Nat. Hist. Res., Vol. 2 No. 2: 103–112. March 1993.

Fossil Ophiuroids (*Ophiura sarsii* Lütken, 1854) from the Pleistocene Ichijuku Formation (Kazusa Group), Chiba Prefecture, Central Japan

Yoshiaki Ishida[1] and Koukichi Inoue[2]

[1] Hitotsubashi High School
1–12–13 Higashikanda, Chiyoda-ku, Tokyo 101, Japan
[2] 314–5 Kônoyama, Abiko-shi, Chiba 270–11, Japan

Abstract Abundant specimens of a fossil ophiuroid were collected from the siltstone and coarse sandstone of the Early to Middle Pleistocene Ichijuku Formation of the Kazusa Group in the Ichijuku area, Kimitsu City, Chiba Prefecture, Central Japan. These fossil ophiuroids are identified as a living species *Ophiura sarsii* mainly because the disk scales are fine and comb papillae are short. This clarifies that origin of the species goes back at least to the Early Pleistocene. This paper provides the first description of the fossil specimens of *Ophiura sarsii*.

Key words: *Ophiura sarsii*, Ophiuroidea, description, Pleistocene, Ichijuku Formation, Kazusa Group.

Over 300 individuals of an ophiuroid species from the Early to Middle Pleistocene Ichijuku Formation of the Kazusa Group (Mitsunashi *et al.*, 1961; Niitsuma, 1976) in the Ichijuku area, Kimitsu City, Chiba Prefecture were collected at a sand quarry on a cliff in this area, about two kilometers northeast of Kanô Mountain (Fig. 1). The occurrence of the ophiuroid from the Ichijuku Formation was reported by Hamada (1975) and Hayami (1987), but taxonomic allocation has not still been done. In this paper, we describe morphological characters of the specimens and allocate the specimens to a living species *Ophiura sarsii*.

The late Pleistocene specimens of *Ophiura sarsii* were recorded from off northern Norway (Jensen and Thomsen, 1987). The specimen from the Pleistocene of South Norway was listed as *Ophiura sarsii* (Bjorlykke, 1898). The occurrence of the fossil *Ophiura sarsii* from the Ichijuku area suggests that origin of this species goes back to the age of the Ichijuku Formation (the Early to Middle Pleistocene).

Geology

The Ichijuku Formation yielding the ophiuroids rests conformably on the Iwasaka Formation, and is overlain unconformably by the Nagahama Formation (Mitsunashi *et al.*, 1961). At the fossil locality, the middle part of the Ichijuku Formation is composed mainly of coarse sand with large-scale cross-bedded sets (Plate II, fig. 1), intercalated are a few siltstone layers of 10–50 cm in thickness (Plate II, fig. 2). A few specimens were collected directly from the outcrop, and over 300 were found in boulders of siltstone and coarse sandstone near by. Since the lithic characters of the boulders are quite the same

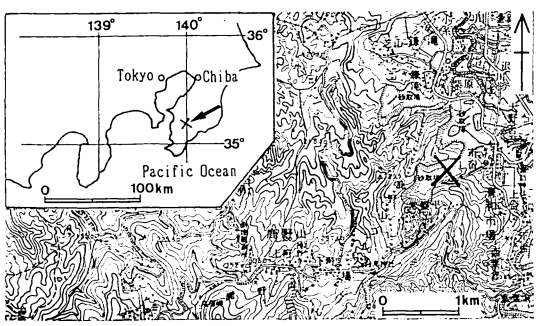

Fig. 1. Locality of fossil *Ophiura sarsii*. A part of the topographic map of "Futtsu" on the scale of 1: 50,000 by the Geographical Survey Institute, Ministry of Construction, Japan. X: Fossil locality.

as those of the mother rocks at the outcrop, it is considered that these boulders were derived from the outcrop. Many specimens are well preserved and not fragmented, and therefore appear to be autochthonous or semi-autochthonous (Plate, I). Together with ophiuroids, we found various additional fossils in the Ichijuku Formation of this locality, vis.: bivalves such as *Pecten* (*Notovola*) *albicans*, *Mizuhopecten tokyoensis*, *Aequipecten vesiculosus*, *Chlamys* (s.s.) *jousseaumei*, *Placopecten akihoensis*, *Crassostrea gigas*, *Arca boucardi miyatensis*, *Glycymeris* (s.s.) *yessoensis*, *G.* (s.s.) *vestita*, *Limopsis* (s.s.) *tokaiensis*, *L.* (*Nipponolimopsis*) *azumana*, *Chama* (s.s.) cf. *reflexa*, *Venericardia* (*Cyclocardia*) *ferruginosa* etc.; Gastropoda such as *Patelloida* (*Asteroacmaea*) *pallida*, *Tegura* (*Chlorostoma*) *pfeifferi*, *Diodora yokoyamai kosibensis*, *Turritella* (*Neohaustator*) *saishuensis*, *Architectonica yokoyamai*, *Cryptonatica janthostomoides*, *Fulgolaria* (*Psephaea*) cf. *kamakurensis* etc.; Scaphopoda such as *Eufistulana grandis*, *Dentalium* (*Antalis*) *septentrionale* etc.; corals *Caryophyllia* sp. and *Flabellum* sp., and shark teeth.

