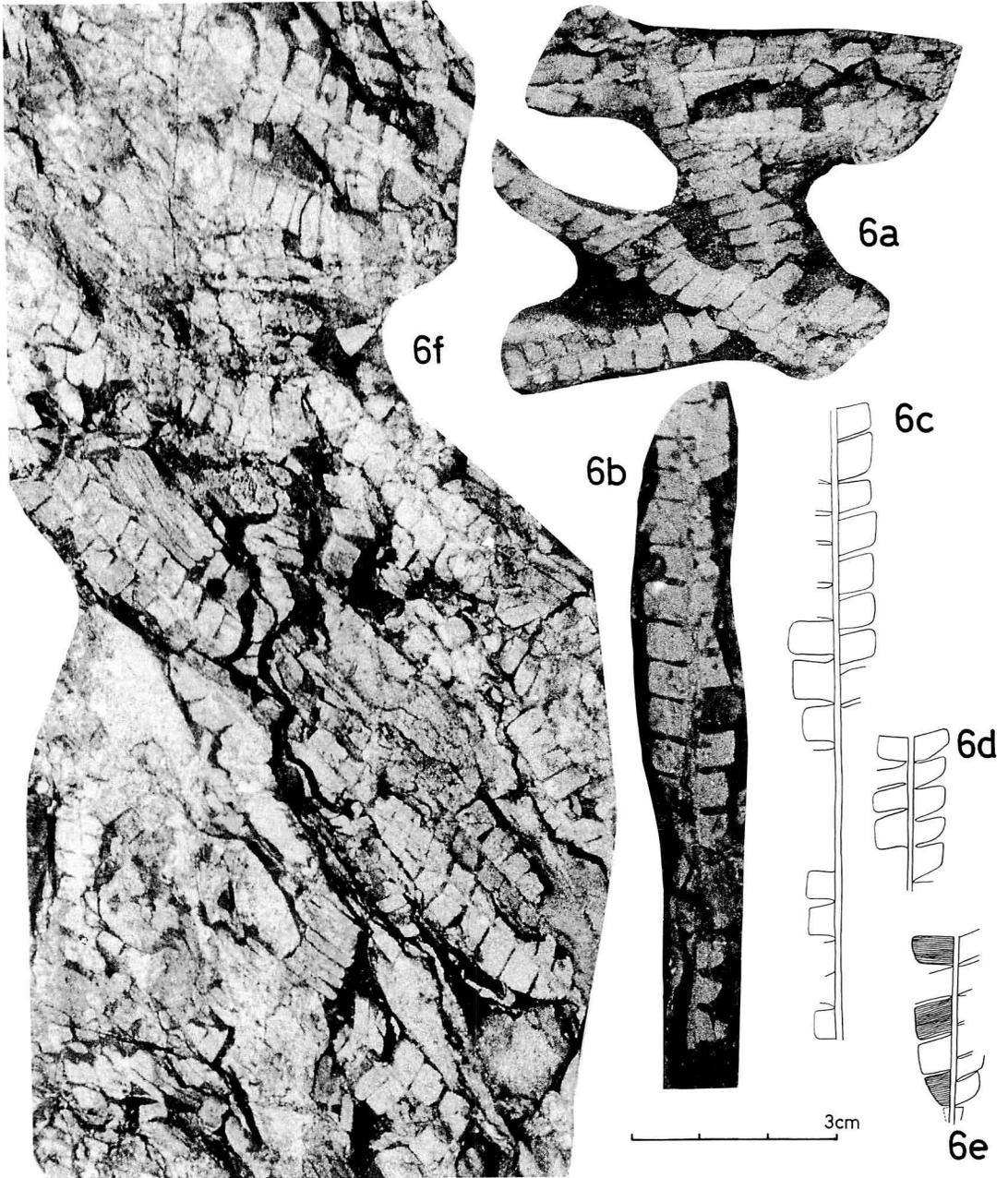
*Chiropteris kawasakii* from the Gobangsan

Formation (Samcheog, Ganweondo and near Pyeongyang City, North Korea: Kon'no, 1938) is easily distinguishable from the present species by having large-sized leaf (ca. 11 cm wide) with thick veins (or ribs).

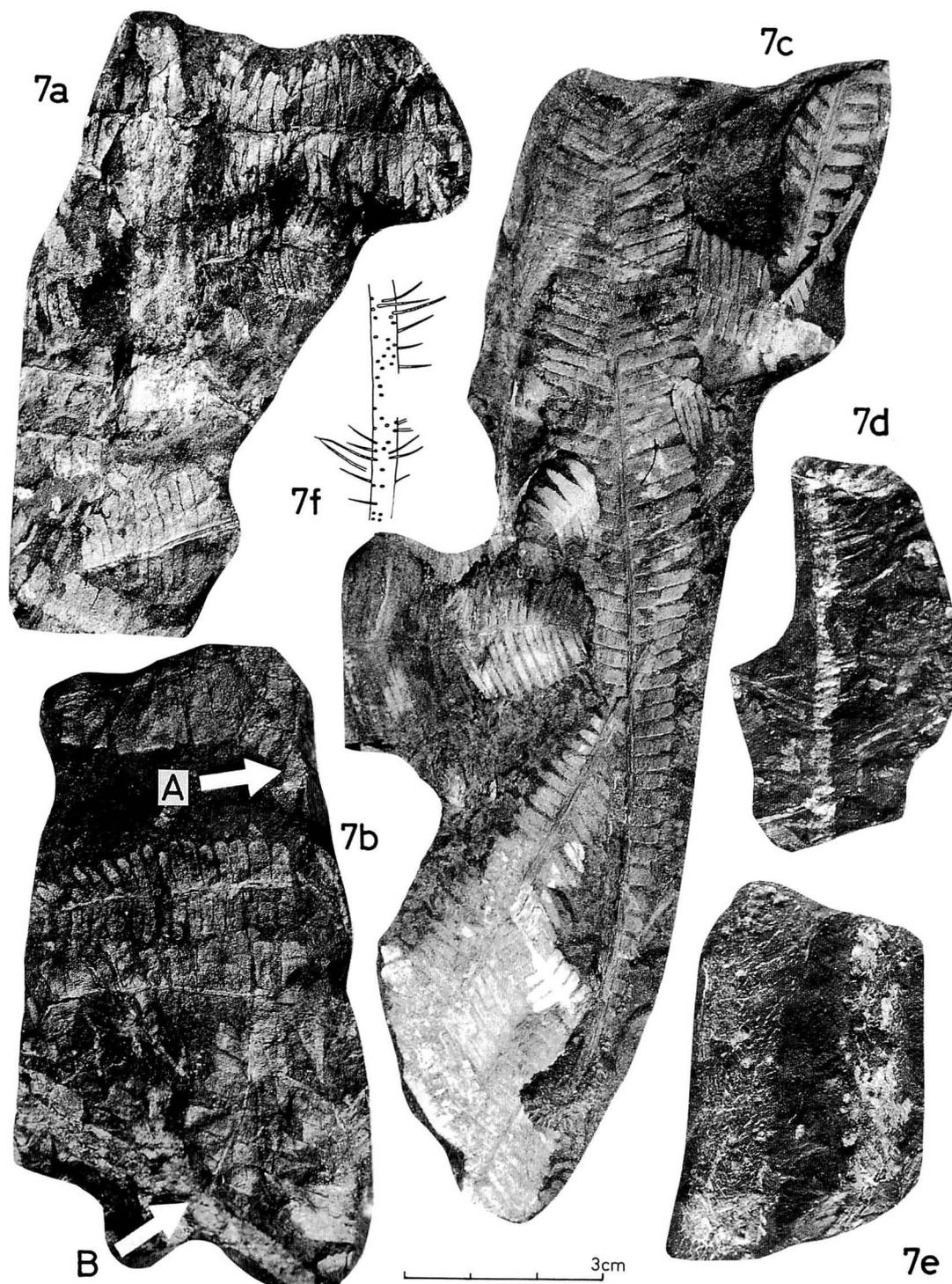
*Cyclopteris cuneata* originally described by Carruthers (1872) from the Upper Triassic of Queensland, and assigned later to *Chiropteris cuneata* (Carruthers) by Seward (1903) together with other leaves from the Upper Triassic of South Africa, is most close to the present species in leaf-form, size and venation. However, it is difficult to compare closely with the present species, because this species from the Southern Hemisphere has not adequately been described.

Kon'no (1938) mentioned that no specimen of well-defined *Chiropteris* had ever been found in the Late Triassic-Early Jurassic floras in Japan, Korea and North China, despite its occurrence in non-Asian regions. Now, we are certain that leaves assignable to *Chiropteris* are present in the Late Triassic floras of Korea (the present work) and of China *Chiropteris ginkgoformis* Liu (MS) (in Feng *et al.*, 1977; Xiaoping Formation, Guangdong), *C. manasiensis* Gu et Hu (*l. c.*), *C. taizihoensis* Zhang (Zhang *et al.*, 1980; Middle Triassic Linjia Formation, Liaoning), *C. ? yuani* Sze (*l. c.*).

*Arthrophyopsis ?* sp. of Yokoyama (1905, p. 12, pl. 3, fig. 6) from the Nariwa Group is too fragmented to compare closely with the present



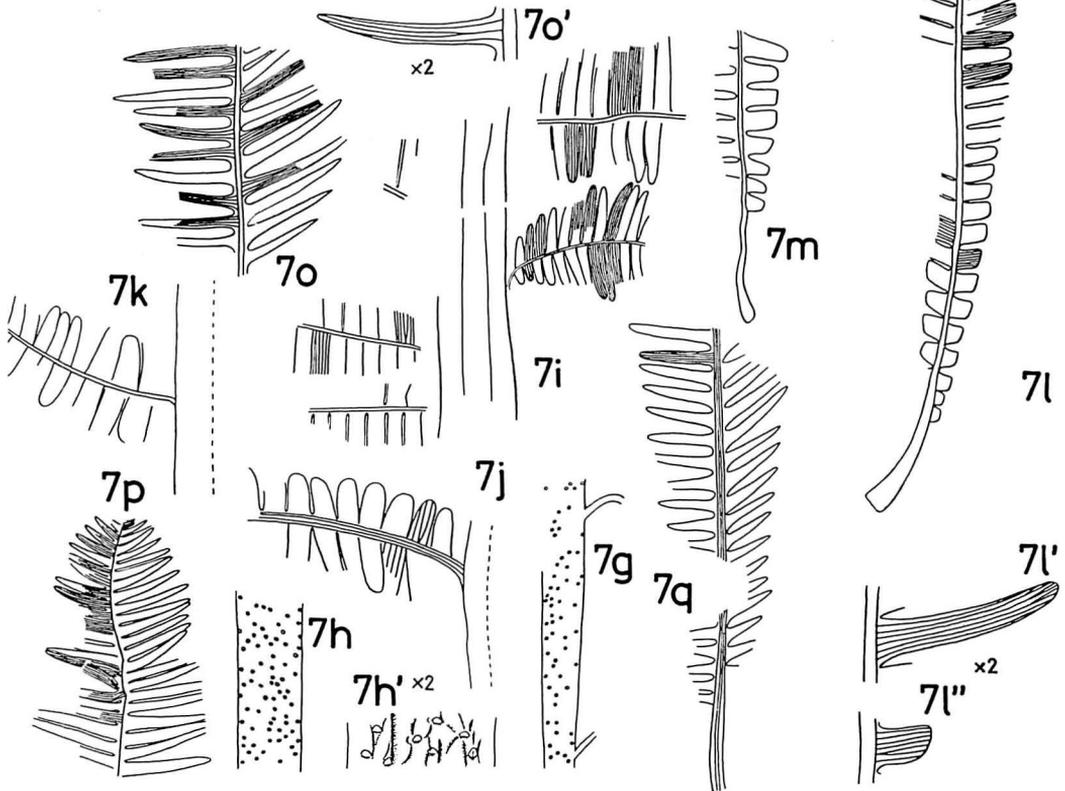
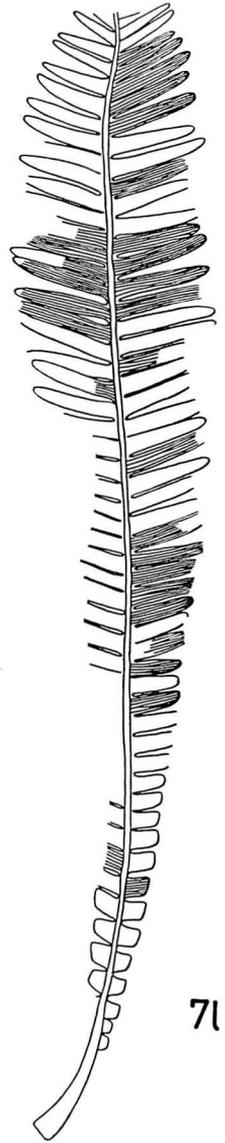
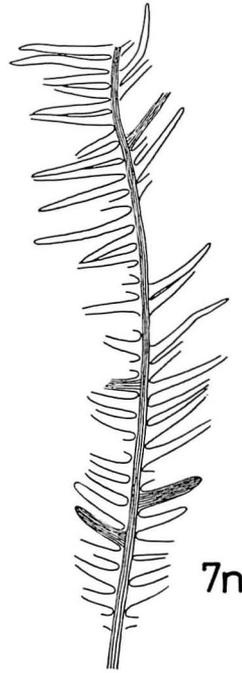
**Figures 6 (a—f).** *Anomozamites mungyeongensis* Kimura et Kim, sp. nov.: All from Hanaeri. **6a.** Detached leaves (paratype; Reg. no. KTM-46A). **6b.** A typical leaf, its both ends are missing. Most segments (pinnae) are truncated distally (Holotype; Reg. no. KTM-15A). **6c.** Drawn from **6b**. **6d.** An irregularly segmented leaf. Distal margin of segment (pinna) is occasionally rounded (paratype; Reg. no. KTB-15B). **6e.** Basal part of lamina (Reg. no. KTM-15c). **6f.** Occurrence of this species (Reg. no. KTM-46A).



**Figures 7 (a—f).** *Coreanophyllum variisegmentum* Kimura et Kim: From Hanaeri unless otherwise mentioned. **7a.** A thick rachis still bearing pinnae considered to be immature or abortive ones on their lateral sides (Holotype, Reg. no. 81-108). **7b.** Ditto (paratype; Reg. no. 81-253). Arrows A and B show the rachises. **7c.** A full grown pinna (paratype; Reg. no. T81-040). Loc. Cheondaeri. **7d.** Hairs on the rachis (paratype; Reg. no. 81-128). **7e.** A thick rachis with numerous hair-scars on its surface (Reg. no. 81-346). **7f.** Drawn partly from Fig. 7d. All figures from Kimura and Kim, 1982).



7r  
3cm



species.

So far as we know, *Chiropteris* has not been recorded from the Jurassic plant-beds and the range of this genus is thought to be from Permian to Triassic in age.

#### Bennettitales

Genus *Anomozamites* Schimper, 1870

*Anomozamites mungyeongensis*

Kimura et Kim, sp. nov.

Figure 6a—f

**Material** : Holotype ; Reg. no. KTM-15A (Hanaeri). Paratypes ; Reg. nos. KTM-15B, 46A. Examined specimens ; about 200 in number. **Stratum typicum** : Bongmyeongri Formation. **Locus typicus** : Hanaeri (west side). **Derivatio nominis** : After Mungyeong, the largest town near the locality.

**Diagnosis** : Leaves shortly petioled, long and narrow, nearly parallel-sided for the most part, small-sized, up to 10 cm long and typically 1 cm wide, noted range between 0.4 cm and 1.4 cm. Lamina attached to the lateral sides of slender rachis, suddenly narrowing near the base, regularly divided into about 20 alternate pairs of nearly square or short-rectangular pinnae ; sinus reaching to the rachis, 1 mm wide; apex typically truncated but sometimes more or less rounded. Basal pair of pinnae extremely small. Pinna base sometimes slightly expanded. Veins numerous, mostly simple, arranged in parallel, typically 15—18 in each pinna (40—42 per cm). (Cuticle not preserved. Reproductive organs not known.)

**Distribution and occurrence** : The present new species is only known from Hanaeri and is quite abundant, sometimes occurring *en masse* with no admixture of other taxa.

**Discussion and comparison** : *Anomozamites*

*mungyeongensis* sp. nov. is characterized by its slender leaf of which lamina is divided into nearly square or short-rectangular pinnae ending truncated distal margin and each with 15—18 simple and parallel veins. The pinnae are nearly uniform with the exception of the small basal ones. The typical length-to-width ratio of pinnae is 1.15, noted range between 0.75 and 1.70.

One might get confused *Anomozamites mungyeongensis* with *Pterophyllum micraequale* and *Coreanophyllum variisegmentum*. In *Pterophyllum micraequale*, however, most of pinnae are longer, the typical length-to-width ratio is 3.5, noted range between 1.3 and 4.5 and each pinna bears 8—13 veins.

In *Coreanophyllum variisegmentum*, the typical ratio is 6.0, noted range between 1.5 and 15, and each pinna possesses 3—6 veins. Thus, *Anomozamites mungyeongensis* is clearly distinguishable from these two species except for the case represented only by the basal part of leaves or pinnae.

The following species are similar to *Anomozamites mungyeongensis* in leaf-form, but they are distinguished from the present species by respective reasons as briefly mentioned below:

*Anomozamites gracilis* Nathorst, 1876, 1878c : Distal margin (or apex) of pinnae not truncated but mostly rounded.

*A. inconstans* (Braun): Zeiller, 1902—3 and Sze *et al.*, 1963: Leaves twice or thrice as large as those of the present specimens and distal margin of pinnae rounded.

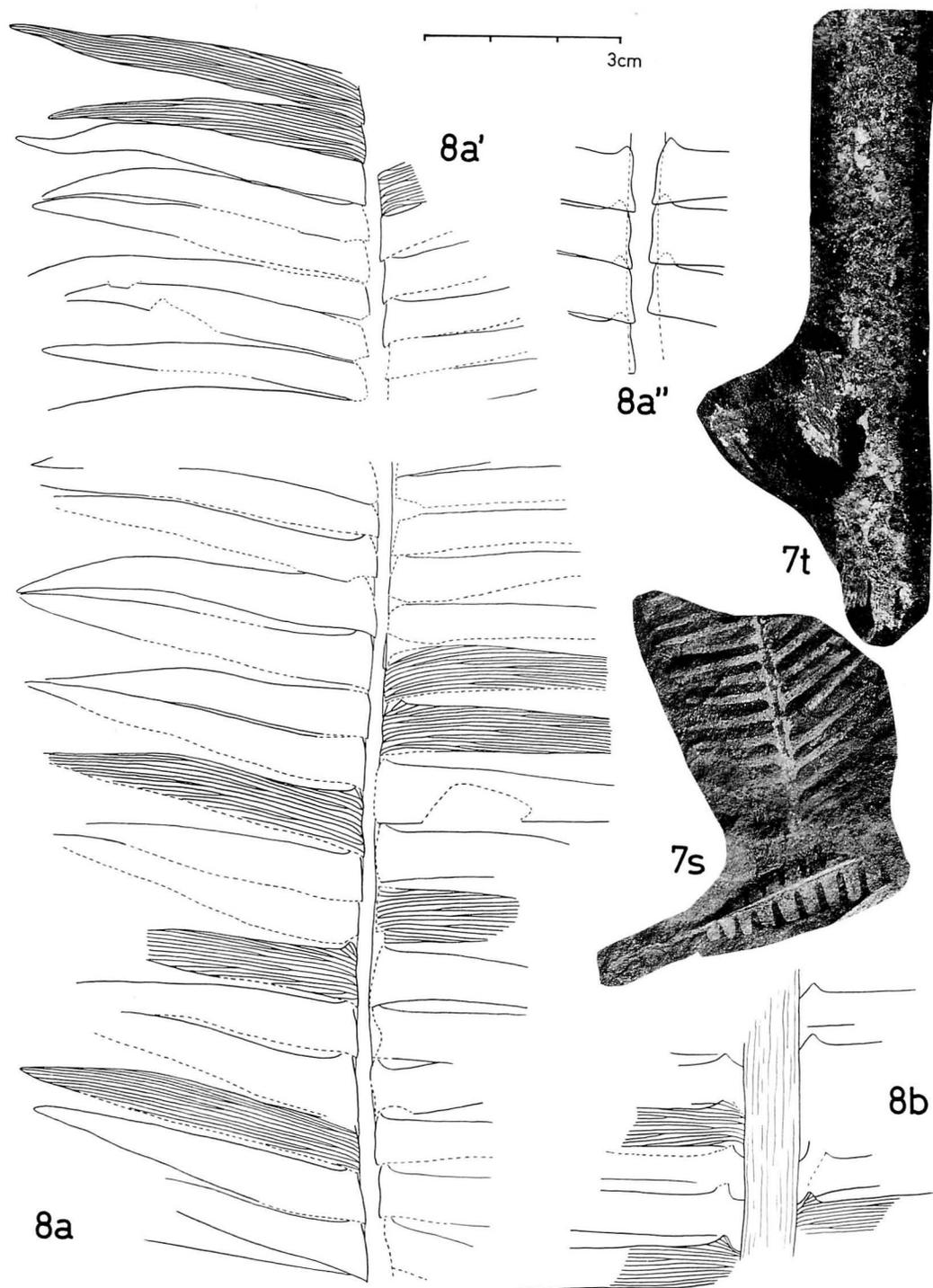
*A. loczyi* Schenk: Schenk, 1884 and Sze *et al.*, 1963: Similar in size and form to *A. inconstans*. In the pinna base, lower veins decurrent and upper veins bending upwards.

*A. minor* Nathorst (non Kawasaki, 1926): Nathorst, 1878c (including *A. gracilis*), 1879; Harris, 1926, 1932b: Basal region of leaves often entire like the lamina of *Taeniopteris*. Most of recorded leaves twice as large as the present specimens. Distal margin of pinnae rather rounded.

*A. nilssoni* (Phillips): Harris, 1969: Leaf not parallel-sided

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← **Figures 7 (g—r)**. *Coreanophyllum variisegmentum* Kimura et Kim: From Hanaeri unless otherwise mentioned. Natural size, unless otherwise indicated. **7g**. A rachis-fragment still bearing two pinna bases. Small circles show hair-scars on its surface (Reg. no. 81-346). **7h**. Hair-scars (Reg. no. 81-346). **7h'**. Detail of hair-scars enlarged partly from **7h**. **7i**. Drawn partly from **7a**. **7j**. Drawn partly from **7b**. **7k**. Rachis with pinna in organic connection (Reg. no. 81-081). **7l**. Drawn from **7c**. **7l'-l''**. Detailed venation drawn partly from **7c**. **7m—q**. Various pinna forms (**7m**, **o—q**; Reg. no. T81-001, **7n**; Reg. no. T75-250). Loc. Cheondaeri. **7o'**. Drawn partly from **7c**. **7r**. Occurrence of distorted and detached penultimate pinnae. All figures from Kimura and Kim, 1982 except for **7r**.



Figures 7 (s—t)—8 (a—b). Natural size unless otherwise indicated. 7. *Coreanophyllum variisegmentum* Kimura et Kim: 7s (upper). Distal part of penultimate pinnae; margins of segments are reflexed (Reg. no. T81-101). 7s (lower). Basal part of a penultimate pinna. 7t. A rachis bearing hair-scars on its under surface (Reg. no. 81-128; enlarged twice). Loc. Cheondaeri and Hanaeri respectively. 8. *Otozamites micrauritus* Kimura et Kim, sp. nov.: 8a, 8a', 8a''. Drawn from 8c. 8b. Basal part of a leaf (paratype; Reg. no. 81-153). Loc. Hanaeri.

for the most part but elongate-lanceolate in form, maximum width 4.5 cm. Number of veins fewer (5—10 at pinna base). Distal margin of nearly all the pinnae finely denticulated.

*A. thomasi* Harris, 1969: Leaf large-sized, attaining 20—30 cm long. Distal margin of some pinnae slightly waved or hollowed.

*Nilssonia formosa* Vachrameev et Vasina (in Genkina, 1963) has pinnae of a similar form to those of the present pinnae, but they are twice as large as the present pinnae.

Genus *Coreanophyllum* Kimura et Kim, 1982

*Coreanophyllum variisegmentum*  
Kimura et Kim

Figures 7a—t

*Coreanophyllum variisegmentum* Kimura et Kim, 1982, p. 152, figs. 1—12.

*Anomozamites* cf. *nathorsti* (Schenk): Kawasaki, 1925, p. 41, pl. 40, fig. 111.

*Anomozamites minor* Kawasaki, 1926 (pars), p. 30, pl. 7, fig. 22b (non 22a).

*Pterophyllum nathorsti* Schenk: Kawasaki, 1939, p. 25, 52, pl. 9, figs. 38—40, text-fig. 4.

*Examined specimens*: About 1000 in number.

*Distribution and occurrence*: Detached pinna fragments are quite abundant, sometimes thickly massed and appressed in the Amisan and Bongmyeongri Formations.

*Comparison and remarks*: The characteristic bipinnate habit of this plant was already mentioned in our previous paper (Kimura and Kim, 1982). We included various specimens described by Kawasaki (1925, 1926, 1939) in our synonymic list. The following species are represented by simply pinnate leaves and are recorded from Japan, China, North Viet Nam and East Siberia. They resemble or partly resemble detached pinnae of *Coreanophyllum variisegmentum*, but they are distinguished from our species because of various features as mentioned below:

*Pterophyllum angustum* (Braun) Gothan: Yabe and Oishi, 1929 (Upper Triassic Anyuan Formation, Hubei); Sze *et al.*, 1963 (ditto); Oishi, 1935 (cf. *P. angustum*; Lower Cretaceous Muling Formation, Heilongjiang); Zhang, *et al.*, 1980 (ditto); Oishi and Huzioka, 1938 (Upper Triassic Nariwa Group); Oishi, 1940 (ditto); Hsü *et al.*,

1979 (Upper Triassic Daqiaode Formation, Sichuan); Feng *et al.*, 1977 (Upper Triassic Anyuan Formation and Xiaoping Formation, Guangdong): Pinnae expanded at base and decurrent in some Chinese leaves, and pinnae broader in Japanese leaves.

*P. bavieri* Zeiller: Zeiller, 1902—3 (Upper Triassic of North Viet Nam); Feng *et al.*, 1977 (*l. c.*); Zhang, 1978 (Upper Triassic of Guizhou); Zhou, 1978 (Upper Triassic Wenbinshan Formation, Fujian); Hsü *et al.*, 1979 (*l. c.*): Pinnae narrower and elongated.

*P. contiguum* Schenk: Schenk, 1883 (Lower Jurassic Xiangxi Formation, Hubei); Hsü *et al.*, 1979 (*l. c.*): Schenk's leaves were included in *P. nathorsti* by most Chinese authors (see below). Other leaves from Sichuan are larger in size and possess broader pinnae.

*P. exhibens* Lee: Lee (Li), 1964 (Upper Triassic Xujiage Formation, Sichuan); Zhou, 1978 (*l. c.*): Leaves larger in size. Pinnae with decurrent base. Veins 5—12 in each pinna.

*P. firmifolium* Ye: In Wu *et al.*, 1980 (Lower Jurassic Xiangxi Formation, Hubei): Pinnae more elongated and decurrent.

*P. furcata* Yang: In Chen *et al.*, 1978 (Upper Triassic Daqiaode Formation): Pinnae shorter and broader. Nine veins in each pinna.

*P. jixiense* Chow et Wang: In Zhang *et al.*, 1980 (Lower Cretaceous Chengzihe Formation, Heilongjiang): Pinnae longer, with expanded and decurrent base.

*P. minutum* Li et Tsao: Li *et al.*, 1976 (Upper Triassic Xiangyun and Yipinglang Groups, Yunnan); He *et al.*, 1979 (Upper Triassic Jieza Group, Qinghai): Pinnae narrower, basally expanded.

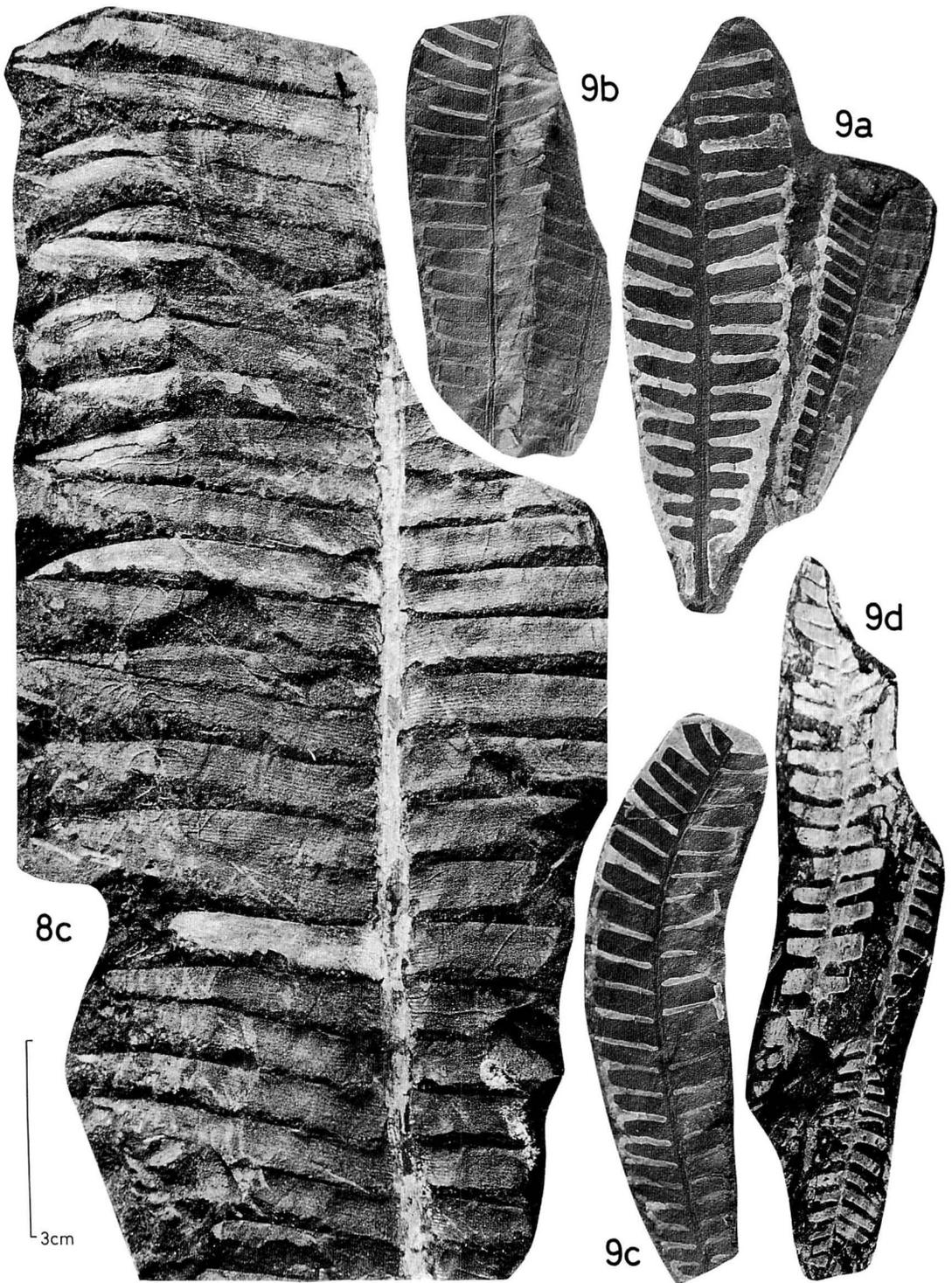
*P. nathorsti* Schenk: Schenk, 1883 (including *Nilssonia compta*) (Lower Jurassic Xiangxi Formation, Hubei); Sze, 1931 (Lower Jurassic of Jiangxi); Sze, 1933a (Upper Triassic-Lower Jurassic of Sichuan); Sze, 1949 (Lower Jurassic Xiangxi Formation); Hsü, 1954 (= Sze's specimen); Sze *et al.*, 1963 (ditto); Hsü *et al.*, 1979 (*l. c.*); Wu *et al.*, 1980 (*Tyrmyia nathorsti*; Lower Jurassic Xiangxi Formation, Hubei): Pinnae rectangular for the most part of a leaf.

*P. sinensis* Lee: Lee (Li), 1964 (*l. c.*); Li *et al.*, 1976 (*l. c.*); Feng *et al.*, 1977 (*l. c.*); Zhou, 1978 (Upper Triassic Dakeng Formation, Fujian); Chen *et al.*, 1978 (Upper Triassic Lamaya Formation, East Xizang); Wu *et al.*, 1980 (*l. c.*): Very close to the present species. Pinnae not varied but uniform, as judged from the position of a leaf.

*P. tyrnense* (Prynada) Krassilov: Krassilov, 1969 (Jurassic-Cretaceous of the Bureja Basin): Rachis rather thick. Pinnae elongate-rectangular. Basal pinnae not square but elongated.

*P. yingchenense* Chang: In Zhang, 1980 (Lower Cretaceous Yingchen Formation, Jilin): Leaf large, pinnae twice as large as ours.

*Tyrmyia chaoyangensis* Chang: In Zhang *et al.*, 1980 (Middle



Figures 8(c)—9(a—d). All natural size. 8c. *Otozamites micrauritus* Kimura et Kim, sp. nov.: (Holotype; Reg. no. 81-082). Loc. Hanaeri. 9. *Pterophyllum micraequale* Kimura et Kim, sp. nov.: 9a. Two detached leaves [Holotype (left); Reg. no. A-5066B]. 9b. (paratype; Reg. no. A-5066c). 9c. (paratype; Reg. no. A-5066A). Loc. All from Seongjuri. 9d. Somewhat deformed leaves (Reg. no. T-0060). Loc. Cheondaeri.

Jurassic of Liaoning): Pinnae set closely, uniform for the most part of a leaf.

*T. latior* Ye: in Wu *et al.*, 1980 (Lower Jurassic Xiangxi Formation): No square or short-rectangular pinnae recognized.

*T. prinadae* Vassilevskaja: Vassilevskaja and Abramova, 1966 (Lower Cretaceous of the Lena Basin): Rachis thick. Pinnae shorter and rectangular.

*Pseudocycas polynovii* (Novopokrovsky) Krassilov: Krassilov, 1969 (*l. c.*): Zhang *et al.*, 1980 (*Tyrnia polynovii*); Lower Cretaceous Sunjiawan Formation, Liaoning): Pinnae not varied but rather uniform.

As mentioned above, many allied leaves have been described from East Asia, but there is no species unquestionably referable to *Coreanophyllum variisegmentum*. The difference between *Coreanophyllum* and *Ctenozamites* (once called *Ctenopteris*) was already discussed in our previous paper (Kimura and Kim, 1982).

As no cuticle is preserved, some uncertainty still exists whether *Coreanophyllum* is a bennettitalean or not, but we are inclined to believe that it is most probably a bennettitalean because of its pinnae being morphologically most close to the simply pinnate leaves of *Pterophyllum* so far.

#### Genus *Otozamites* Braun, 1842

*Otozamites micrauritus* Kimura et Kim,  
sp. nov.

Figures 8a—c

*Material*: Holotype; Reg. no. 81-082 (Hanaeri). Paratype; Reg. no. 81-153 (Hanaeri). *Stratum typicum*: Bongmyeongri Formation. *Locus typicus*: Hanaeri (west side). *Derivatio nominis*: Small-sized auricle in each pinna.

*Diagnosis*: Leaves more than 20 cm long and 11.5 cm wide at the middle. (Whole leaf unknown.) Rachis 8 mm wide below and 4.5 mm above; surface longitudinally striated. Pinnae attached perpendicularly to the upper sides of rachis. Pinnae long and narrow, typical ones 5.4 cm long and 0.7 cm wide near the base, nearly parallel-sided, then gradually narrowing towards the acutely pointed apex. Acroscopic basal margin slightly auriculated, auricle triangular and free, and basisopic basal margin slightly expanded. Margins entire. Veins arising from the rachis, numbering 8—9 at the base

of each pinna; 4—5 acroscopic veins forking at or near the base, radiating towards the auricle and acroscopic margin, each auricle receiving one or two sets of veins; 4—5 basisopic veins forking twice or thrice at all levels, one persisting to the tip and others ending at the basisopic margin. (Cuticle not preserved. Reproductive organs not known.)

*Distribution and occurrence*: Only two leaf-fragments were obtained from the Bongmyeongri Formation.

*Discussion and comparison*: *Otozamites micrauritus* is characterized by its small-sized triangular auricle. As shown in Fig. 8a'', each basal half of acroscopic margin was covered by the basisopic part of upper adjacent pinna. Thus, most of the basisopic margins of pinnae broke off when a rock was split for recovering plant fossils. Accordingly, it is difficult to see the pinna-auricle in this specimen without removing the matrix. Fig. 8b shows the basal portion of a leaf clearly exposing the auricles.

*Otozamites micrauritus* resembles *O. bornholmensis* Möller in pinna-form, small-sized auricle and venation, but the former is distinguished by its triangular auricles instead of semi-circular ones in the latter species.

According to our present knowledge, no *Otozamites* leaves with such triangular auricles as our leaves have been found in the literature.

#### Genus *Pterophyllum* Brongniart, 1828

*Pterophyllum micraequale* Kimura et Kim,  
sp. nov.