Description of fossils

Order Ophiurida Müller and Troschel, 1840
Family Ophiuridae Lyman, 1865
***Ophiura sarsii* Lütken, 1854**
(Figs. 2A–E, 3A–E; Plates I–III)

Materials. Over 300 specimens were collected at Ichijuku area, Kimitsu City, Chiba Prefecture. Ichijuku Formation, Kazusa Group, Early to Middle Pleistocene. Stored at the Natural History Museum and Institute, Chiba Prefecture, Central Japan (CBM-PI 01399).

Measurements. The smallest specimen has a disk diameter of about 3 mm, while that in the largest specimen is about 19 mm, mean diameter being 9.6 mm. The arms are about three times as long as the disk diameter.

Description. The disk is circular in outline, low and flat. The disk is covered with small, flat, and imbricated scales (Fig. 2B). The primary plate is circular in shape (Fig. 2A). The radial shields are irregularly triangular, about twice as long as wide, separated from each other, about half the length of the disk radius. The comb plates are elliptical in shape, vertical to the disk radius. The comb papillae are arranged along the margin of the plate, narrowly separated by gaps, conical or rather broad and apically obtuse, short, or about one third of the basal arm joint in length (Fig. 2C, D). The comb papillae are discernible 10 in number along the comb plate, but there is room for 1 or 2 additional papillae. The interradial marginal plates are elliptical in outline, and about 0.34 times as long as the interradial length. The external surface of the plate is arched along the shorter axis. The oral shields are pentagonal in shape with rounded distal borders, wider within than without, slightly longer than broad (Fig. 3A). The length of the oral shields equals the distance from their outer edge to the edge of disk, but is occasionally twice this length, however this is rare. The teeth and oral papillae are long, slender and acute at the tips. Eight tooth papillae are counted at the apex of a jaw; these are wide and longer than the oral papillae (Fig. 3C). The oral papillae number six or seven (Fig. 3B). The adoral plates are slender and rectangular in shape, in contact with each other at the adoral margin. The oral plates are rather long, rectangular in shape, in contact with each other at the adoral side. The genital slits are long with squarish, flat, short, closely-set genital papillae along the abradial border of the genital slit (Fig. 3D). The oral slits are U-shaped. The first 4 or 5 arm segments insert laterally into the disk (Fig. 3A). The arms are rather wide at the base and taper gently. The arms are flattened, much wider than high and keeled at the aboral side. The dorsal arm plates are well developed, rectangular in shape, with straight or slightly convex outer edges, and in contct over their whole breadth. About 4 dorsal arm plates at the base of the arm are incorporated into the disk. The proximalmost of the dorsal arm plates are triangular or rectangular in shape (Fig. 2C). The free dorsal arm plates in the proximal part are about 3.5 times as broad as long. The ventral arm plates are triangular in shape with rounded corners, wider than long,

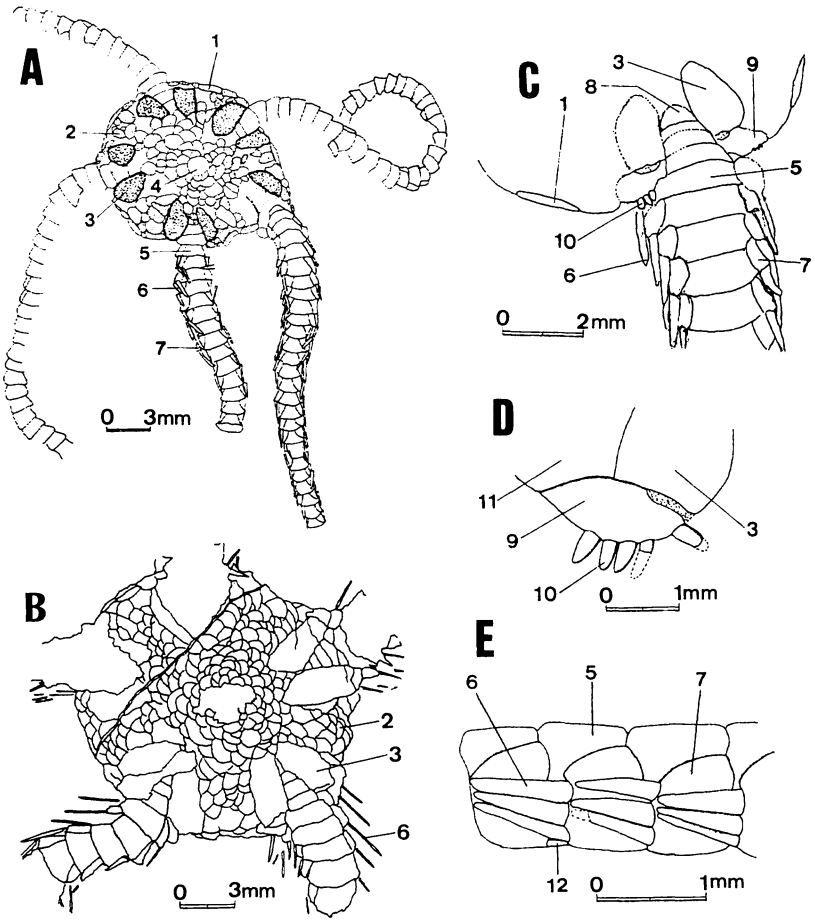

Fig. 2. Sketch showing the aboral and lateral view of fossil *Ophiura sarsii*. A: Disk and arms, aboral view. B: Disk, aboral view. C: Basal arm and disk edge, aboral view. D: Arm comb, aboral view. E: Arm, lateral view. 1: Interradial marginal plate, 2: Disk scale, 3: Radial shield, 4: Primary plate, 5: Dorsal arm plate, 6: Arm spine, 7: Lateral arm plate, 8: First dorsal arm plate, 9: Arm comb plate, 10: Arm comb papilla, 11: Disk, 12: Ventral arm plate.

about 2.5 times as broad as long, with straight or slightly convex outer edges, separated from each other. The shape of the first ventral arm plates is trapezoidal with curved distal margin (Fig. 3A). The lateral arm plates are separated by the dorsal arm plate on the dorsal side of the arm, but, they are in contact with each other on the ventral side. The distal margin of the lateral arm plates is uneven due to the presence of sockets of the spines. The basal margin of the lateral arm plates has a shallow sinus in its center. The outer surface of the lateral arm plates is smooth, sloping towards the distal margin. Tentacle pores occur over most of the arm, are larger and more pronounced near the disk than elsewhere on the arm. The second oral tentacle pores are very large and are protected by 4–5 square tentacle scales on each side of the pore (Fig. 3B). Proximal arm segments have 2 or 3 tentacle scales, whereas middle and distal arm segments have a single tentacle scale. The arm spines are 3 in number, long and tapering, twice as long as the corresponding arm segment at basal arm and almost equal to the length of the corresponding arm segment at mid-arm (Fig. 2E). The three arm spines are appressed or often somewhat detached, and placed at equal distance from each other. The arm spines are