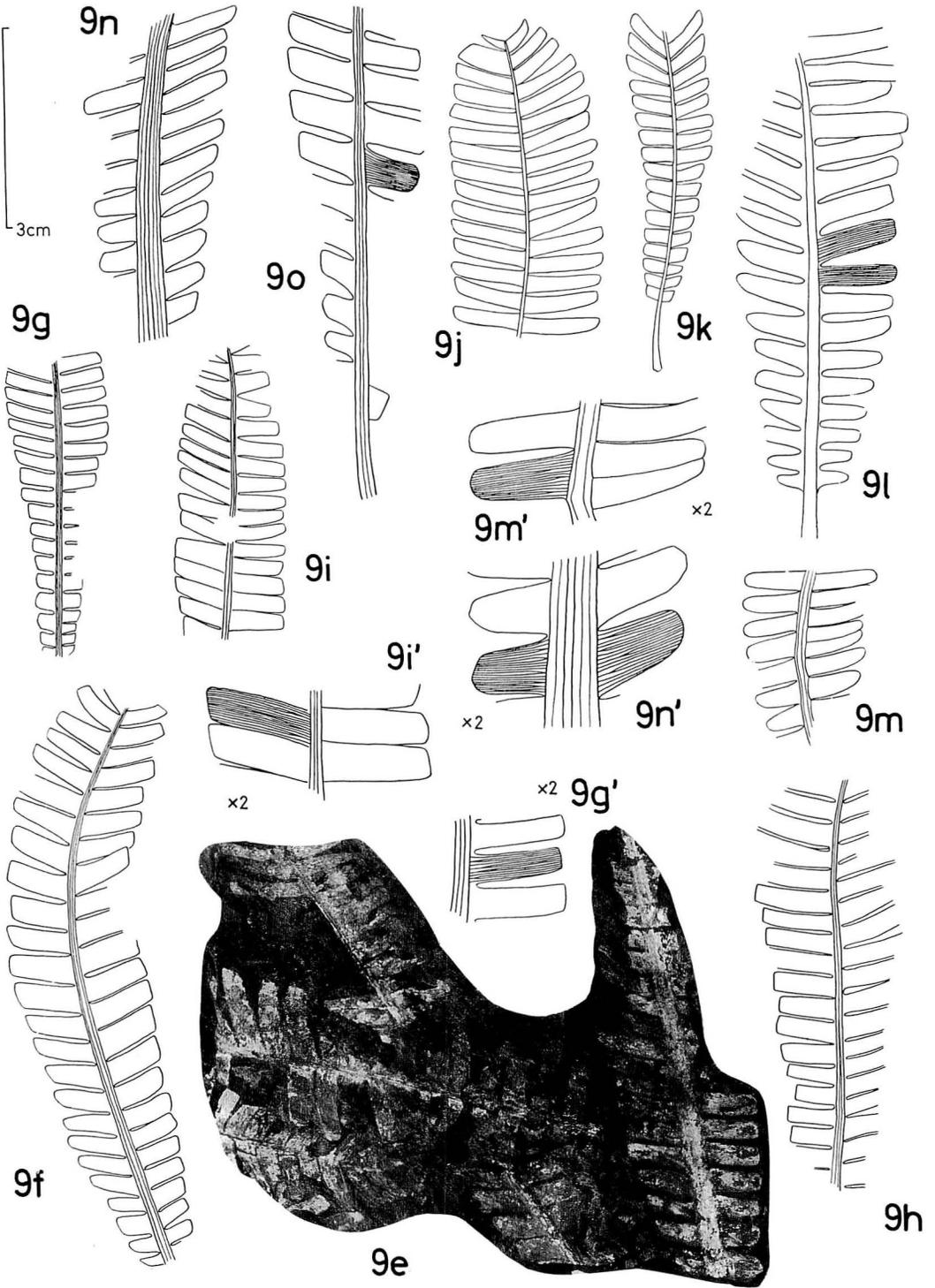
Figures 9a—o

*Anomozamites nilssoni* (Phillips): Kawasaki, 1925, p. 40, pl. 21, fig. 66.

*Anomozamites minor* Kawasaki, 1926 (pars), p. 30, pl. 7, fig. 22b (non fig. 22a).

*Pterophyllum aequale* Brongniart: Kawasaki, 1926, p. 27, pl. 6, figs. 24, 24a', 24a''.

*Material*: Holotype; Reg. no. A-5066B (Seongjuri). Paratypes; Reg. nos. 81-293 (1-4), 203Z (Hanaeri), A-5066A, C (Seongjuri). Examined specimens; about 500. *Stratum typicum*: Amisan Formation. *Locus typicus*: Seongjuri.



*Derivatio nominis* : Leaf-form resembling the typical *Pterophyllum aequale* known from Europe but usually smaller in size.

*Diagnosis* : Leaf petiolate. Lamina elongate-oval or elongate-oblongate in outline, up to 10 cm long and 3 cm wide at the widest portion, regularly segmented. Rachis thick, some attaining 4 mm wide, with longitudinal ridges on its surface, and rounded below. Petiole more than 1.2 cm long. (Very base unknown.) Pinnae consisting of 25—26 alternate pairs in fully developed leaf, varied in form and size according to the position of a leaf, attached perpendicularly to the lateral margins of rachis, but that angle of attachment becoming oblique towards the apex. Division between pinnae extending near to or up to the rachis. Pinnae on the distal two-thirds of a leaf elongate-rectangular in form, typical ones being 1.0—1.4 cm long and 3—3.5 mm wide; apex obliquely truncated or asymmetrically rounded. Pinnae on the basal one-third of a leaf short-rectangular, nearly square or sometimes deltoid; distal margin truncated or rounded. Veins parallel, numbering 8—13 at the base of each pinna, about half of them forking once near the base, but others simple. Terminal pair of pinnae abruptly diminishing their size. (Cuticle not preserved. Reproductive organs not known.)

*Distribution and occurrence* : Leaf-fragments are quite abundant, especially in several horizons of the Nampo Group and Bansong Group in the Mungyeong Coal-Field. They are also known from the Kimpo Group.

*Discussion and comparison*: *Pterophyllum micraequale* is characterized by its small-sized leaf with quadri-lateral pinnae bearing simple or once forked veins, numbering 8—13 at each base.

Those leaves which have been reported as *Pterophyllum aequale* (Brongniart) Nathorst from

Europe (e. g. Nathorst, 1878a, b; Antevs, 1919; Johansson, 1922) and from other regions (e. g. Zeiller, 1902—3; Stanislavsky, 1971; Iminov, 1976) resemble those of *P. micraequale* in the pinna form, but the former differs especially in the leaf-size being twice as large as those of *P. micraequale*.

The leaf-size of *Pterophyllum micraequale* is less than 10 cm in length and 3 cm in width.

*Pterophyllum (Anomozamites) schenki* described by Zeiller (1886, 1902—3) and reported by many subsequent authors resembles *P. micraequale* in leaf-form and vein-density, but the former differs in its large-sized leaf attaining 20—30 cm in length and 5—12 cm in width.

According to Harris (1937), the leaf-cuticle of Johansson's *Pterophyllum aequale* agree with that of *P. schenki* from Greenland. Furthermore, Lundblad (1950) instituted *Pterophyllum compressum* on the basis of the Swedish material, and included in its synonymy most Swedish *Pterophyllum* leaves which had been regarded as *P. aequale* and *P. affine* as well as Greenland leaves which were reported as *P. schenki*. At any rate, *Pterophyllum micraequale* is distinguished from these European species by its small-sized leaves.

Leaf-fragments of *Pterophyllum micraequale* are locally quite abundant, often thickly massed and appressed to form singly a distinct fossil population. However, its leaves are sometimes associated with those of *Coreanophyllum variisegmentum* in some sparsely fossiliferous horizons.

*Pterophyllum micraequale* is distinguished from *Coreanophyllum variisegmentum* by the following features: 1) The lamina of a full-grown leaf of *Pterophyllum micraequale* is divided into 25—26 alternate pairs of segments (or pinnae), whereas that number in *Coreanophyllum variisegmentum*

← **Figures 9(e—o)**. *Pterophyllum micraequale* Kimura et Kim, sp. nov.: Natural size unless otherwise indicated. **9e**. Occurrence of this species (Reg. no. 81-033). Loc. Hanaeri. **9f**. Drawn from **9c**. **9g** and **9i**. Drawn from **9a** (**9i**; Holotype). **9g'**. Venation drawn partly from **9g**. **9h**. Drawn from **9b**. **9i**. A typical leaf (paratype, Reg. no. 81-293-1). Loc. Hanaeri. **9i'**. Venation drawn partly from **9i**. **9j**. Leaf apex (Reg. no. A-5001). Loc. Seongjuri. **9k**. A small-sized leaf with preserved petiole (Reg. no. T-0020). Loc. Cheondaeri. **9m**. Basal part of a broken leaf (paratype; Reg. no. 81-293-4). Loc. Hanaeri. **9m'**. Venation drawn partly from **9m**. **9n**. Basal part of a leaf with a thick rachis (paratype; Reg. no. 81-203Z). Loc. Hanaeri. **9n'**. Venation drawn partly from **9n**. **9o**. Basal part of a leaf (paratype; Reg. no. 81-293-2). Loc. Hanaeri.

comes to 54—55. 2) The rachis of *P. micraequale* is ornamented by several longitudinal striations on its basal upper surface and is usually thicker than the pinna axis of *C. variisegmentum* with a median furrow above. 3) The pinnae of *P. micraequale* are broader and typically quadri-lateral in form with a truncated apex, while those of *C. variisegmentum* are narrower and typically possess a rounded or obtusely pointed apex, although they are variable in form depending upon the position of penultimate pinna. 4) Veins at the base of each pinna are denser in *P. micraequale* (8—13) than in *C. variisegmentum* (3—6). 5) The penultimate pinna fragments of *C. variisegmentum* are also locally quite abundant, often thickly massed and appressed to form a monospecific fossil population like that of *P. micraequale*. It would be worthy to note that in monospecific population of *C. variisegmentum*, no *P. micraequale* leaf has so far been recognized and that the same is true for the population consisting singly of *P. micraequale*. Therefore, we consider both species to be distinct from each other and each species is thought to have maintained its own exclusive community. It is, however, difficult to distinguish these two species solely on the basis of small leaf- or pinna-fragments in which veins are invisible.

In Japan and China, many bennettitalean leaf-fragments have been described under the name of *Pterophyllum aequale*. However, we now consider

most of them to be not referable to *P. aequale*, because they are far smaller in size than the leaves identified as *P. aequale* in Europe and Middle Asia. Among them, fossil plants in the following records are similar in size, form and venation to *Pterophyllum micraequale*:

- Yabe and Oishi, 1929, p. 93, pl. 18, fig. 4, pl. 20, fig. 3: Upper Triassic Anyuan Formation, Jiangxi, China.  
 Sze, 1931, p. 11, pl. 2, fig. 5; Hsü in Sze and Hsü, 1954, p. 57, pl. 50, fig. 5: The same as the above.  
 Sze, 1933a, p. 20, pl. 4, figs. 2—7: Upper Triassic Xujiahe Formation, Sichuan, China.  
 Oishi and Huzioka, 1938, p. 85, pl. 10, fig. 4, 4a; Oishi, 1940, p. 339: Upper Triassic Nariwa Group: Somewhat larger in leaf-size.  
 Sze *et al.*, 1963, p. 152, pl. 60, figs. 5—6, pl. 69, figs. 7—8, 8a, pl. 71, fig. 9: Upper Triassic and Lower Jurassic of Sichuan and Guangdong: Leaf base is markedly swollen.  
 Li *et al.*, 1976, p. 118, pl. 33, figs. 8—10: Upper Triassic of Yunnan: Veins in each pinna denser, 16—20 in number.  
 Zhou, 1978, p. 108, pl. 21, fig. 5: Upper Triassic Wenbinshan Formation, Fujian (non his pl. 21, fig. 6).

*Pterophyllum micraequale* resembles *P. nathorsti* described by Schenk (1883) from China, but the former is distinguished by its typically quadri-lateral pinnae with a truncated apex. *Pterophyllum nathorsti* has pinnae formed of narrower segments with a rounded apex.

(To be continued)

**868. GROWTH OF ANTLER IN THE SUBGENUS *SIKA*  
(CERVID, MAMMAL) FROM THE PLEISTOCENE FORMATION  
IN THE SETO INLAND SEA, WEST JAPAN\***

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**Abstract.** This paper presents the results of a paleontological study of fossil antlers of the Pleistocene *Sika*-deer collected together with numerous specimens of Naumann's elephant (*Palaeoloxodon naumanni*) and many kinds of herbivorous mammals from the Bisan-seto area, of the Seto Inland Sea, West Japan. To determine the tempo and mode of forking of fossil antlers, corresponding aspects of living Japanese deer were examined in detail, based on individuals whose ages were determined by the cementum layers of the teeth. This study confirmed that several forms of antler which had been identified as belonging to four fossil species (*i.e.* *katokiyomasai*, *natsumei*, *paleoezoensis* and cf. *greyi* of the subgenus *Sika*) in previous studies, merely represent several different growth stages of a single subspecies of the subgenus *Sika*. The subspecies *Cervus (Sika) greyi katokiyomasai* Shikama and Hasegawa is selected as a valid name for the Pleistocene *Sika*-deer from the Seto Inland Sea examined here, according to the rules of zoological nomenclature. The forking in *C. greyi katokiyomasai* is, however, slighter and more slender than that of *C. greyi* throughout the course of life. *C. greyi katokiyomasai* flourished in the lowland area of West Japan as a characteristic island form in association with other endemic deer species descended from earlier migrants such as *Nipponicervus* and *Elaphurus*. *Cervus nippon yesoensis* of the Jomon Period of Early Holocene age might have derived from *C. greyi katokiyomasai* in Late Pleistocene time and become distributed throughout the Japanese Islands.

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**Introduction**

It is known that abundant mammalian fossils of Pleistocene age occur on the floor of the Seto Inland Sea, West Japan. These fossils are regarded as derived fossils which were washed out from Pleistocene formations flooring the sea bottom (Hasegawa, 1972; Otsuka and Shikama, 1977; Bando *et al.*, 1978). These mammalian fossils have been studied from a paleontological point of view by many authors (Makiyama, 1938; Matsumoto, 1924; Naora, 1970; Shikama, 1941; Hasegawa, 1972; Otsuka, 1977; Otsuka and Shikama, 1977). The fauna is mainly composed of elephants (such as the genus *Stegodon* and *Palaeoloxodon*),

buffalos (*Bison occidentalis*), and several kinds of Cervidae (including *Sinomegaceroidea*, *Elaphurus*, *Nipponicervus* and *Sika*). Among them, *Stegodon orientalis* was inferred to have derived from Early Pleistocene deposits, while the Naumann's elephant and other associated mammals are thought to have washed out from Middle to Late Pleistocene formations, called the Bisanseto Group (Bando *et al.*, 1978). The stratigraphic position of the mammalian fossils in this area will be discussed in the next section.

Hasegawa (1972) regarded Naumann's elephant and its associated fauna to be a part of the "*Palaeoloxodon — Sinomegaceroidea* Complex" which had a wide distribution in Middle to Late Pleistocene formations over the Japanese Islands (Hasegawa, 1972). Among the mammalian

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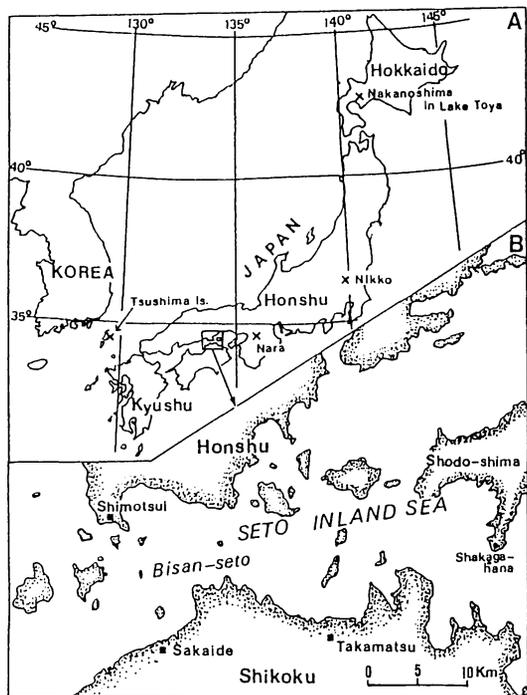


Figure 1. Localities of examined, living Japanese *Sika*-deer (A) and fossil *Sika*-deer in the Seto Inland Sea (B) in the Japanese Islands.

assemblages from the Seto Inland Sea, the deer assemblage is predominated by *Nipponicervus* and *Sika*, and is accompanied by a few species of *Sinomegacerooides* and *Elaphurus*. For this reason, the deer assemblage from this area may be called the *Sika-Nipponicervus* assemblage (Otsuka and Shikama, 1977). This assemblage is distributed over nearly the entire area of the Seto Inland Sea from the bay-mouth area of Osaka Bay to the vicinity of Hiroshima City.

*Cervus kazusensis* of early Early Pleistocene age is the first species of the subgenus *Nipponicervus* to appear in northeastern Asia and subsequently spread from central to western Japan during Middle and Late Pleistocene times (Otsuka and Shikama, 1977). Continuous change in the antler morphology can be observed from the Early Pleistocene species, *Cervus (Nipponicervus) kazusensis* to the Middle to Late Pleistocene species, *Cervus (Nipponicervus) prae nipponicus*. These two species of *Nipponicervus* occur in the same frequency from the Seto Inland Sea.

Therefore, the *Sika-Nipponicervus* assemblage in the Seto Inland Sea seems to represent a transition period from *C. kazusensis* to *C. prae nipponicus*. To date, the following species belonging to the subgenus *Sika* have been recorded from the Seto Inland Sea.

1. *Cervus (Sika) yesoensis* Heude (Shikama, 1941)
2. *Cervus (Sika) nippon nippon* Temminck (Shikama, 1941)
3. *Cervus (Sika) cf. hortulorum* Swinhoei (Naora, 1970)
4. *Cervus (Sika) katokiyomasai* (Shikama and Hasegawa) (Shikama and Hasegawa, 1965; Otsuka, 1977)
5. *Cervus (Sika) natsumei* Matsumoto (Otsuka and Shikama, 1977)
6. *Cervus (Sika) cf. greyi* (Zdansky) (Otsuka and Shikama, 1977; Otsuka, 1977)
7. *Cervus (Sika) paleozoensis* Otsuka and Shikama (Otsuka and Shikama, 1977; Otsuka, 1977)

Among these species, the first three species were identified with the living species and their names were merely listed without any paleontological description, whereas the other species were proposed as new to science. The last three were described on the basis of abundant antler specimens in the Takao Collection, recovered from the sea bottom off Shodoshima (Otsuka and Shikama, 1977). However, a systematic relationship among these species remains unresolved.

Recently, I have had an opportunity to study many well-preserved fossil antler specimens of cervids in the "Yamamoto" collection, gathered from the Bisan-seto area about 38 km west of Shodoshima by Mr. Keiichi Yamamoto, a junior high school teacher. The collection includes abundant specimens of elephants from the same area (Otsuka, 1987).

Based on a statistical and comparative morphological analysis of the fossil antlers of *Sika* deer in the Yamamoto and Takao collections, I reached the conclusion that those fossil antlers, thought to represent the four species, *C. natsumei*, *C. cfr. greyi*, *C. paleozoensis* and *C. katokiyomasai*, represent different growth stages

of a single species. To demonstrate this, the antler growth of living Japanese Sika-deers such as; *Cervus (Sika) nippon yesoensis*, *Cervus (Sika) nippon centralis* and *Cervus (Sika) pulchellus*; has been examined in detail. The ages of the animals were determined by the cementum layers of their teeth by using Mitchell's method (1963). These growth data clearly indicate that those several forms of antlers previously identified with four fossil species (*katokiyomasai*, *natsumei*, *paleoezoensis* and cfr. *greyi*) are merely different growth stages of antler of a single subspecies. A valid name to represent the fossil Sika-deers examined here is the subspecies name "*greyi katokiyomasai*". The antler of this subspecies in the mature stage is characterized by a very wide angle in the first forking with a much lyrated beam. This mode of forking resembles that of *Cervus (Sika) greyi* Zdansky in the Middle Pleistocene Choukoutien Fauna of North China, but the Japanese subspecies has a somewhat smaller and more slender antler. *C. (Sika) greyi katokiyomasai* is probably derived from *C. (S.) greyi* during the early Middle Pleistocene when the latter species migrated to the Japanese Islands from the Asian Continent. The subspecies flourished in the lowland area in association with such mammals of the forest habitat as Naumann's elephant and other endemic deers including *Elaphurus* and *Nipponicervus*.

### Descriptive terms of antler

In this paper, descriptive terms and measurements of antler of the genus *Sika* follow those proposed by Otsuka and Shikama (1976) (Fig. 2).

- WL: Whole length of antler
- PL: Minimum length of pedicle measured along the posterior border
- PD: Minimum width of pedicle
- BD: Side-to-side diameter of burr
- LT1: Length of the first tine measured along its inner surface from the base of the fork to its tip.
- LT2: Length of the second tine measured along its inner surface from the second fork to its tip
- LT3: Length of the third tine, measured as in LT1 and LT2
- LB1: Length of the beam between the bases of the first and the second forks

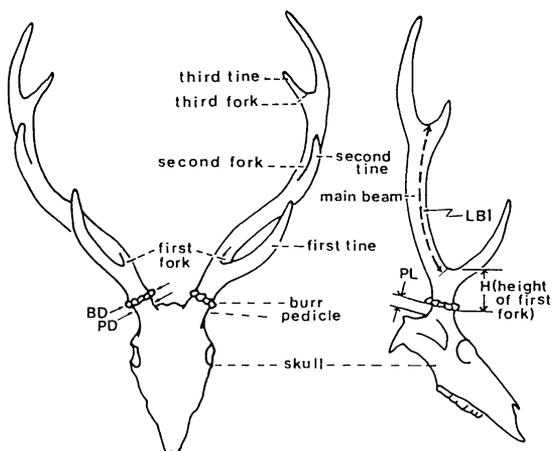


Figure 2. Terminology for antler of the subgenus *Sika*.

- LB2: Length of the beam between the bases of the second to the third forks
- $\alpha 1$ : Angle of the first fork
- $\alpha 2$ : Angle of the second fork
- $\alpha 3$ : Angle of the third fork
- H: Height of the first fork measured from the base of the burr to the uppermost surface of the "webb"
- DF1: Distance between inner surfaces of the base of the first forking of opposed antler
- DF2: Ditto between the second forking
- DF3: Ditto between the third forking

### Growth of antler in the living Japanese Sika

#### 1. Materials

The specimens used to study the growth of antler of living Japanese Sika-deer are listed below. The specimens of antler, with skull attached, were borrowed from a number of universities and museums in Japan.

By using Mitchell's method (1967); Noriyuki Ohtaishi, Hiroko Koike, and Mitsuharu Matsumoto; estimated the ages of these specimens from the cementum layers of the teeth.

#### 2. Results

To determine the tempo and mode of forking of antlers in life, the diameter of the burr (BD), the diameter and length of the pedicle (PD, PL), the whole length of the antler (WL), the length of the beam between the first and the second forks (LB1) and the rate of lateral expansion of antler (DF1, DF2, DF3) were investigated.

Laboratory	Specific Name	Number of specimens	Locality
Dept. of Anatomy, Hokkaido Univ.	<i>C. nippon yesoensis</i>	15	Nakanoshima in Lake Toya, Hokkaido
	<i>C. nippon centralis</i>	11	Nara park
	<i>C. pulchellus</i>	11	Tsushima Is.
Tochigi Prefectural Museum	<i>C. nippon centralis</i>	13	Nikko area
Lab. of Verterinary Medicine, Kagoshima Univ.	<i>C. pulchellus</i>	22	Tsushima Is.

1) Pedicle Index. Usually, deer antler is shed annually. When shedding occurs, a thin layer from the topmost part of the pedicle adheres to the antler and is removed, causing the pedicle to become shorted with every shedding. As the same time the pedicle diameter broadens continuously with growth. Therefore, it can be stated that a male with a long narrow pedicle is younger than one bearing a short broad pedicle. For those specimens treated in the present study, the pedicle widths of *C. nippon yesoensis*, *C. nippon centralis* and *C. pulchellus* broaden continuously with age, increasing from 2.5 to 3.0 mm per year in width, while shortening at a rate ranging from 1.0 to 1.2 mm per year in *C. nippon centralis* and *C. nippon pulchellus*, and 1.0 to 3.0 mm per year in *C. nippon yesoensis*. Consequently, it can be assumed that deers shedding larger antlers such as *C. nippon yesoensis* tend to break larger pieces from the top of the pedicle than those shedding rather smaller antlers, such as *C. nippon centralis* in Nara.

To determine an approximate age of male deer, a "Pedicle Index" is proposed. It is defined as [the ratio between the diameter of pedicle (PD) and the length of pedicle (PL)]  $\times 100$ . As shown in Fig. 3, values of this index increase with the age of animal. An index value of 100 represents 2.5 years of age in *C. nippon yesoensis*, and about 3.5 years of age in *C. nippon centralis* in Nikko and *C. pulchellus*. An Index value of 200 represents about 9 years of age in *C. nippon yesoensis*, 10 to 13 years of age in *C. pulchellus* and 14 years of age in *C.*

*nippon centralis*. Thus, the pedicle index seems to be a useful method to estimate the age of deer in a single population using antlers. In this study, this method was applied to estimate the age of fossil deer from the Seto Inland Sea which will be discussed in the next section.

2) Diameter of Burr (Figs. 4, 5). In *C. nippon yesoensis*, the burr increases in width from a yearling to adult of eight years in age at a rate of about 4.8 mm per year, then after eight years old it increases at only about 3.0 mm per year, and finally settles at the rate of a seven year old animals.

In the case of *C. nippon centralis* from Nikko and *C. pulchellus*, for yearlings to eight year old animals the burr diameter increases at an average rate of 3.3 mm per year. Although antlers of five to ten year old adult *C. nippon centralis* from Nara were not examined, they seem to show the same tendency as those of *C. pulchellus* (Fig. 5).

3) Length of Antler (Figs. 4, 5). The antlers of both *C. nippon yesoensis* and *C. pulchellus* have a maximum length (WL) at the age of seven; for instance, the three-forked antler is 720 mm long in *C. nippon yesoensis* and 520 mm long in *C. pulchellus*.

The length of the beam between the first and the second forks (LB1) in *C. nippon yesoensis* has a maximum value at the age of seven and it is about 2.5 times its length at two years. For juveniles, from four to five, this length varies considerably, as much as 130 mm, which is the largest

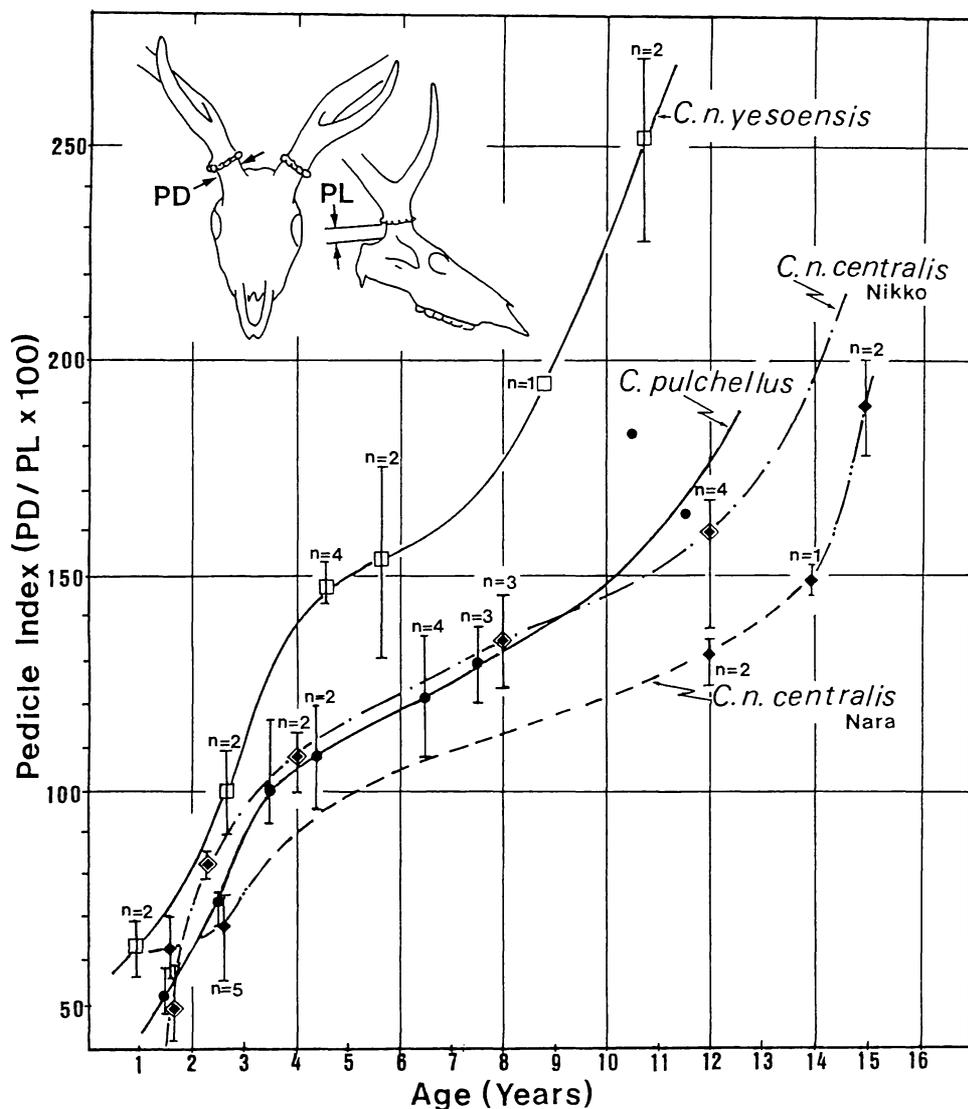


Figure 3. Relationships between the Pedicle index (PD) and the age (years) of living Japanese Sika-deer.

variation found during the life cycle. In *C. pulchellus*, this length shows a considerable variation before the age of seven (the prime of life) and the maximum value is reached in animals from seven to ten years old (Fig. 6). In *C. nippon centralis* from Nikko, this length increases in value until eight years of age, but animals older than ten years have almost the same value as for those of eight years of age.

4) Height of the First Forking. In *C. nippon*

*yesoensis* and *C. pulchellus*, the height of the first fork increases at a rate of 8 mm per year until the age of six years. The height is almost constant from six to eight years and after nine years it gradually decreases, eventually reaching the value of a four or five year old. Growth of the height of the first fork of *C. nippon centralis* from the Nikko and Nara areas shows a similar tendency as those of *nippon yesoensis* and *pulchellus*.

5) Angle of the First Forking (Figs. 6, 7).

In *C. pulchellus*, the angle of the first forking in specimens from two to six years of age ranges from 55 to 85 degrees; from six to nine years of age, the range is from 65 to 80 degrees; and after ten years of age, it is less than 65 degrees.

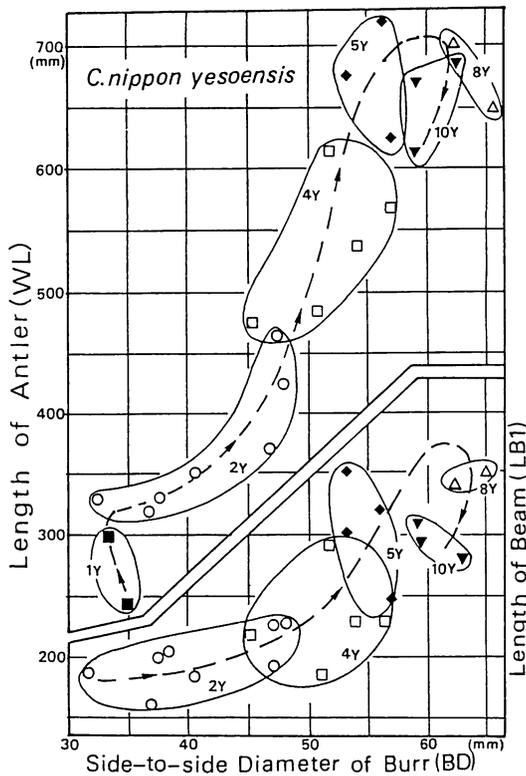
The same angle for males of *C. nippon yesoensis* younger than eight years shows a small variation ranging from 65 to 75 degrees; for those older than eight it tends to decrease. Finally, deer older than ten years of age tend to have narrow fork angles nearly equal to young males of about five. The growth pattern of *C. nippon centralis* shows a similar tendency as that of *C. pulchellus*.

6) Lateral Expansion of Antlers. To understand the growth related changes in the mode of lateral expansion of antlers, the distance between the forking points of opposite sides (DF1, DF2) was

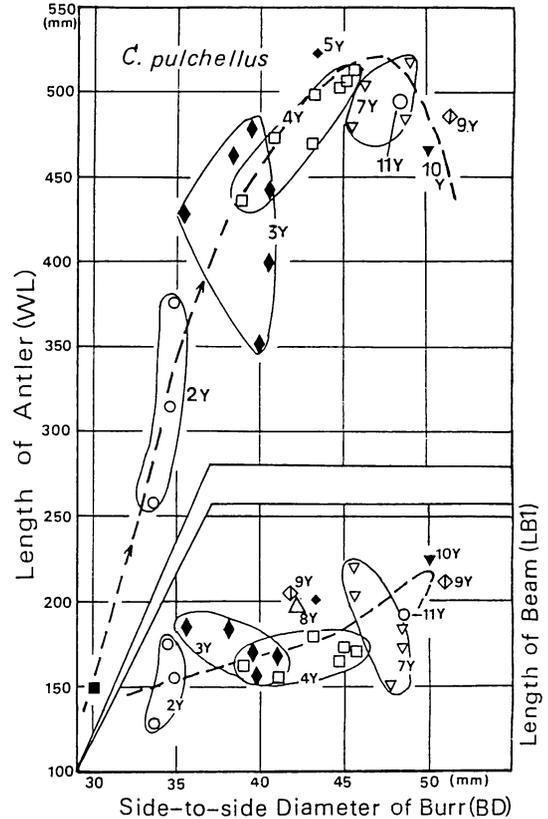
examined. In *C. nippon yesoensis*, the distance between the first forking points (DF1) increases gradually at a rate of about 3 mm per year until eight years; thereafter it increases more slowly, equal to that of a four or five year old. In the young of *C. pulchellus*, this distance increases slowly. After nine years of age, the distance tends to decrease.

In *C. nippon yesoensis*, the distance between the second forking points (DF1) at the juvenile stage, from yearling to three years old, increases at a rate of 130 mm per year, and thereafter at a rate ranging from 50 to 60 mm per year until eight years of age. After eight years, however, the increase is only about 42 mm per year, a rate nearly the same as that of four or five years old.

In *C. pulchellus*, the distance between the



**Figure 4.** Relationships between side-to-side diameters of the burr (DB) and whole length of antler (WL) (upper), and between side-to-side diameter of the burr and length of the beam (LB1) (lower), of living *Cervus (Sika) nippon yesoensis* Heude, collected from the Nakanoshima in Lake Toya, Hokkaido.

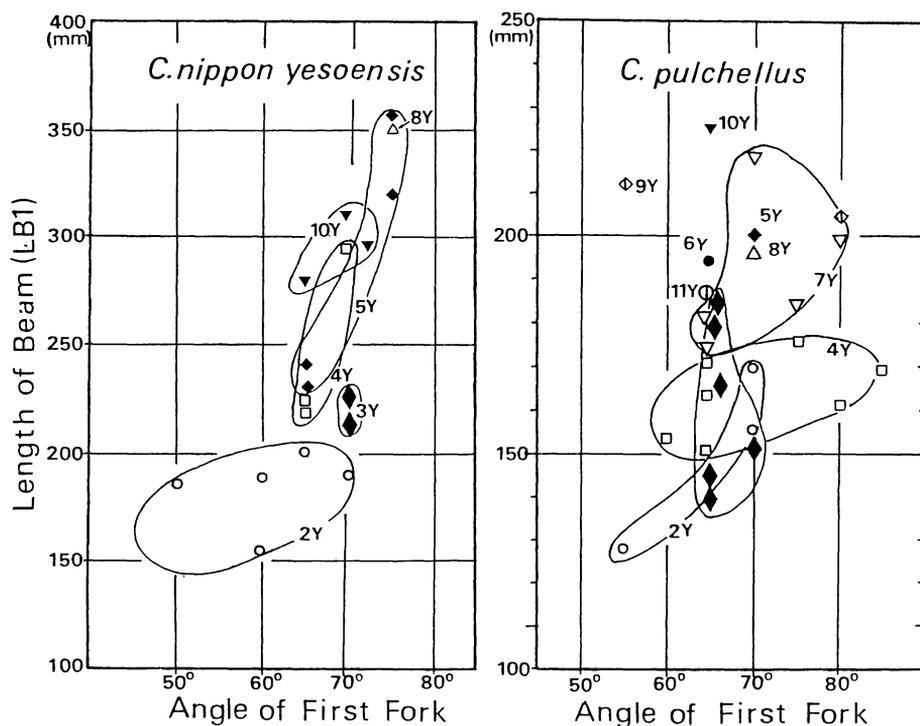


**Figure 5.** Relationships between side-to-side diameter of burr (DB) and length of the antler (WL) (upper), and between side-to-side diameter of burr and length of the beam (LB1) (lower) of *Cervus (Sika) pulchellus* Imaizumi from Tsushima Island.

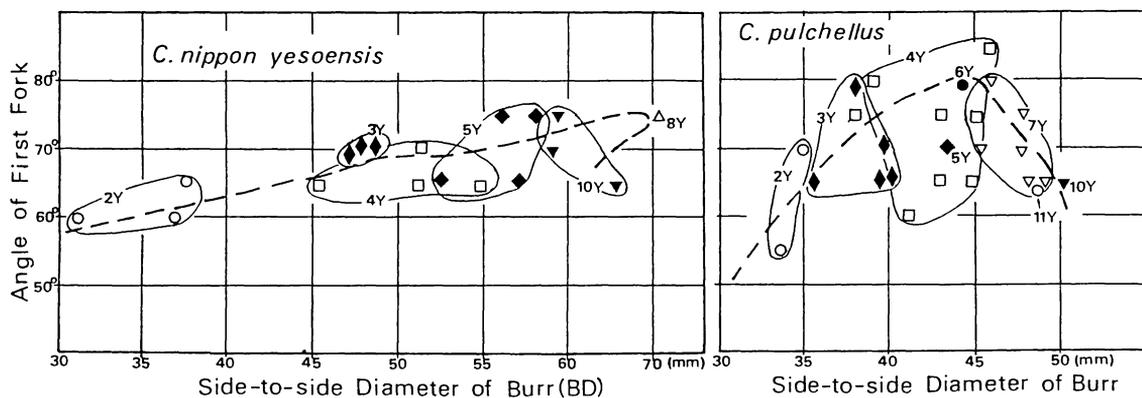
second forking points (DF2) increases at a rate of 120 mm per year until the age of three years. For the young males of from four to eight years old, this distance increases irregularly. After eight years of age, however, the rate tends to decrease.