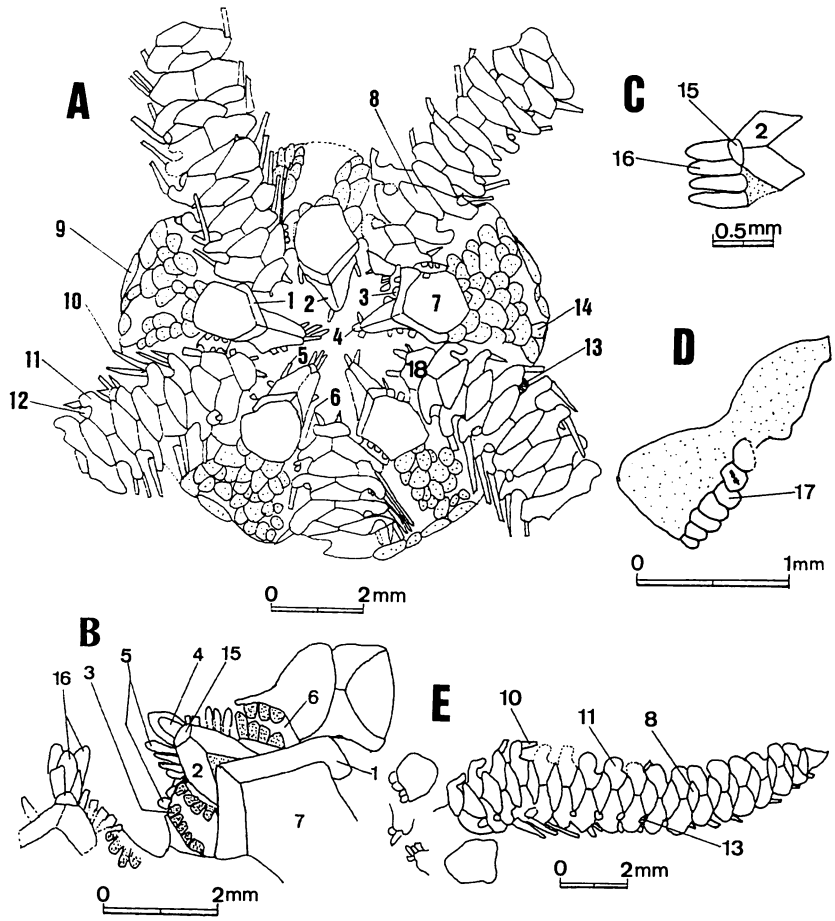

Fig. 3. Sketch showing the oral view of fossil *Ophiura sarsii*. A: Disk. B: Jaw apparatus. C: Tooth papillae. D: Genital papillae. E: Arm. 1: Adoral plate, 2: Oral plate, 3: Second oral tentacle scale, 4: Teeth, 5: Oral papilla, 6: Second oral tentacle pore, 7: Oral shield, 8: Ventral arm plate, 9: Interradial marginal plate, 10: Arm spine, 11: Lateral arm plate, 12: Tentacle pore, 13: Tentacle scales, 14: Disk scale, 15: Torus angularis, 16: Teeth, 17: Genital papilla, 18: First ventral arm plate.

not completely round, being somewhat flattened on two sides, so that the cross section would be elliptical in outline.

Comparisons. The species of these specimens is identified with the living species, *Ophiura sarsii* because comb papillae are very short and 11 or 12 in number, disk scales fine, and arm spines 3 in number. In the living subspecies, *Ophiura sarsi vadicola* D'yakonov (D'yakonov, 1954), the arm comb papillae are long, slender and subacute. The radial shields are short, usually oval or round, and almost as broad as long. The arm spines are short and rather obtuse. In fossil *O. sarsii*, however, the arm comb papillae are short, rather broad and apically obtuse. The radial shields are long, irregularly triangular, and about twice as long as wide. The arm spines are long and tapering. In the living species, *Ophiura texturata* Lamarck, the arm comb papillae are very fine, rather long, and ca. 30 in number (Mortensen, 1927). The papillae of fossil *O. sarsii*, however, are rather broad, short, and ca. 11–12 in number. The oral shields of *O. texturata* are longer than those of fossil *O. sarsii*. The arm spines of the former are short and blunt, whereas those of the latter are long and tapering. The arm comb papillae of the modern *Ophiura kinbergi* Ljungman are longer than those of fossil *O.*

sarsii. In the fossil species, *Ophiura marylandica* Berry (Berry, 1934, 1939), the dorsal disk scales are large, and few in number. The lateral arm plates are not in contact with each other on the ventral side. The interradial marginal plates are well developed. The arm spines are very short. In fossil *O. sarsii*, however, the dorsal disk scales are small. The lateral arm plates are in contact with each other on the ventral side. The interradial marginal plates are not well developed. The arm spines are long. In the fossil species, *Ophiura texana* Clark (Clark, 1915; Berry, 1941), the form of the ventral arm plates is trapezoidal, length equalling width. The ventral ends of the lateral arm plates are in contact with each other at the lateral side of the arm and appear to be thick massive plates. In fossil *O. sarsii*, however, the ventral arm plates are triangular in shape with rounded corners, and wider than long. The lateral arm plates are not thicker than those of *Ophiura texana*. In the fossil species, *Ophiura wetherelli* (Wetherell) (Wetherell, 1834; Forbes, 1852; Rasmussen, 1972), the arm spines are 4 or 5 in number, and rather short. The disk scales are rather large. The ventral arm plates vary in shape from broad quadrangular to subtriangular. In fossil *O. sarsii*, however, the arm spines are 3 in number. The disk scales are rather small. The ventral arm plates are triangular in shape. In the fossil species, *Ophiura graysonensis* (Alexander) (Alexander, 1931; Berry, 1941), the disk scales are very large, forming a rosette at the center of the disk. *O. graysonensis* has no true interradial marginal plates. The oral shields show a concavity on their lateral sides. The shape of the ventral arm plates is a truncated triangle. The arm spines are short, and 4 in number. In fossil *Ophiura sarsii*, however, the disk scales are rather small, and do not form a rosette. *Ophiura sarsii* has interradial marginal plates. The oral shields do not show a concavity on their lateral sides. The ventral arm plates are triangular in shape. The arm spines are long, and 3 in number. In the fossil species, *Ophiura travisana* Berry (Berry, 1941), the oral shields are cordate in shape. The teeth are broad and flat. The ventral arm plates are pentagonal in shape with rounded corners. In fossil *O. sarsii*, however, the oral shields are pentagonal in shape. The teeth are long and slender. The ventral arm plates are triangular in shape. In the fossil species, *Ophiura? hagenowi* Rasmussen (Rasmussen, 1950; Maryánska and Popiel-Barczyk, 1969), the dorsal arm plates are subtriangular in shape. The ventral arm plates are markedly hexagonal. In fossil *O. sarsii*, however, the dorsal arm plates are rectangular in shape. The ventral arm plates are triangular in shape. In the fossil species, *Ophiura? parviformis* Küpper (Küpper, 1954), the ventral arm plates are longer than wide, whereas those of fossil *O. sarsii* are wider than long. In the fossil species, *Ophiura? vindobonesis* Küpper (Küpper, 1954), the ventral arm plates are pentagonal in shape, whereas those of fossil *O. sarsii* are triangular in shape. In the fossil species, *Ophiura serrata* Roemer (Forbes, 1843; Rasmussen, 1950), the arm spines are short, 4–8 in number. The ventral arm plates are in contact with each other. In fossil *O. sarsii*, however, the arm spines are long, 3 in number. The ventral arm plates are not in contact with each other. In the fossil species, *Ophiura? substriata* Rasmussen (Rasmussen, 1950), the ventral arm plates are wedge-shaped or shield-shaped, whereas those of fossil *O. sarsii* are triangular in shape. In the fossil species, *Ophiura achatae* Rasmussen (Rasmussen, 1972), the height of the arm is about equal to the width, whereas the arms of fossil *O. sarsii* are wider than high. In the fossil species, *Ophiura furiae* Rasmussen (Rasmussen, 1972), the disk is pentagonal in outline, whereas that of fossil *O. sarsii* is circular in outline. The radial shields of fossil *Ophiura bognoriensis* Rasmussen (Rasmussen, 1972) are larger than those of fossil *O. sarsii*. The dorsal arm plates of fossil *Ophiura bartonensis* Rasmussen (Rasmussen, 1972) are longer than those of fossil *O. sarsii*. The dorsal arm plates of fossil *Ophiura carpelloides* Rasmussen (Rasmussen, 1972) are smaller than those of fossil *O. sarsii*. The lateral arm plates of fossil *Ophiura davisi* Rasmussen (Rasmussen, 1972) are larger than those of fossil *O. sarsii*. The disk scales of fossil *Ophiura*

murravii Forbes (Forbes, 1843) are larger than those of fossil *O. sarsii*. In the fossil species, aff. *Ophiura straini* (Cornell *et al.*, 1991), the dorsal arm plates are triangular in shape, whereas those of fossil *O. sarsii* are rectangular in shape.

Acknowledgments

We wish to thank Masae Omori, Prof. Emeritus of Azabu University for his critical reading of the manuscript and identification of the molluscan fossils. Our deep gratitude is due to Dr. John W. M. Jagt, Dr. Seiichi Irimura and Dr. Frederick H. C. Hotchkiss of the Panametrics company for critical reading of the manuscript, and to Dr. Rihito Morita of the Natural History Museum and Institute, Chiba for permission to examine the fossil ophiuroids stored at the Museum. The writers' thanks also go to Dr. Hans K. Hess, and to Dr. Tatsuo Oji of the University of Tokyo for supplying useful information on fossil ophiuroids. Finally, thanks are also due to the following persons Dr. Ienori Fujiyama, a former curater of the National Science Museum, Tokyo, Dr. Jean P. Roman of National Natural History Museum, Paris, Mr. Takumu Kato of Isogo High School, Dr. Seiko Miyagi of Mukogaoka High School, Mr. Hisao Adachi of Shinobugaoka High School and Mr. Matthew Willemsen of Hitotsubashi High school for fruitful discussion.

References

Alexander, C. I. 1931. A new Lower Cretaceous ophiuroid. J. Paleont. 5(1): 152–153.

Berry, C. T. 1934. Miocene and Recent *Ophiura* skeletons. Johns Hopkins Univ. Stud. Geol. 11: 9–135.

Berry, C. T. 1939. More complete remains of *Ophiura marylandica*. Proc. Amer. Phil. Soc. 80(1): 87–94.

Berry, C. T. 1941. Cretaceous ophiurans from Texas. J. Paleont. 15(1): 61–67.

Bjorlykke, K. O. 1898. Geologisk Kart med beskrivelse over Kristiania by. Norges Geol. Underog. 25: 1–86.