The rate of expansion of the antler of *C. nippon centralis* from Nikko resembles that of *C. nippon yesoensis* but it is smaller. That of *C. pulchellus* is similar to *C. nippon centralis* with growth.

From these data, it is concluded that the antler



**Figure 6.** Relationship between the angle of the first fork ( $\alpha$  1) and the length of the beam (LB1) in living Japanese Sika-deer, *Cervus nippon yesoensis* Heude (left) and *Cervus pulchellus* Imaizumi (right).



**Figure 7.** Relationship between the angle of the first fork ( $\alpha$  1) and side-to-side diameter of the burr (DB) of living Japanese Sika-deer, *Cervus nippon yesoensis* Heude (left) and *Cervus pulchellus* Imaizumi (right).

of *Sika*-deer shows a gradual increase in its total length, angle of the first forking, and antler diversion until about eight years of age is reached. Thereafter, all these values tend to decrease eventually equalling those of four or five years old. This may imply a low metabolic rate of older *Sika*-deer.

### Morphology and systematic position of the fossil *Sika*-deer from the Seto Inland Sea

Order Artiodactyla

Family Cervidae Gray, 1821

Genus *Cervus* Linnaeus, 1785

Subgenus *Sika* Sclatter, 1870

Type-species.— *Cervus nippon* Temminck, 1873

*Cervus (Sika) greyi* Zdansky subsp.

*katokiyomasai* Shikama and Hasegawa, 1965

Figures 14—16

cfr. *Pseudaxis greyi* Zdansky, Zdansky, 1925, *Pal. Sinica*, ser. C, vol. 2, fasc. 3, p. 65—72, pl. 13, figs. 2—12.

*Cervus (Pseudaxis) greyi* Zdansky, Teilhard de Chardin and Pei, 1941, *Ibid.*, N.S. ser. C, no. 11, p. 76—80, pl. 2, fig. 3.

*Pseudaxis greyi* var., Young, 1923, *Ibid.*, ser. C, vol. 8, fasc. 2, p. 21—37.

*Cervus* cf. *greyi* Zdansky var. *etva* Teilhard de Chardin, Teilhard de Chardin, 1936, *Ibid.*, ser. C, vol. 7, fasc. 4, p. 39—42.

*Cervus (Sika)* cf. *greyi* (Zdansky), Otsuka and Shikama, 1976, *Bull. Nat. Sci. Mus.*, ser. C, *Geol., Paleont.*, vol. 12, no. 3, p. 1—40; Otsuka, 1977, *Rep. Fac. Sci. Kagoshima Univ.*, (*Earth Sci., Biol.*), no. 10, p. 47—48.

*Cervus (Rucervus?) katokiyomasai* Shikama and Hasegawa, 1965, *Sci. Rep. Yokohama Nat. Univ.*, ser. 2, no. 12, p. 45—47; Otsuka, 1977, *Rep. Fac. Sci. Kagoshima Univ.*, no. 10, p. 48—51.

*Cervus (Sika) natsumei* Matsumoto, Otsuka and Shikama, 1977, *Bull. Natn. Sci. Mus.*, ser. C (*Geol., Paleont.*), vol. 3, no. 1, p. 17—19, pl. 1, figs. 4—7.

*Cervus (Sika) paleoezoensis* Otsuka and Shikama, 1977, *Ibid.*, vol. 3, no. 1, p. 19—24, pl. 2, figs. 2, pl. 2, figs. 1—12.

*Type specimen*: Right, shed immature antler stored in the Department of Geology, Kumamoto University. A plaster cast of the type specimen is kept in the National Science Museum, Tokyo (NSM Reg. No. 6586) and in Kagoshima Univer-

sity (ESK Reg. No. F-6052).

*Referred specimens*: 107 antler specimens including 80 shed antlers are treated; 65 of the specimens are right antlers and 42 specimens are left antlers. These specimens were collected from the sea bottom in several areas of the Seto Inland Sea, and are kept in the National Science Museum of Tokyo (Takao Collection) and the Natural Science Museum of Kurashiki City (Yamamoto Collection).

*Collection localities*: The Bisan-seto area of the Seto Inland Sea and off Shodosima Island, in the eastern part of the Seto Inland Sea.

*Horizon*: The exact horizon is uncertain, but many field data suggest that the deer fossils were washed out from the Late Pleistocene Tsuchino-seto Formation (Mindel/Riss interglacia — Riss glacial age).

*Subspecific diagnosis*: *Sika*-deer bearing a medium to large antler, showing a great morphological variation in life. The antler in the adult stage is characterized by a much lyrated beam with a long first tine and general form somewhat resembling that of the subgenus *Rucervus*, but the antler of the young stage has almost the same shape as that of many other species of the subgenus *Sika*.

*Remarks*: Among the 195 antler specimens of *Sika*-deer from the Bisan-seto sea and area off Shodosima Island, 31 specimens (about 16%) are non-shed antler bearing a pedicle. Specimens retaining the portion between the burr and second forking point make up less than 12 percent of the total and most of the remaining specimens have lost the upper part of the antler. Although these antler specimens are imperfectly preserved, statistical analyses of the antler population strongly suggest that they belong to a single species that shows a large morphological variation in its growth pattern.

Furthermore, there is a strong possibility that several forms of antler previously reported from the Seto Inland Sea under such different specific names as *katokiyomasai* (Shikama and Hasegawa, 1965; Otsuka, 1977), *natsumei*, cf. *greyi* and *paleoezoensis* (Otsuka and Shikama, 1977; Otsuka, 1977), represent different growth stages of a single species. To prove this hypothesis, the following

points regarding various characteristic of antlers were examined.

1. Age of the fossil antler of *Sika* from the Seto Inland Sea (estimation based on Pedicle Index).

1) Non-shed antler

For the 29 non-shed antler specimens, the maximum length (PL) and minimum width (PD) of pedicle were measured and each of the pedicle indices was calculated. The indices for each antler specimen were compared with those of living Japanese deer (*C. nippon yesoensis*, *C. nippon centralis*, *C. pulchellus*) and the ages of the 29 fossil antler specimens were roughly estimated.

As already mentioned in the preceding section, the rate of shortening of the pedicle with age is five to eight percent larger in *C. nippon yesoensis* than in *C. nippon centralis* or *C. pulchellus*. Therefore, if the fossil antlers with pedicle attached are compared with those of *C. nippon yesoensis*, their ages are likely to be estimated as being two or three years younger than those for *C. nippon centralis* or *C. pulchellus*.

The fossil antlers of *Sika*-deer from the Seto Inland Sea are characterized as rather long and slender and their size nearly corresponds to that of *C. nippon centralis* or *pulchellus*. The shortening ratios of the pedicle of fossil aged deers to those of juveniles, for examples, are 0.54, 0.58 and 0.61. These values correspond to those for a 12 to 13 year old *C. nippon centralis* and for a 10 to 11 year old *C. nippon yesoensis*. Accordingly, if the fossil antlers are compared with those of *C. nippon yesoensis*, age estimates are younger than those of *C. nippon centralis* or *C. pulchellus* by two or three years.

2) Shed antler

As already mentioned, the burr diameter of the antler in a single population seems to be a useful clue to the growth stage of antlers. To ascertain the age of a shed antler, the angle of the first fork and diameter of burr were plotted to show their relationship and are then compared with the non-shed antlers whose ages were estimated by the pedicle index (Fig. 10).

The general tendency shown in this figure resembles the curve of the morphological growth change of the antler of the living Japanese *Sika*-

deer shown in Fig. 7. In the case of *C. nippon centralis* and *C. pulchellus*, the curves rise convexly upward, showing the largest angle at six years of age.

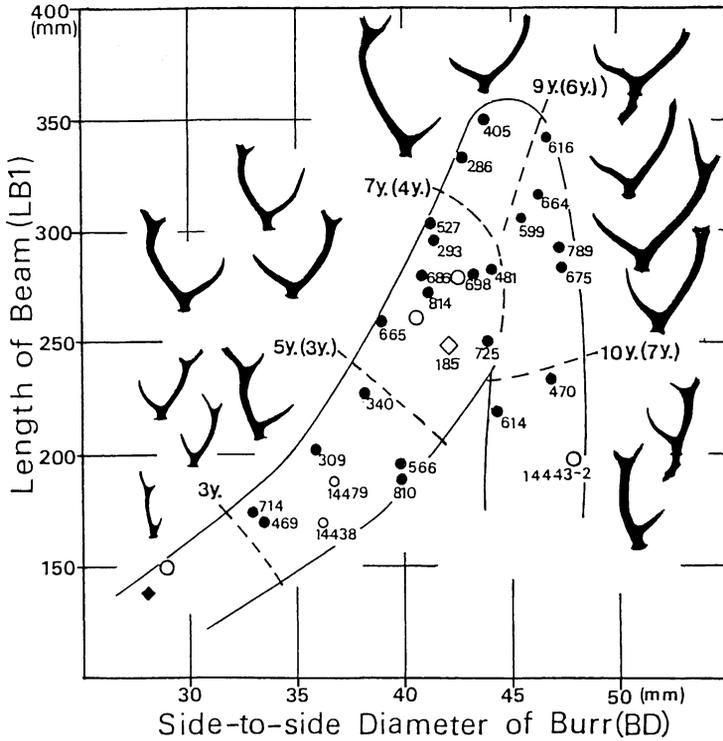
As stated earlier, antlers of *Sika*-deer from the Seto Inland Sea are herein regarded as those of a single subspecies *Cervus (Sika) greyi katokiyomasai* (Shikama and Hasegawa), representing growth stages of from two to eleven years based on the age data of living *Sika*-deer. Furthermore, this antler assemblage is roughly classified into six age-classes ranging from juvenile to adult males.

2. Changes in the beam length

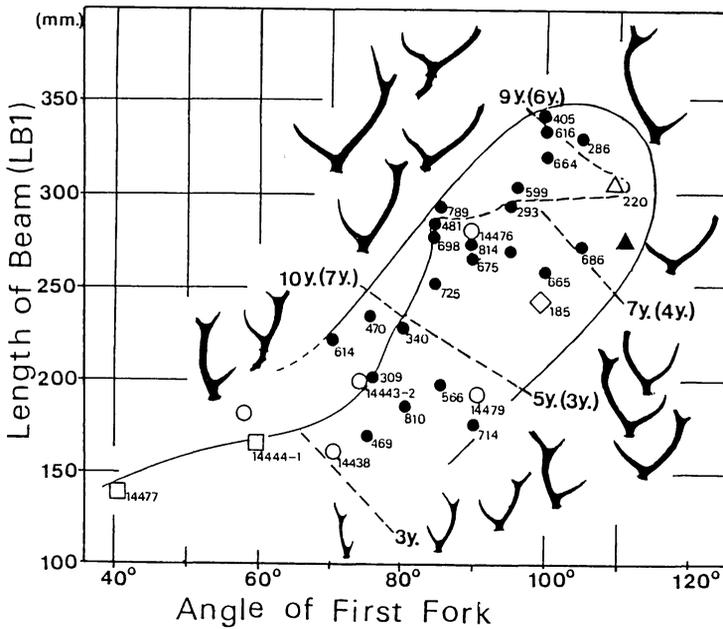
Fig. 9 shows the relationship between the beam length (LB1) and the diameter of burr, and Fig. 10 shows the relationship between beam length and the angle of the first fork of *C. (S.) greyi katokiyomasai*.

The rate of growth of the beam (LB1) of *C. (S.) greyi katokiyomasai* resembles more closely that of *C. nippon yesoensis* than *C. nippon centralis*. Namely, that of *C. greyi katokiyomasai* shows a rather wide variation of up to 200 mm for juvenile to senescence. This value is almost equivalent to that of *C. nippon yesoensis*, but is larger than that of both *C. nippon centralis* and *C. pulchellus*. In *C. greyi katokiyomasai*, the beam lengths between the first and the second forks (LB1) from the ages of seven to nine, age estimated based on living *C. nippon centralis* and *C. pulchellus* (or from four to six years based on *C. nippon yesoensis*) are almost 1.5 times longer than juveniles under five (three) years old. Hereafter all age estimates are given twice, the first time is based on *C. nippon centralis* and *C. pulchellus* and the second, in parentheses, is based on *C. nippon yesoensis*. Adult males, older than ten (seven), have stunted antler corresponding in size to those of five (three) year old individuals. Thus, the beam length of *C. greyi katokiyomasai* in life resembles that of *C. nippon yesoensis*, however, their burr diameter at eight years of age does not exceed 50 mm and equals that of the young stage of *C. nippon yesoensis* under four years of age.

3. On the re-examination of previously recorded species on the subgenus *Sika* from the Seto Inland Sea



**Figure 8.** Relationship between the length of the beam (LB1) and side-to-side diameter of burr (DB) of *Cervus greyi katokiyomasai* Shikama and Hasegawa from the Seto Inland Sea.



**Figure 9.** Relationship between the length of beam (LB1) and the angle of the first fork ( $\alpha 1$ ) of *Cervus greyi katokiyomasai* Shikama and Hasegawa from the Seto Inland Sea.

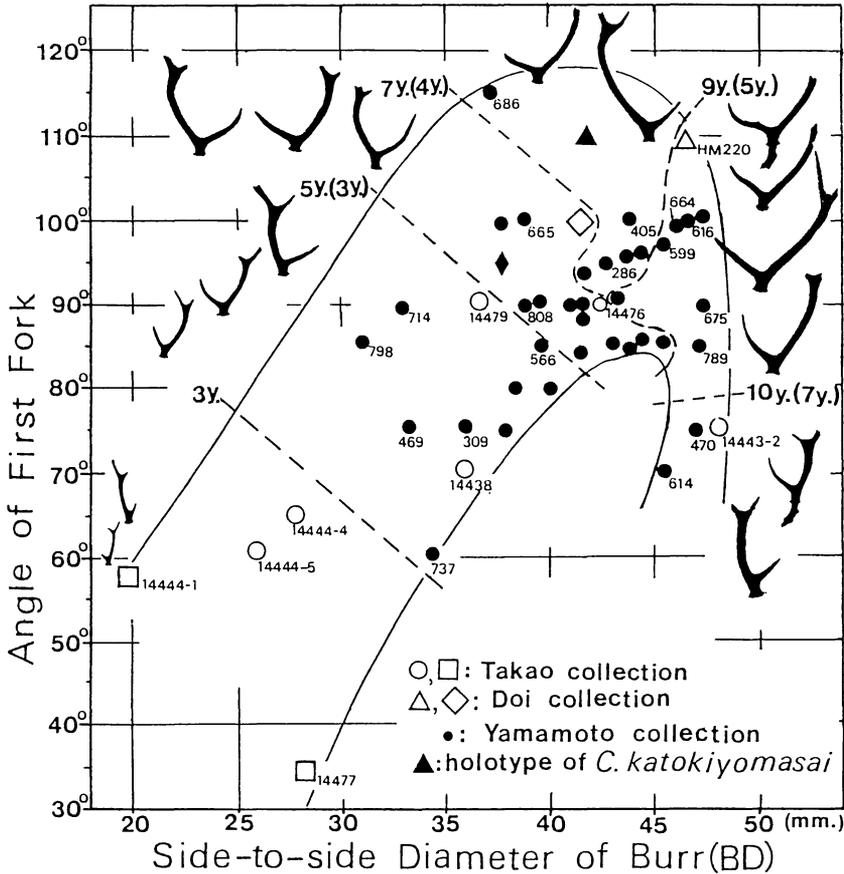


Figure 10. Relationship between the angle of the first fork ( $\alpha$ ) and side-to-side diameters of burr (DB) of *Cervus greyi katokiyomasai* Shikama and Hasegawa from the Seto Inland Sea.

The dimensions of the antlers which had previously been identified as the species *katokiyomasai*, cf. *greyi*, *natsumei*, and *paleoezoensis* are plotted in Figs. 8 to 10. As far as these data are concerned, the type and referred specimens of these species probably represent several growth stages of a single species.

*Cervus (Sika) natsumei* Matsumoto (Otsuka and Shikama, 1977) characterized by the triple-forked, small antler (NSM Reg. No. 14444-1, NSM Reg. No. 14477) is interpreted to come from a young deer comparable to that of the living Japanese *Sika*-deer under three years of age.

The antler specimens described under the name of *Cervus (Sika) paleoezoensis* Otsuka and Shikama (Otsuka and Shikama, 1977) include

antlers of various growth stages older than three (two) years of age. The holotype (NSM Reg. No. 14476) characterized by a long first tine and wide angle of the first forking represents antlers of mid-life individuals, ranging from five (three) to seven (four) years of age, while the paratype (Reg. No. NSM14443-2) characterized by a short beam and short but stout pedicle (pedicle index = 168) appears to correspond to that of an aged male of *C. nippon centralis* older than ten (seven) years.

The type specimen of *C. (?Rucervus) katokiyomasai* (Shikama and Hasegawa, 1965) is represented by a right, shed, incomplete antler of a young male lacking the upper half of the beam. Based on the diameter of burr and rather wide angles of the first fork, it is estimated to be middle

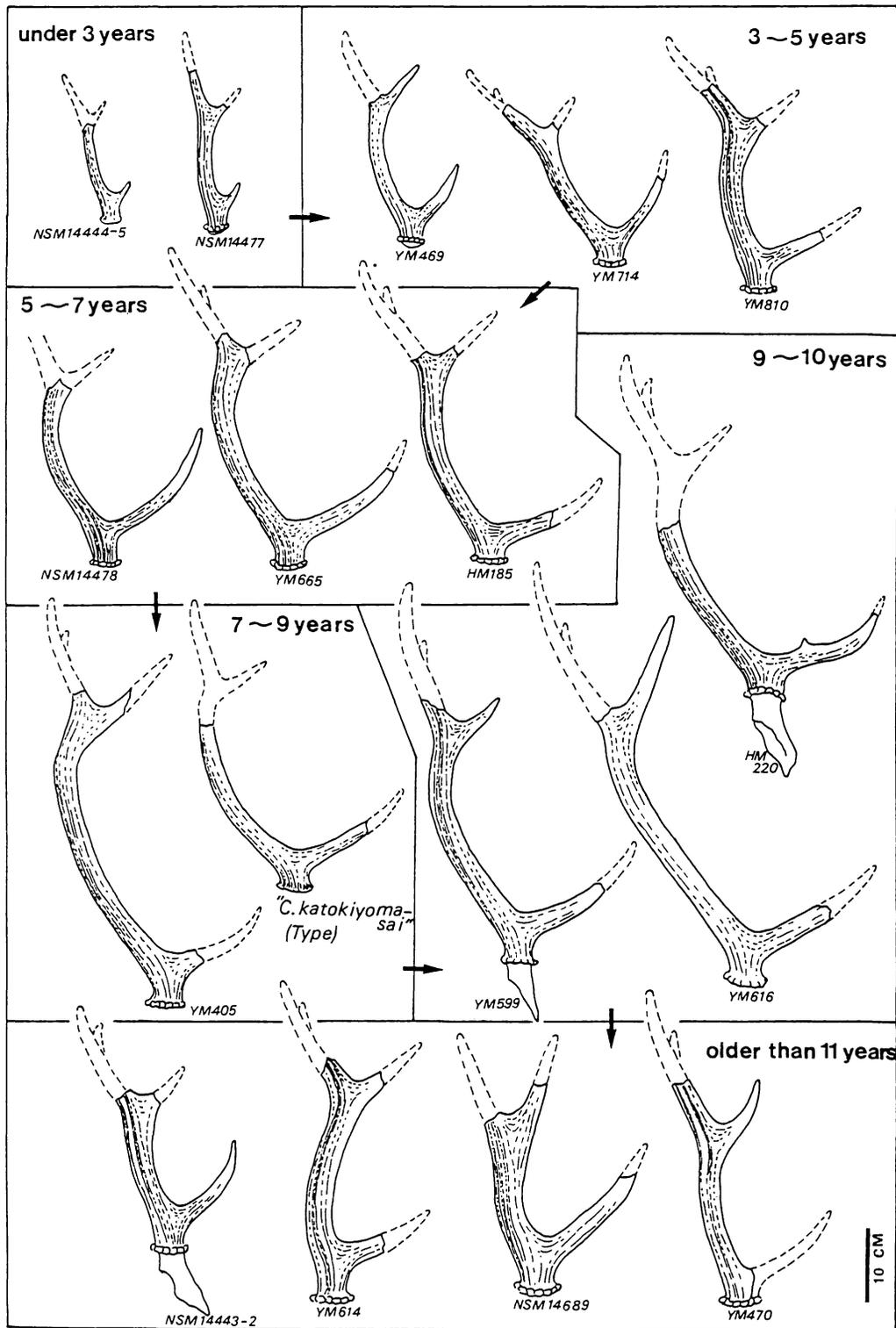


Figure 11. Growth series for antler of *Cervus (Sika) greyi katokiyomasai* Shikama and Hasegawa. Approximate ages of each antlers were estimated from data on living *Cervus nippon centralis* Kishida from the Nikko and Nara areas.