Clark, W. B. 1915. The Mesozoic and Cenozoic Echinodermata of the United States. U. S. Geol. Survey Mon. 54: 1–341.

Cornell, W. C., D. V. Lemone and W. D. Norland. 1991. Albian Ophiuroids Cerro de Cristo Rey, Dona Ana County, New Mexico. J. Paleont. 65(6): 1009–1013.

D'yakonov, A. M. 1954 [1967; English version]. Ophiuroids of the USSR Seas. Trud. Zool. Inst. Akad. Nauk SSSR. 55: 1–123.

Forbes, E. 1843. On the fossil remains of starfishes of the order Ophiuridae found in Britain. Proc. Geol. Soc. London 4(2) 97: 232–234.

Forbes, E. 1852. Monograph of the Echinodermata of the British Tertiaries. VII+36 pp. London, Palaeontographical Society.

Hamada, T. 1975. Living fossils, Animals. 151 pp. Hoikusha, Osaka. (In Japanese)

Hayami, I. 1987. The science of fossils. 130 pp. Palaeontological Society of Japan, Asakurasyoten, Tokyo. (In Japanese)

Jensen, M. and E. Thomsen. 1987. Ultrastructure, dissolution and "pyritization" of Late Quaternary and Recent Echinoderms. Bull. Geol. Soc. Denmark 36: 275–287.

Küpper, K. 1954. Ophiuroidea aus dem Torton des Wiener Beckens. Paläont. Z. 28(3/4): 159–166.

Maryánska, T. and E. Popiel-Barczyk. 1969. On the remains of Ophiuroidea from the Uppermost Maastrichtian and Danian deposits at Nasilow near Pulawy, Poland. Prace Muzeum Ziemi 14: 131–138.

Mitsunashi, T., K. Yazaki, K. Kageyama, T. Shimada, E. Ono, N. Yasukuni, T. Makino, Y. Shinada, K. Fuziwara and S. Kamata. 1961. Geological map of the oil fields and gas fields of the Futtsu and Otaki district, 1:50,000. Geological Servey of Japan.

Mortensen, T. 1927. Echinoderms of the British Isles. 471 pp. Oxford Univ. Press.

Niitsuma, N. 1976. Magnetic stratigraphy in the Boso Peninsula. J. Geol. S. Japan 82: 163–181. (In Japanese with English abstract)

Rasmussen, H. W. 1950. Cretaceous Asteroidea and Ophiuroidea with special reference to the species found in Denmark. Danm. Geol. Unders. 2(77): 3–134.

Rasmussen, H. W. 1972. Lower Tertiary Crinoidea, Asteroidea and Ophiuroidea from northern Europe and Greenland. Det Kongelige Danske Videnskabernes Selskab, Biologiske Skrifter 19 (7): 1–83.

Wetherell, N. T. 1834. On Ophiura found at Child's

Hill, to the N. W. of Hampstead. Proc. Geol. Soc. London, (1832–1833) 1(29): 417.

千葉県の更新統市宿層（上総層群）より産出したクモヒトデ化石 (*Ophiura sarsii* Lütken, 1854)

石田吉明[1]・井上浩吉[2]

[1]東京都立一橋高校
〒101 東京都千代田区東神田 1-12-13
[2]〒270-11 千葉県我孫子市高野山 314-5

千葉県の下部–中部更新統市宿層（上層総群）より，密集したクモヒトデ化石を発見した．筆者らはこれらのクモヒトデ化石を，現生種の *Ophiura sarsii* と同定し，記載した．これは *Ophiura sarsii* のもっとも古い化石記録であり，現生種の *Ophiura sarsii* が前期–中期更新世までさかのぼって生存したことを示している．クモヒトデ化石が現生種に同定された例は，日本で初めてである．

Explanation of Plates

Plate I (p. 110). fig. 1. Gregarious occurrence of fossil *Ophiura sarsii*, most specimens showing the dorsal side. The matrix is siltstone. fig. 2. Superposed occurrence of fossil *Ophiura sarsii*, showing the ventral side. The matrix is coarse sandstone. fig. 3. More or less isolated occurrence of fossil *Ophiura sarsii*, showing the ventral side. The arms are sigmoidal in attitude on the bedding plane. The matrix is siltstone.

Plate II (p. 111). fig. 1. The outcrop near the collection site of fossil *Ophiura sarsii*, referred to the Ichijuku Formation, composed of coarse sand with large-scale cross-bedded sets. fig. 2. Close-up of the former, showing on intercalation of a siltstone layer (arrow). fig. 3. Dorsal view of a complete specimen of *Ophiura sarsii*, collected from the coarse sandstone. fig. 4. External cast of *Ophiura sarsii*, showing ventral view of the oral shield (arrow). The matrix is siltstone. fig. 5. Cross-section of arms. The arms are keeled dorsally. Vertebral ossicles are discernible.

Plate III. (p. 112). Various parts of fossil *Ophiura sarsii.* fig. 1. Ventral side of disk, buried in coarse sandstone. Lateral arm plates, ventral arm plates, tentacle pores, teeth, etc. are discernible. 1: Second oral tentacle pore, 2: Oral shield, 3: Tentacle pore, 4: Margin of the disk. fig. 2. Dorsal side of disk in siltstone. Fine scales on disk are discernible. fig. 3. Ventral side of disk in coarse sandstone. 1: Teeth, 2: Oral papillae, 3: Second oral tentacle pore, 4: Second oral tentacle scales, 5: Oral plate. fig. 4. Ventral side of arm in ditto. 1: Tentacle pore, 2: Ventral arm plates, 3: Lateral arm plates, 4: Arm spine. fig. 5. Ventral side of disk in ditto. Genital papillae are indicated by arrow. fig. 5'. Close-up of genital papillae. fig. 6. Aboral view of disk and basal part of arm in ditto. 1: Comb papillae, 2: Interradial marginal plate, 3: Dorsal arm plate, 4: Arm spine. fig. 6'. Close-up of comb papillae. fig. 7. Dorsal side of arm in ditto. 1: Dorsal arm plate, 2: Arm spine. fig. 8. Lateral side of arm and appressed arm spines in ditto. 1: Dorsal arm plate, 2: Arm spine.