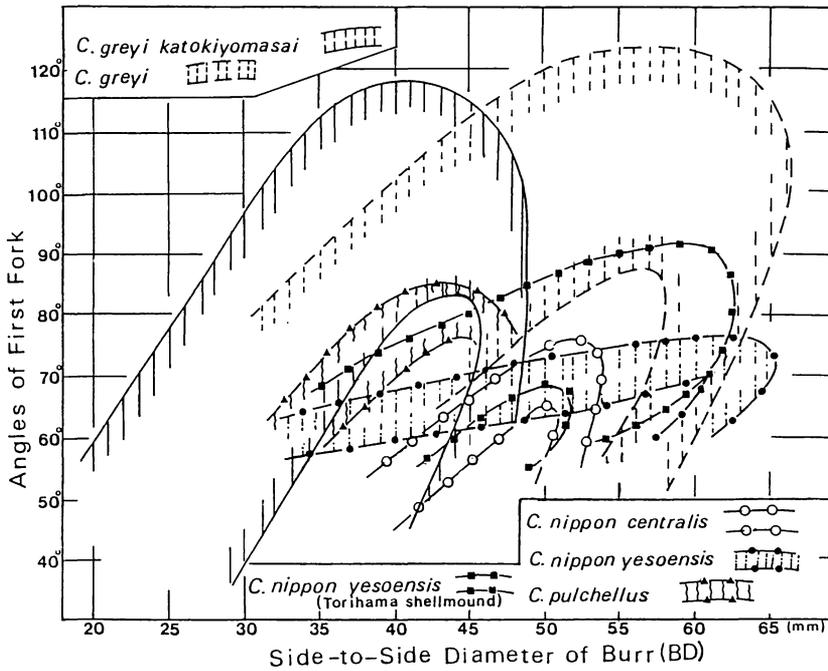


Figure 12. Relationship between the length of the beam (LBI) and side-to-side diameter of burr (BD) of living and fossil Sika-deer.

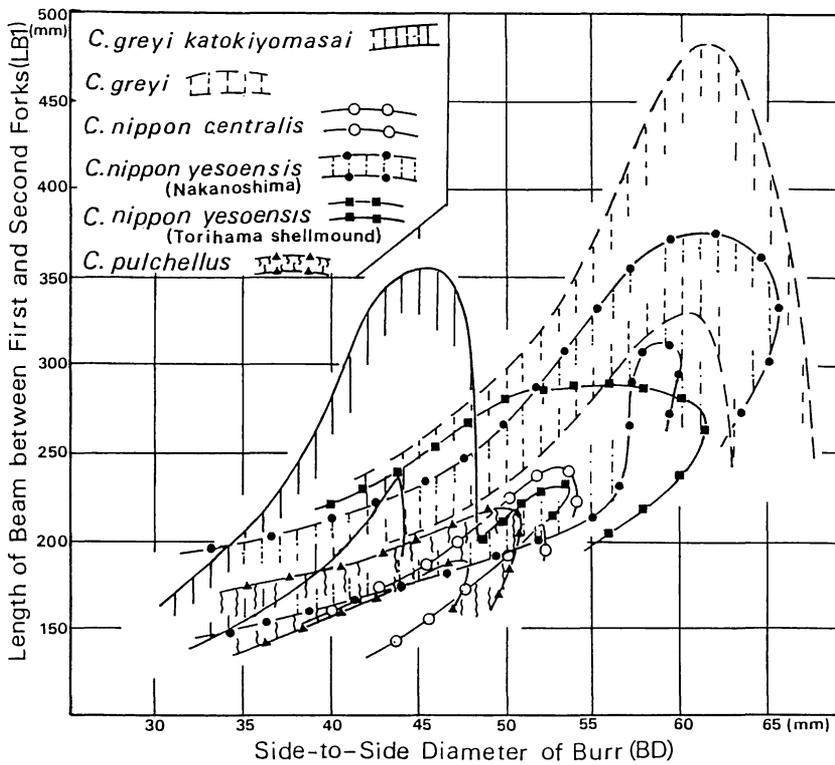


Figure 13. Relationship between the angle of the first fork ( $\alpha$ ) and side-to-side diameter of burr (BD) of the living- and fossil Sika-deer.



aged between seven (four) and nine (five) years old. Another, well-preserved antler of *C. katokiyomasai* was recovered from the sea bottom off Tomogashima and this specimen was included in the subgenus *Sika* (Otsuka, 1977). Judging from the pedicle index (Pd = 152), wide angle of the first forking, and the diameter of the burr, this antler specimen roughly corresponds to that of nine (five) year old *C. nippon centralis*.

*Cervus (Sika) cf. greyi*, described from the sea bottom off Shodoshima based on 33 incomplete antler specimens (Otsuka and Shikama, 1977), was considered to be one of the *Sika*-deers characterized by "triple-forked, small- or moderate-sized antler with short fore-tine and wide angles of the first forking". This species was, however, discriminated from *C. (S.) greyi* Zdansky, known in the Middle Pleistocene Choukoutien Fauna in North China, by having wider angles and a lower position of the first fork. Furthermore, it was regarded to be a species different from *C. (S.) paleozoensis* by its "wider angle of the first fork and rather short beam between the first and the second forks" (Otsuka and Shikama, 1977). So far as the present statistical analyses of abundant antler specimens from the Seto Inland Sea are concerned, most of these antler specimens of *C. cf. greyi* (Otsuka and Shikama, 1976) seem to represent antlers of middle-aged individuals probably between about four (three) and seven (four) years old based on comparisons with *C. nippon centralis* and *C. nippon yesoensis*.

These morphological characters of the fossil antlers as mentioned above strongly suggest that specimens identified as *katokiyomasai*, cf. *greyi*, *natsumei*, and *paleozoensis* do indeed represent several different growth stages of a single species of the subgenus *Sika*. Among these four species of *Sika*-deer reported from the Seto Inland Sea, *katokiyomasai* (Shikama and Hasegawa, 1965) is selected as a specific name based on the rules of zoological nomenclature. As will be discussed later,

*katokiyomasai* can be regarded as a subspecies of *C. (S.) greyi* Zdansky (Zdansky, 1925) known from China.

*Cervus greyi* (Zdansky) which is a representative fossil deer in China, is mostly known in the Middle Pleistocene Choukoutien Fauna. The type specimen of *C. greyi* (Zdansky, 1925) is represented by the basal part of a left antler with pedicle attached and is characterized by a much lyrated beam forming wide angles of more than 95 degrees with a long first tine. By the angles of the first forking and the diameter of the burr, this specimen is comparable to those of *C. nippon yesoensis* between five and seven years of age. This type specimen also resembles the antler of *C. greyi katokiyomasai* of the same age range, but differs slightly from the latter in its lower first forking. Furthermore, the antlers of *C. (Pseudaxis) greyi* (Zdansky) (Teilhard de Chardin and Pei, 1941) and *Pseudaxis greyi* var. *Zdansky* (Young, 1932) are comparable to those of the adult stage of *C. greyi*, probably older than eight years of age, on the basis of their pedicle indices. The antler of *Pseudaxis greyi* var. *elata* (Teilhard de Chardin, 1936; Teilhard de Chardin and Pei, 1941) is regarded as that belonging to aged *C. greyi* older than eleven years. This interpretation is supportive of a theory that many types of antler of *C. greyi* (s.s.) from Choukoutien do represent various growth stages of a single species.

#### 4. Comparisons and observations

On the whole, the Japanese endemic species, *C. greyi katokiyomasai*, is closely allied to *C. greyi* (s.s.) in its forking mode, but the antler of the former is more slender than the latter through its entire lifespan. For instance, the thickness of burr of *C. greyi katokiyomasai* at the prime age is about 15 mm smaller than that of *C. greyi* from China. Furthermore, it is inferred that *C. greyi katokiyomasai*, a representative species of the Middle Pleistocene island form, might have derived from *C. greyi* of China.

← **Figure 14.** Shed antlers of *Cervus greyi katokiyomasai* Shikama and Hasegawa. All figures are outer views, excepting 6,  $\times 0.3$ . Estimated ages of each antler are as follows: 1—3: under three years old; 4—8: three to five years of age; 9—11: five to seven years old. 1 (NSM Reg. No. 14444-5), 2 (NSM Reg. No. 14444-4), 3 (NSM Reg. No. 14477), 4 (NSM Reg. No. YM666), 5 (Reg. No. YM469), 6 (Reg. No. YM309), 7 (Reg. No. YM810), 8 (Reg. No. YM714), 9 (Reg. No. HM185), 10 (NSM Reg. No. 14476), 11 (Reg. No. YM665).



*Cervus (Sika) greyi katokiyomasai* is also allied to *Cervus harbinensis* excavated from the latest Pleistocene fluvial deposits at Ku-hsian-tung near Harbin, North China (Tokunaga and Naora, 1939) by its long first tine and short beam, but is distinguished from the latter by much lyrated beam in the adult stage.

*Cervus greyi katokiyomasai* is similar to *C. nippon yesoensis* in the length of beam (LB1), however, it is distinguished by its slender antler and wide angle of the first forking.

Numerous remains of hunted *Sika*-deer were excavated from the Torihama Shellmound of the Early Jomon Period (5910 ± 30 years B.P. ~ 5170 ± 30 years B.P.) in Honshu (Education Committee of Fukui Prefecture, 1981—1985). Judging from the mode of the forking and the size of the antler, *Sika*-deers from this shellmound are referred to the living *Yezo-sika* (*C. nippon yesoensis*) in Hokkaido. However, they had rather smaller antlers than those of living *C. nippon yesoensis*. *C. greyi katokiyomasai* resembles more closely the *Yezo-sika* from Torihama than those from Hokkaido because of its wide angles of the first fork. However, *C. greyi katokiyomasai* is distinguished from the *Sika*-deer from Torihama by the long beam length between the first and second forks (LB1), and slender antler. *C. greyi katokiyomasai* is clearly distinguishable from *C. nippon centralis* by the large beam length between the first and second forks (LB1) and the wide angles of the first fork.

The phylogeny of the subgenus *Sika* may be inferred as follows: In the Middle Pleistocene, a population of *C. greyi* with a pair of slender and rather small antlers migrated to the Japanese Islands, accompanied by Naumann's elephant (*Palaeoloxodon naumanni*) and "Maya Su-pu-hsian" (*Elaphurus mayai*). The species flourished over in the lowland area of west Japan and gave rise to a characteristic, endemic, island form — *Cervus greyi katokiyomasai*. *C. nippon*

*yesoensis* of the early Jomon Period might have derived from *C. greyi katokiyomasai* in the Late Pleistocene and had dispersed throughout the Japanese Islands, including Hokkaido. After the Early Holocene, the *Yezo-sika* (*C. nippon yesoensis*) diverged into the medium-sized *Sika*-deer in the Kyushu and Honshu Islands, namely the *Kyushu-sika* (*C. nippon nippon*), *Honshu-sika* (*C. nippon centralis*) and a few other island subspecies (*C. nippon yakushima*, *C. pulchellus* etc.).

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← **Figure 15.** Antlers of *Cervus greyi katokiyomasai* Shikama and Hasegawa. All figures are outer views, × 0.3. Estimated ages are as follows. 1—2: seven to nine years of age; 3—6: nine to ten years of age. 1 (Holotype of *Cervus katokiyomasai* Shikama and Hasegawa, 1965), 2 (Reg. No. YM405), 3 (Reg. No. HM220), 4 (Reg. No. YM559), 5 (Reg. No. YM665), 6 (Reg. No. YM616).



**Figure 16.** Antlers of *Cervus (Sika) greyi katokiyomasai* Shikama and Hasegawa. All figures are outer views,  $\times 0.3$ . These are estimated as aged antler, older than eleven years of age. 1 (NSM Reg. No. 14443-2), 2 (Reg. No. YM614), 3 (Reg. No. YM470), 4 (NSM Reg. No. 14689), 5 (Reg. No. YM789).

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瀬戸内海の更新統産Sika亜属の成長：瀬戸内海からは、ナウマンゾウをはじめ鹿科や牛科などに属する哺乳動物化石群が豊富に産する。このうち、これまで記載されたか、リストされたSika亜属は7種にのぼり、絶滅種のほかに、現生のニホンジカや満州のウスリージカと同種の化石鹿まで含まれているとされたことがある。近年、備讃瀬戸海域の海底から引き揚げられた山本慶一氏のコレクション中には、120点を越すSika亜属の角や四肢骨を含んでいる。それらの角の集団標本には種々の形態・大きさのものがあり、その多様性は単一の種の加齢変化である可能性がでてきた。これを立証するために、セメント層板法によって年齢が査定されている現生ニホンジカ（エゾジカ、ホンシュウジカ、ツシマジカ）の3種の角の形態・大きさの加齢変化について検討した。その結果、従来単一またはいくつかの角の標本を基に提唱された瀬戸内海産の化石Sika亜属の4種（*katokiyomasai*・*natsumei*・cf. *greyi*・*paleozoensis*）は、単一の種あるいは亜種内の異なった年齢期の角を代表としていることが明らかとなった。新たに認識されたSika亜属は、その角の特徴によって、中国の中期更新世の周口店動物群に特徴的なグレイ班鹿（*Cervus greyi*）に似るが、後者に比べて、その角はやや小型であり、その亜種とみなされ、動物命名規約上、亜種名 *katokiyomasai* が選択され、カトウキヨマサジカ *Cervus greyi katokiyomasai* を提唱する。同亜種は中期更新世の後半に、ナウマンゾウや、先住者であり、固有種のムカシジカ亜属（*Nipponicervus*）などととともに、日本列島の低地部に繁栄した。大塚 裕之

## 869. SOME ABERRANT FUSULINACEANS FROM THE UPPER CARBONIFEROUS SEQUENCE OF THE AKIYOSHI LIMESTONE GROUP, SOUTHWEST JAPAN\*

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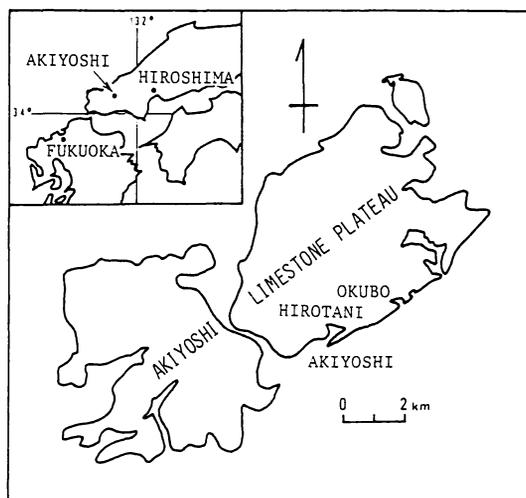
**Abstract.** Some aberrant lenticular fusulinaceans are found from the Upper Carboniferous sequence in the lower part of the Akiyoshi Limestone Group, Southwest Japan. These foraminifers are characterized by two different stages of growth; planispirally coiled in the early stage of growth and rectilinear in the last stage. The following species are described and discussed herein; *Rectomillerella okubensis*, sp. nov., *R. sp. A*, *R. sp. B*, *Palaeoreichelina disvolvata*, sp. nov., and *P. ? sp.* As far as the present knowledges are concerned, it is possible that *Palaeoreichelina* is paleobiogeographically related to the Tethyan realm.

### Introduction

The Akiyoshi Limestone Group is exposed in the western central part of Yamaguchi Prefecture, Southwest Japan, and forms a large limestone plateau measuring 17 km (NE-SW) by 8 km (NW-SE). This limestone sequence spans a long time interval from the Early Carboniferous (Tournaisian) to late Middle Permian and has been regarded as an organic reef complex developed on the basaltic basement of an isolated seamount (Ota, 1968, 1977; Kanmera and Nishi, 1983; Haikawa, 1986). The limestone is generally light-gray in color without showing any stratification, except for the basal part which includes dark-reddish tuffaceous matters. Therefore, the geological structure of this limestone can be analyzed mainly by discriminating biostratigraphical zones and by mapping them. These biozones have been established on the basis of fusulinaceans, brachiopods, corals, and conodonts.

The present author has restudied a foraminiferal

biostratigraphy of the lower part of the Akiyoshi Limestone Group in the Okubo area, southern margin of the Akiyoshi Limestone Plateau, largely examining the smaller foraminifers and primitive fusulinaceans (Matsusue, 1986). This paper deals with the systematic paleontology of a part of these



**Figure 1.** Map showing the location of the Okubo area in the Akiyoshi Limestone Plateau.

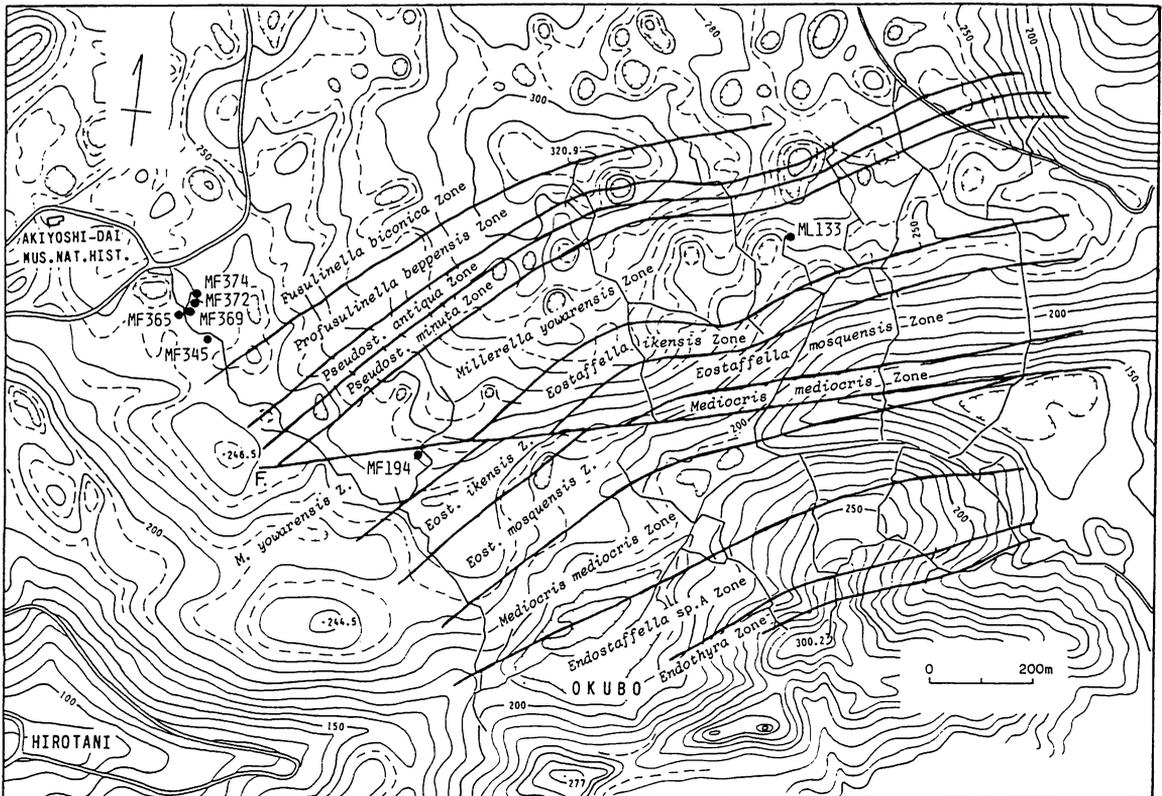
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foraminifers. The present author divided the lower part of the Akiyoshi Limestone Group into the following 10 foraminiferal zones in ascending order: *Endothyra* Zone, *Endostaffella* sp. A Zone, *Eostaffella mosquensis* Zone, *Eostaffella ikensis* Zone, *Millerella yowarensis* Zone, *Pseudostaffella minuta* Zone, *Pseudostaffella antiqua* Zone, *Profusulinella beppensis* Zone, and *Fusulinella biconica* Zone. These biozones range in age from the early Viséan to Moscovian.

A large number of fusulinaceans have been described from the Akiyoshi Limestone Group by many micropaleontologists (Ozawa, 1925; Toriyama, 1958; Ota, 1971; Sada, 1975, etc.). However, very few fusulinaceans with an aberrant form of coiling were reported until present. Toriyama (1953) described an aberrant fusiform genus *Akiyoshiella* from the *Profusulinella* Zone in the northeastern part of the limestone plateau.

Yanagida *et al.* (1971) discriminated the *Akiyoshiella ozawai* Zone between the *Profusulinella beppensis* and *Fusulinella biconica* Zones in this area.

Although the present author could not discover any species of *Akiyoshiella* in the Okubo area, he has found some aberrant lenticular fusulinaceans. They occur at seven localities which are stratigraphically grouped into two levels. The lower level (Locs. MF194 and ML133) is equivalent to the middle part of the *Millerella yowarensis* Zone (redefined by Matsusue, 1986, not Ota, 1977). The limestones of this zone is distinguished by the development of a true-reef facies. The microfauna of the zone is characterized by the first appearance of the genus *Millerella*, namely *Millerella yowarensis* and *M. toriyamai*. This microfauna is considered to be earliest Late Carboniferous age. The upper level (Locs. MF345, MF365, MF369, MF372)



**Figure 2.** Map showing fossil localities in the Okubo area of the southern margin of the Akiyoshi Limestone Plateau. Elevation contours in meters. Distributions of foraminiferal zones are after Matsusue (1986).

and MF374) is slightly above the base of the *Fusulinella biconica* Zone, and the zone is characterized by an algal micrudite. The microfauna of the zone is represented by *Fusulinella biconica*, *Profusulinella*, *Bradyina*, *Climacammina*, and staffellids, and is referable to the early Moscovian.

The present author wishes to express his sincere thanks to Professor Juichi Yanagida of Kyushu University for his kind advice and critical reading of the manuscript. Acknowledgment is also due to Dr. Masamichi Ota, Director of the Kitakyushu Museum of Natural History, and Messrs. T. Haikawa and A. Sugimura, Curators of the Akiyoshi-dai Museum of Natural History for their supports of the field survey.

#### Paleontological notes

Aberrant fusulinaceans with a deviated coiling pattern at the last stage of growth are common in the Upper Permian, such as *Reichelina* and *Codonofusiella*.

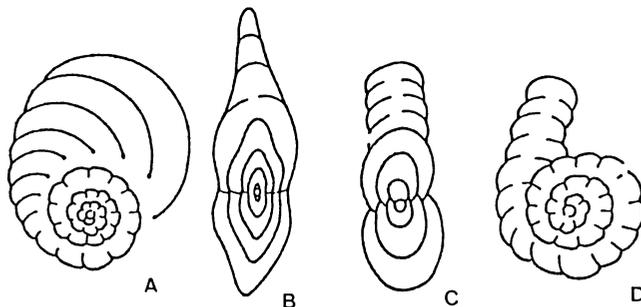
Ganelina *et al.* (1972) discussed a taxonomic value of aberrant forms of some Paleozoic foraminifers. They concluded that straightened tests had a highly taxonomic significance, and the character should be recognized as a generic one. They considered that these essentially new characters appeared in the advanced species of a genus clearly represented the qualitative change for the new genus, whereas the increase in number of chambers in the rectilinear part revealed only the

specific or subspecific character.

The aberrant forms are divided into two fundamentally different groups by Liem (1974). The first group (Figures 3-A, B) is planispirally coiled except for the last volution, and then the last volution abruptly increases its height. In the transverse sections, the last volution takes a fan-shape. Foramina are basal throughout the growth. The second one (Figures 3-C, D) is coiled in the inner volutions, but then test becomes straightened at the last stage of growth. Chambers of the straightened part are arranged uniserially and rectilinearly, and have an almost constant dimension both in width and height.

The term "uncoiling" has been used in many different senses, representing a rapid increase in height of volution, straightening, and even evolute coiling. Liem (1974) proposed to use the term "uncoiled" (*razvernutyi*) in a restricted sense to define such a fan-shape as developed in the last volution of *Reichelina*, and to use the term "rectilinear" (*vypryamlennyi*) to define a straightened shape in the last stage of growth. He also proposed to use these terms not only for fusulinaceans but also for endothyrids.

Leven (1970) established the genus *Pseudoreichelina*, characterized by an aberrant lenticular form, from the Lower Permian of Darvaz of Pamir, USSR. In general, the form of *Pseudoreichelina* is similar to that of *Reichelina*, but the former genus is quite distinct from the latter by having the staffellid wall. Some Early



**Figure 3.** Schematic sections of the aberrant fusulinaceans (after Liem, 1974). A, B: uncoiled fusulinaceans. C, D: rectilinear fusulinaceans.

Permian species described as *Reichelina* were included by Leven in the genus *Pseudoreichelina*. He suggested that *Pseudoreichelina* evolved from a staffellid ancestor in the Early Permian, and *Reichelina*, on the other hand, evolved from an ozawainellid stock in the Late Permian.

Subsequently, Liem (1974) described an aberrant staffellid genus *Palaeoreichelina* from the Moscovian of Vietnam, Southeast Asia. This genus is lenticular in the early coiled part and rectilinear in the last stage of growth.

At the same time, he established an aberrant ozawainellid genus *Rectomillerella* which was rectilinear in the last stage of growth. Carboniferous foraminifers with a straightened part in the last stage of growth have been well known as *Endothyranella* since Harlton and Galloway established it in 1930. This genus shares the same character with *Endothyra* in the early coiled part, but the coiled part straightens out in the last stage of growth. Generally, it is regarded that *Endothyranella* is streptospirally coiled, and most abundant in the early Late Carboniferous, especially in the Moscovian interval (Armstrong and Mamet, 1977, p. 53). *Rectomillerella* is similar to *Endothyranella* in the general shape of the test. But the former genus differs from the latter by its planispiral coiling in the early stage of growth.

Davydov (1981) discussed the morphology and systematics of two genera *Pseudoreichelina* and *Palaeoreichelina*. He described some aberrant staffellids, from the Upper Carboniferous of Darvaz, which are uncoiled in the last stage of growth. Although the character of the last stage of them disagreed with Liem's original diagnosis, Davydov conditionally included them with the genus *Palaeoreichelina*. Furthermore, he remarked that the Early Permian genus *Pseudoreichelina* also included two types in the last stage of growth. Therefore, this implies that the uncoiled and rectilinear types coexist in the Late Carboniferous and in the Early Permian genera. He concluded that *Pseudoreichelina* and *Palaeoreichelina* were distinct from each other, since they were originated from a different species and also they have markedly different stratigraphic ranges. Rauzer-Chernousova (1985) noted that further details were

required on these two genera to discuss their generic independences from each other. The present author herein wants to regard them as independent genera as suggested by Davydov.

#### **Paleobiogeographical significance of aberrant fusulinaceans from Akiyoshi**

The occurrence of aberrant lenticular fusulinaceans in the Late Carboniferous and the Early Permian is scarce globally. The Early Permian aberrant fusulinacean, *Pseudoreichelina* has been reported from Pamir of USSR (Leven, 1970), Yugoslavia (Kochansky-Devidé, 1966), Nevada of U. S. A. (Douglass and Nestell, 1974), and South China (Huang and Zeng, 1984). On the other hand, *Palaeoreichelina* was originally described from the lower Upper Carboniferous of Vietnam and Thailand, Southeast Asia. Davydov (1981) described some species, conditionally attributing them to the genus *Palaeoreichelina* from the Moscovian of Darvaz, Pamir. These two genera are very close in their geographical distribution. Although *Pseudoreichelina* has not been reported from Japan, the occurrence of *Palaeoreichelina* in the Akiyoshi Limestone Group strongly suggests a close paleobiogeographic relationship between the above mentioned areas and the Akiyoshi Limestone Group.

Summarizing the Late Carboniferous aberrant fusulinaceans, it is apparent that they are characteristic elements of the Tethyan realm. These genera together with the Upper Permian aberrant ones formed a part of important constituents of the Tethyan fusulinacean fauna.

#### **Systematic descriptions**

All the described specimens are kept in the Department of Geology, Faculty of Science, Kyushu University whose abbreviation GK is the prefix for the specimens' repository numbers.

Order Foraminiferida Eichwald, 1830

Suborder Fusulinina Wedekind, 1937

Superfamily Fusulinacea Moeller, 1878

Family Ozawainellidae Thompson and Foster,  
1937

Genus *Rectomillerella* Liem, 1974

*Type species*:—*Rectomillerella texasensis* Liem, 1974, p. 25—26. = *Millerella marblensis* var. Moore, 1964, p. 301—305, pl. 48, figs. 1—14, 19—21.

*Millerella*; Thompson, 1951, pl. 14, fig. 4 (only)

*Millerella*; Moore, 1964, p. 301—305, pl. 48, figs. 1—14, 19—21.

*Rectomillerella*; Liem, 1974, p. 25—26.

*Rectomillerella*; Loeblich and Tappan, 1988, p. 253.

*Diagnosis*:—Test is composed of two parts. The early coiled part is lenticular, planispirally coiled, involute in the inner volutions and evolute in the last one. The straightened part of the last growth stage is rectilinear and uniserial. Wall is thin and consists of a tectum, primatheca and upper tectorium. Septa are straight. Foramina are simple, basal in the coiled part, becoming median in the rectilinear part. Secondary deposits are weakly developed in the coiled part as upper tectorium.

*Remarks*:—The type species of this genus was originally described as a variant of *Millerella marblensis* Thompson by Moore (1964). He already regarded that this variant had a possibility of being a new species of *Millerella*. In 1974, Liem established the monotypic genus *Rectomillerella* based on Moore's specimens, renaming it as *R. texasensis* Liem.

The early coiled part of *Rectomillerella* is very similar to that of *Meillerella*. But the former differs from the latter by having a rectilinear part in the last stage of growth. The general test morphology of *Rectomillerella* resembles *Palaeoreichelina*, but they are quite distinct from each other by the difference in wall structure. *Rectomillerella* is also very similar to *Endothyranella* in the general test form and has a similar stratigraphic range. The difference between *Rectomillerella* and *Endothyranella* is only based on the mode of coiling; the former is planispirally coiled and the latter is coiled streptospirally.

Three species of *Rectomillerella* are discriminated from the Akiyoshi Limestone Group.

*Rectomillerella okubensis*, sp. nov.

Figures 4-1, 2

*Material studied*:—Description is based on a sagittal section (holotype, GK-D7001a) and a tangential section of paratype which is obliquely cut along the rectilinear part (GK-D7001b).

*Description*:—Test is small, composed of two parts. Whole length of test in a direction parallel to the rectilinear part is 416  $\mu\text{m}$ . The early part is planispirally coiled, lenticular. Periphery subrounded in the inner two volutions and subangular in the last one half volution. Coiling is two and a half volutions, involute in the inner volutions and evolute in the last one, and expands gradually and uniformly. The last volution contains 15 chambers. The later rectilinear part is uniserial, cylindrical, about 80  $\mu\text{m}$  in width, 261  $\mu\text{m}$  in length, and consists of 6 chambers. Septal spacings are constantly disposed with the length of about 43  $\mu\text{m}$ . Proloculus is small, 24  $\mu\text{m}$  in diameter. Septa are almost straight or slightly curved forward. Septal sutures are not seen. Secondary deposits are weakly developed as inconstant pseudochomata in the coiled part. Foramina are basal in the coiled part, but in the rectilinear part they are not visible on account of the obliquely oriented section. Wall is thin, dark, and undifferentiated. Thickness of wall is 13  $\mu\text{m}$  in the last volution and 8  $\mu\text{m}$  in the rectilinear part.

*Remarks*:—The present species has a rectilinear part in its last stage of growth and develops planispiral volutions in the coiled part with a thin, microgranular, and undifferentiated wall. Therefore, this species should be attributed to the genus *Rectomillerella*. *Rectomillerella okubensis* differs from *R. texasensis* Liem by its narrower rectilinear part and more angular periphery in the last volution.

*Occurrence*:—Loc. MF194 in the *Millerella yowarensis* Zone (earliest Late Carboniferous).

*Rectomillerella* sp. A

Figures 4-3, 7, 9.

*Material studied*:—Description is based on a

tangential section (GK-D7002a) and two oblique sections (GK-D7002b and GK-D7007).

*Description*:—Test is composed of two parts. The whole length of the test ranges from 540 to 637  $\mu\text{m}$ . The early part is lenticular with subangular periphery, and is an almost planispiral coil with a gradual rate of expansion. Number of volution is 2 to 3. Diameter of the coiled part is between 360 and 502  $\mu\text{m}$ . The later rectilinear part comprises up to 4 chambers. Width of the rectilinear part is the same as that of the coiled part, measuring from 233 to 280  $\mu\text{m}$ . Septal spacings in the rectilinear part are constant and similar to those of the coiled part. Septa are slightly convex forward throughout the growth. Septal sutures are visible. Foramina are basal in the coiled part, but central in the rectilinear part. Wall is thin, dark, and undifferentiated. Thickness of wall ranges from 10 to 14  $\mu\text{m}$  in the last volution and from 14 to 20  $\mu\text{m}$  in the rectilinear part. Secondary deposits are present as chomata in the coiled part and also appear as thickenings of septa around the foramen in the rectilinear part.

*Remarks*:—This species differs from other taxa of *Rectomillerella* by its comparatively large test. The presence of thickenings of septa around the foramen in the rectilinear part reminds the present author of the apertural neck of *Endothyranella recta* described by Rich (1980, p. 27). However, this species belongs to *Rectomillerella* because of its planispirally coiled volutions in the early stage of growth.

*Occurrence*:—Loc. ML133 in the *Millerella yowarensis* Zone (earliest Late Carboniferous), and Loc. MF345 in the *Fusulinella biconica* Zone (Moscovian).

#### *Rectomillerella* sp. B

Figures 4-4, 5.

*Material studied*:—Description is based on two tangential sections (GK-D7003 and GK-D7006).

*Description*:—Test is composed of two parts. Whole length of the test ranges from 820 to 899  $\mu\text{m}$ . The early coiled part is lenticular, planispirally coiled, and periphery becomes subangular in the last volution. So far as visible, diameter of

the coiled part measures from 364 to 447  $\mu\text{m}$ , and axial length from 137 to 164  $\mu\text{m}$ . The rectilinear part is relatively long, being composed of 3 or 4 chambers. Width of the rectilinear part is almost constant, between 85 and 137  $\mu\text{m}$ , and narrower than the axial length of last volution. Septal spacings in the rectilinear part are relatively long in comparison with the width of chamber. Septa are straight in the coiled part and convex forward in the rectilinear part. Wall is thin, dark, and undifferentiated in the coiled part, and partially differentiated with a tectum, primatheca and inner tectorium in the rectilinear part. Thickness of wall is 12  $\mu\text{m}$  in the last volution, and 13  $\mu\text{m}$  in the rectilinear part. Foramina are median in the rectilinear part. Secondary deposits are weakly developed as pseudochomata in the coiled part, and as thickenings of septa around the foramen in the rectilinear part.

*Remarks*:—This species differs from other taxa of this genus in having the long rectilinear part which shows a comparatively rapid expansion.

*Occurrence*:—Locs. MF365 and MF374, in the *Fusulinella biconica* Zone (Moscovian).

Family Staffellidae Miklukho-Maklay, 1949

Genus *Palaeoreichelina* Liem, 1974

*Type species*:—*Palaeoreichelina donghoiensis* Liem, 1974, p. 25, figs. 1–8.

*Pseudoendothyra* (part); Igo, 1972, p. 75, pl. 9, figs. 22–25.

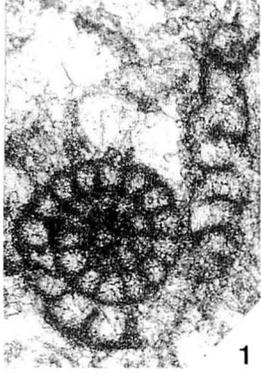
*Palaeoreichelina*; Liem, 1974, p. 24–25.

*Palaeoreichelina*?; Davydov, 1981, p. 121–124.

*Palaeoreichelina*; Rauzer-Chernousova, 1985, p. 15.

*Palaeoreichelina*; Loeblich and Tappan, 1988, p. 286.

*Diagnosis*:—Test is composed of two parts; the essentially lenticular, involute, planispirally coiled part with subangular periphery, and the last straightened part with uniserially arranged chambers. Wall is thick, undifferentiated in the inner volutions, but becomes three-layered with luminotheca in the last volution and in the rectilinear part. Septa are straight. Foramina are simple, basal in the coiled part, and median in the rectilinear part.



1



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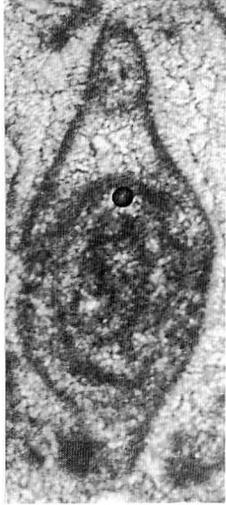
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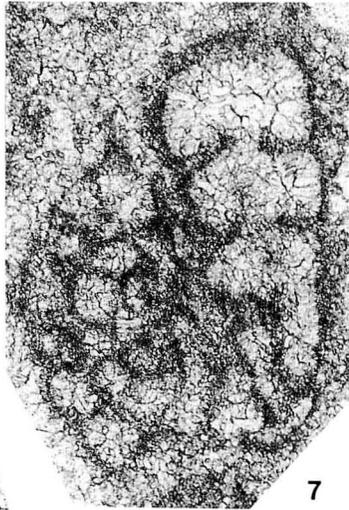
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5



6



7



8



9



10

*Remarks:*—Previous authors all agreed to attribute this genus to the Staffellidae by its wall structure, which is clearly distinguishable from that of other fusulinaceans by the presence of luminotheca in the last stage of growth.

However, there is a problem which the last stage of this genus is either uncoiled or rectilinear. Liem (1974) noted that the last stage of growth of *Palaeoreichelina* gave rise to the rectilinear form with uniserial arranged chambers. He conditionally included *Pseudoendothyra* sp. C of Igo (1972, pl. 9, figs. 4, 5, 22—24) in *Palaeoreichelina*. Davydov (1981) described three new species from the Upper Carboniferous of Darvaz, namely *Palaeoreichelina? igoi*, *P.? distincta*, and *P.? vozginensis*. He stated that all of them were uncoiled in the last stage of growth. In spite of his disagreement with the original diagnosis given by Liem (1974), Davydov conditionally attributed his three species to Liem's *Palaeoreichelina*. He assigned those specimens figured by Igo (1972) to *P.? igoi* which was described as having the uncoiled form in the last stage of growth. Therefore, the genus *Palaeoreichelina* now has two different types in the last stage of growth. The Early Permian genus *Pseudoreichelina* also has two types in the last stage of growth and is very similar to *Palaeoreichelina*. However, they are quite different from each other in their stratigraphic ranges.

It is probable that the uncoiled species belongs to a new genus. This problem has not been solved in this study, but a specimen from Akiyoshi shows the rectilinear mode in the last stage of growth. These two species are discriminated from the Akiyoshi Limestone Group.

*Palaeoreichelina disvolvata*, sp. nov.

Figures 4-8, 10.

*Material studied:*—Description is based on a

sagittal section (holotype, GK-D7004) and an oblique section (GK-D7005a).

*Description:*—Test is small, planispirally coiled with four volutions. Coiling expands moderately, but bluntly increases its height at the last stage of growth. Last two chambers straighten out, and become free from the previous volution. Septa are straight or slightly convex and incline forward. Sutural depressions are unrecognizable. Wall is rather thick, but wall structure is indistinct due to recrystallization. Wall is undifferentiated, dark, microgranular in the inner volutions and differentiated with luminotheca in the last stage of growth. Whole length of test ranges between 862 and 894  $\mu\text{m}$ . Thickness of wall in the last volution is 23  $\mu\text{m}$ , and that of antetheca 22  $\mu\text{m}$ . Foramina are basal in the coiled part, and not visible in the last stage of growth.

*Remarks:*—The recrystallized, indistinct wall structure of this species well reveals character of staffellids. The aberrant stage of growth is poorly developed in the described specimens. However, a figured specimen (Figure 4—8) shows a tendency for the last few chambers to become free from the earlier portion of the test. Although foramina of the rectilinear part are unclear, it is highly possible that the test of this species is rectilinear in the last stage of growth. These features are taken to assign that this species to *Palaeoreichelina*.

*Occurrence:*—Locs. MF369 and MF372 in the *Fusulinella biconica* Zone (Moscovian).

*Palaeoreichelina?* sp.

Figure 4-6.

*Material studied:*—Description is based on a tangential section (GK-D7005b).

*Descriptive remarks:*—Only one tangential section is available. Test is subspherical in the early stage of growth, but in the last stage it becomes

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← **Figure 4-1—2.** *Rectomillerella okubensis*, sp. nov., **1**, sagittal section of the holotype, Loc. MF194, GK-D7001a; **2**, tangential section of the paratype which cuts the rectilinear part obliquely, Loc. MF194, GK-D7001b. **3, 7, 9**, *R. sp. A*, **3**, tangential section, Loc. MF345, GK-D7002a; **7, 9**, sagittal sections, Loc. ML133 and MF345, GK-D7007 and 7002b, respectively. **4, 5**, *R. sp. B*, tangential sections, Loc. MF365 and MF374, GK-D7003 and 7006, respectively. **8, 10**, *Palaeoreichelina disvolvata*, sp. nov., **8**, sagittal section of the holotype, Loc. MF369, GK-D7004; **10**, oblique section, Loc. MF372, GK-D7005a. **6**, *P.? sp.*, tangential section, Loc. MF372, GK-D7005b. All figures  $\times 100$ .

lenticular with prolonged, keeled periphery, concave lateral slopes, and broadly rounded umbilical regions. Luminotheca is not visible, however, the recrystallized and obscure wall structure of the present species reminds the author of the character of staffellids. Measurements are as follows: width, 602  $\mu\text{m}$ ; length, 261  $\mu\text{m}$ ; thickness of wall in the last stage of growth, 13  $\mu\text{m}$ . Although no sagittal section of this species is known, a sudden increase of height of volution at the last stage is interpreted to indicate the uncoiling mode of growth of this species. As mentioned above, this species is probably assignable to *Palaeoreichelina*. However, the present author could not conclude whether or not the last stage of growth of this species reveals an uncoiled or rectilinear type.

*Occurrence*:—Loc. MF372 in the *Fusulinella biconica* Zone (Moscovian).

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秋吉石灰岩層群上部石炭系より産する異常巻フズリナ類：山口県秋吉石灰岩層群下部層の上部石炭系より異常巻フズリナ類を発見した。これらの異常巻フズリナ類は、成長の初期には平面旋回し、後期には巻が解けて直線状になる。今回 *Rectomillerella okubensis*, sp. nov., *R.* sp. A, *R.* sp. B, *Palaeoreichelina disvoluta*, sp. nov., *P.* ? sp. を記載した。現在知られている *Palaeoreichelina* の古生物地理上の分布はテチス地域と関連性が強い。松未 和之

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SHORT NOTES

**21. NEWLY DISCOVERED LATE TRIASSIC HEXACORALS  
FROM CENTRAL NEPAL\***

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Some hexacoral specimens were collected by Shiraishi in 1977 and Yoshida and Tokuoka in 1982 from limestone in the formation reported by Bordet *et al.* (1975) as Rhaetian age at the hill slope northeast of Jarsgeng River in Nyi-Shang area, Central Nepal. According to Bordet *et al.*, the formation is composed of sandstone, shale and limestone. They collected pelecypods and fasciculate corals from the limestone, but the species belonging to them (pelecypods and fasciculate corals) were not reported. Therefore, the exact age of the formation was not clear.

The present authors found the following hexacorals in a collection from the limestone.

1. "*Thecosmilia*" sp. A
2. "*T.*" sp. B
3. *Thamnasteria (Astraeomorpha?) major* Vinassa de Regny

The first species (Fig. 1-1) is similar to "*Thecosmilia*" *clathrata* (Emmrich), described by Frech (1890, p. 15, pl. 4, figs. 1—5, 7-11) and Zankl (1969, p. 29, pl. 9, fig. 1) from the Upper Norian and Rhaetian in the Austrian Alps and also by Roniewicz (1974, p. 108, pl. 4, fig. 1, pl. 5, fig.

3) from the Rhaetian in the Tarta Mountains in many respects, but exact comparisons cannot be made because of poor preservation of the material in longitudinal section.

The second species (Fig. 1-2) resembles original specimens of "*Thecosmilia*" *norica*, described by Frech (1890, p. 9, pl. 1, figs. 14—24a; pl. 10, figs. 6, 6a) from the Upper Norian to Rhaetian Zlambach beds but differs from the latter in having smaller corallites.

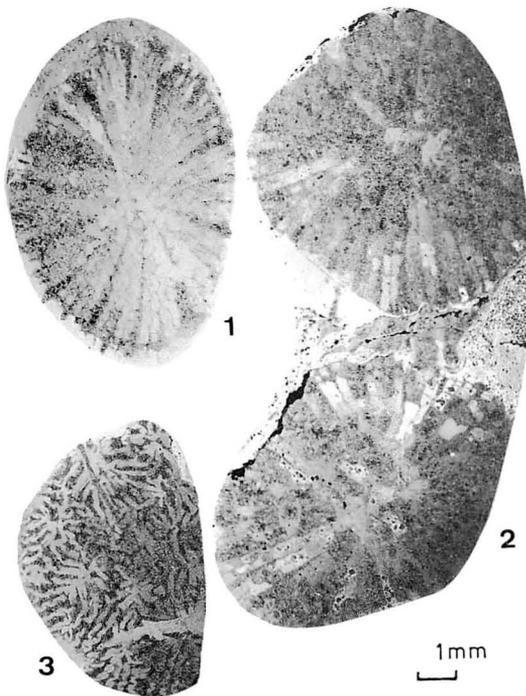
The third species (Fig. 1-3) is closely allied to original specimens of *Thamnasteria (Astraeomorpha?) major* Vinassa de Regny (1915, p. 103, pl. 68 (6), figs. 13—15) from the Upper Triassic in Timor in many important characters.

Judging from the evidence given above, the age of the present hexacorals indicates Late Triassic (probably Late Norian to Rhaetian). They will be described in detail on another occasion.

This short paper is the first report of a Late Triassic hexacoral faunule found in Nepal.

The authors express their hearty thanks to Professor Makoto Kato of Hokkaido University, Professor Emeritus Keiji Nakazawa of Kyoto University and Dr. Ienori Fujiyama of the National Science Museum, Tokyo for their kind advice and

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**Figure 1.**

1. "*Thecosmilia*" sp. A — Transverse section
2. "*T.*" sp. B — Transverse section
3. *Thamnasteria (Astraeomorpha?) major* Vinassa de Regny — Transverse section

suggestions, and to Professor Takao Tokuoka of Shimane University, who permitted them to study the present interesting materials.

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SHORT NOTES

22. A PERMIAN RUGOSE CORAL FROM KAMIKAGEMORI,  
CHICHIBU CITY, SAITAMA PREFECTURE, CENTRAL JAPAN\*

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Fossiliferous Upper Paleozoic limestones are frequently intercalated in the so-called Chichibu Paleozoic System in the Kanto Mountains. These limestones were interpreted as autochthonous interbeds and were accepted as the most reliable indicators of geochronology of the Chichibu System. Fossils described from these limestones are mostly fusulinaceans. Corals and other fossils are also locally abundant, but these fossils have not yet been described. Many thin sections of corals collected by Fujimoto and myself are now kept at our institute and some of these specimens seem to be important to discuss the similarity of coral faunas reported from the various limestone blocks in the Japanese Islands.

A Permian rugose coral, *Yokoyamaella* (*Yokoyamaella*) *tertioseptata* (Yokoyama) which was collected at limestone quarry of Kamikagemori, Chichibu City, Saitama Prefecture (Fig. 1) is described herein. This species has been reported from the Taishaku (Yokoyama, 1960) and Atetsu Limestones (Yamagiwa, 1962) of southwest Japan. Limestone of this quarry is pale gray, massive to thickly bedded, and it yields abundant fusulinaceans. Fujimoto (1936) described *Triticites simplex* (Schellwien) and several species of *Pseudofusulina*. Subsequently, Morikawa (1955) added the occurrence of *Schwagerina* and other species of *Pseudofusulina*. Some of the listed species by them have need of taxonomic revision, but they are characteristic representatives of the

upper part of the *Pseudoschwagerina* Zone or the so-called *Pseudofusulina* Zone of Japan, and they indicate a Sakmarian age.

Recently, Hisada (1983) studied the geology of this area, and he interpreted the mentioned limestone as a large allochthonous block embedded in his sheared strata of the Urayama Group. The Urayama Group is now believed to be a Jurassic olistostrome by Hisada (op.cit.).

Before continuing the paleontological description, I thank the late Professor Haruyoshi Fujimoto for his offer of the present material. The present study is supported by the Grant-in-Aid for Scientific Research from the Ministry of Education, Science and Culture (No. 62540597).

Description of species

Family Waagenophyllidae Wang, 1950

Genus *Yokoyamaella* Minato and Kato, 1965

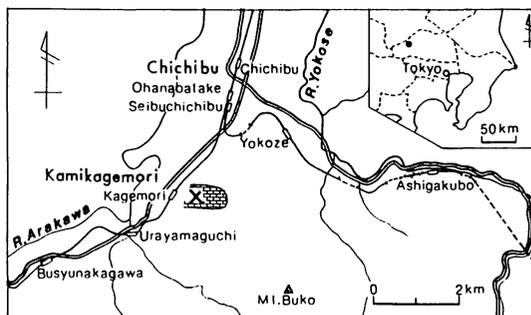


Figure 1. Map showing fossil locality (x).

\*Received September 30, 1988; accepted October 20, 1988.



2a

2c

**Figure 2.** *Yokoyamaella* (*Yokoyamaella*) *tertioseptata* (Yokoyama)  
a, Tangential section; b, tangential section of the peripheral portion of corallum; c, longitudinal section.  
× 3.8.

Subgenus *Yokoyamaella* Minato and Kato,  
1965

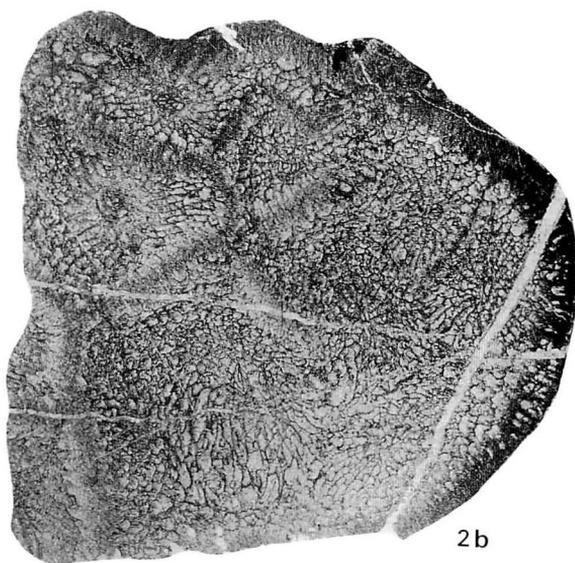
*Yokoyamaella* (*Yokoyamaella*) *tertioseptata*  
(Yokoyama, 1960)

Figures 2a—c

*Stylidophyllum yokoyamai tertioseptatum* Yokoyama,  
1960, p. 245, pl. 27, figs. 1a—c; Yamagiwa, 1962, p. 91,  
pl. 4, figs. 4—6.

*Yokoyamaella* (*Yokoyamaella*) *tertioseptata*; Minato and  
Kato, 1965, p. 139—140, pl. 11, figs. 1—2.

*Description.*—Corallum compound, cerioid and attains more than 30 cm in diameter. Corallites irregularly polygonal, but mostly five sided with straight or slightly curved walls in transverse section. Mature corallites about 7 to 10 mm in diameter. Periphery of corallum surrounded by a circular outer wall. Some corallites tend to circular in transverse section and partly fasciculate in peripheral portion of corallum. Walls originally a thin dark layer but strengthened by thick mural septa. Median layer of wall sometimes translucent.



2b

Septa two orders, major and minor and strengthened by a very thick coating in peripheral zone and forming mural septa. They have a dark layer in their middle part and dilated by stereoplasmic deposits. Middle part of septa, however, rarely provides a translucent layer in some corallites. Major and minor septa partly interrupted by lonsdaleoid dissepiments where they discontinuous and appear as a septal projection.

Major septa long, sinuous or more or less zigzag, and reach nearly axial structure. Counter septum directly unites with median plate of axial structure. Minor septa alternate with major septa but slightly shorter than the latter. Very short septa sporadically developed between minor septa in some immature corallites.

Axial structure more or less solid and consists of thick median plate conjoined with counter septum, and encircling axial tabellae. Septal lamellae poorly developed and form loose spider-web structure in some corallites.

Dissepiments mostly concentric and not so numerous. Rather small vesicular lonsdaleoid dissepiments partly developed in every corallite.

In longitudinal section peripheral dissepimentarium, very narrow tabularium and distinct axial zone well differentiated and they dilated by stereoplasmic deposits. Dissepimentarium consists of several rows of elongate and rather large dissepiments facing inward. Axial column consists of a thick median plate, steeply ascending crowded tabellae and sporadically developed septal lamellae. Tabulae very narrow, thin and nearly horizontal.

*Remarks:*—The type specimen of this species was originally described by Yokoyama (1960) from the Taishaku Limestone of Hiroshima Prefecture. Subsequently, Minato and Kato (1965) criticized Yokoyama's original specimen, and they pointed out that the holotype of *Y. (Y.) tertioseptata* does not have any true tertiary septa. The present form rarely has the so-called tertiary septa in some immature corallites. As already suggested by Minato and Kato (op. cit.) these short septa seem

to be immature secondary septa. Translucent layer which was also pointed out by Minato and Kato in the median part of septa and wall appears more frequently than that of the original specimen.

*Occurrence.*—Collected from Loc. 12 (Morikawa, 1955, Fig. 9) of limestone quarry of the Showa Denko Co. LTD., Kamikagemori, Chichibu City, Saitama Prefecture.

*Depository.*—Paleontological collection, Institute of Geoscience, University of Tsukuba, Reg. No. IGUT 5400 (Collected by Haruyoshi Fujimoto in 1960).

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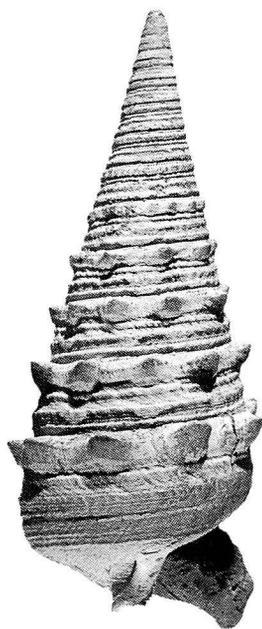
# 日本古生物学會 報告・紀事

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The heading in Japanese commemorates the handwriting of Prof. Matajiro YOKOYAMA, father of Japanese palaeontology, who was a professor of stratigraphy and palaeontology at the Geological Institute, Imperial University of Tokyo.

The fossil on the cover is *Vicarya yokoyamai* Takeyama, an Early Middle Miocene gastropod from the Kurosedani Formation at Kakehata, Yatsuo-cho, Nei-gun, Toyama Prefecture, central Japan (Collected by T. Kotaka and K. Ogasawara, IGPS No. 99075, photo by S. Ohtomo and Y. Kikuchi,  $\times 0.9$ ).

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