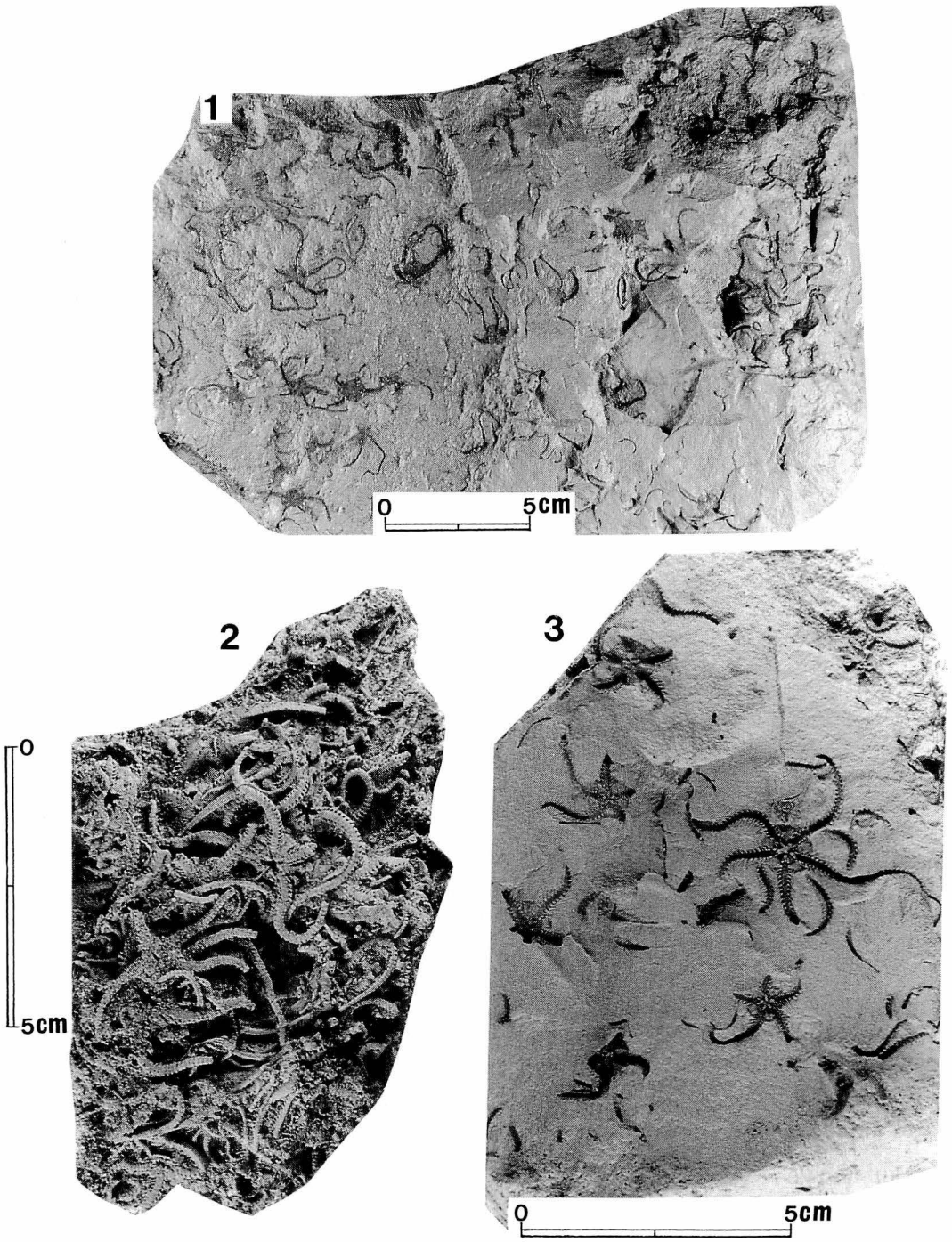

Plate I

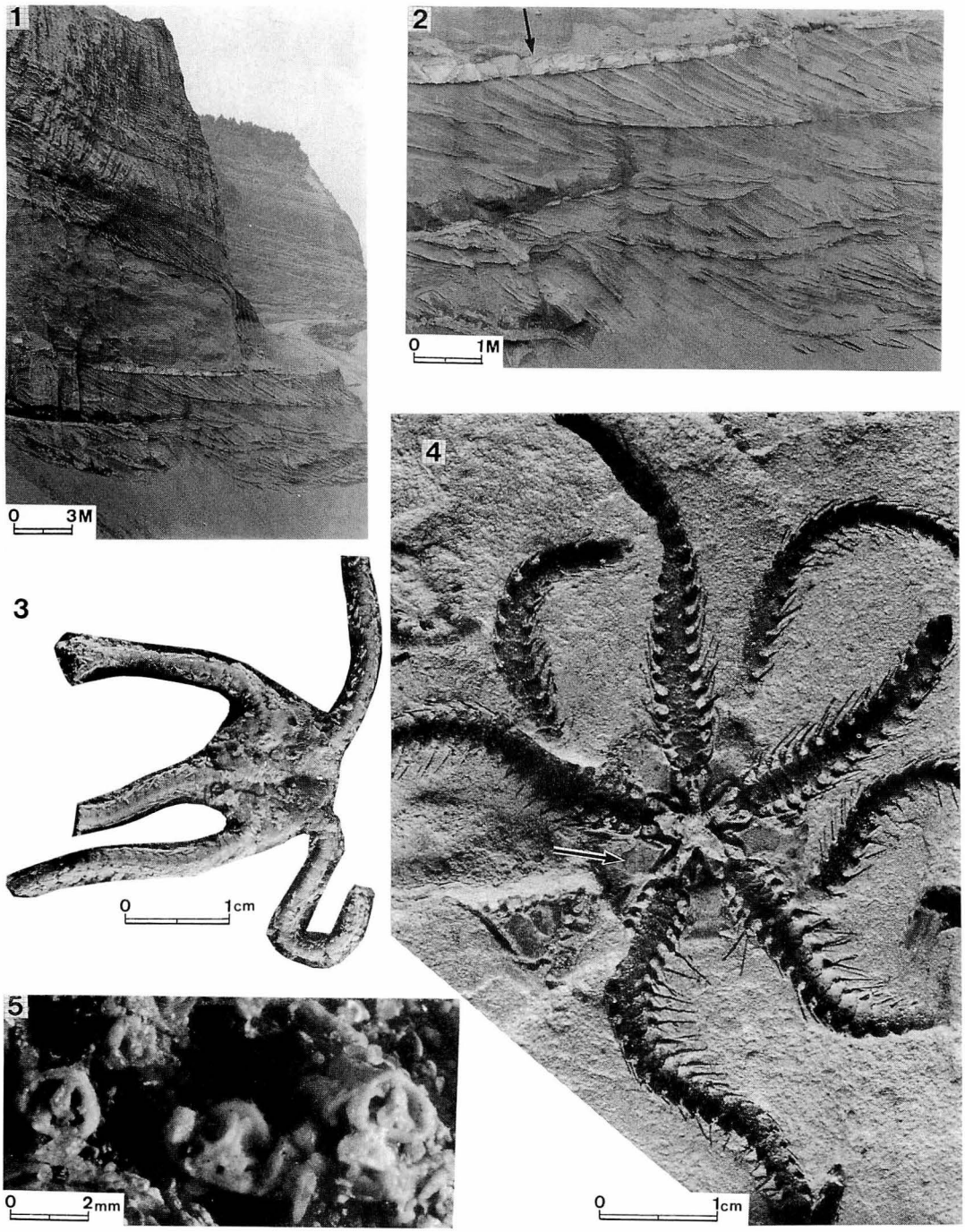

Plate II

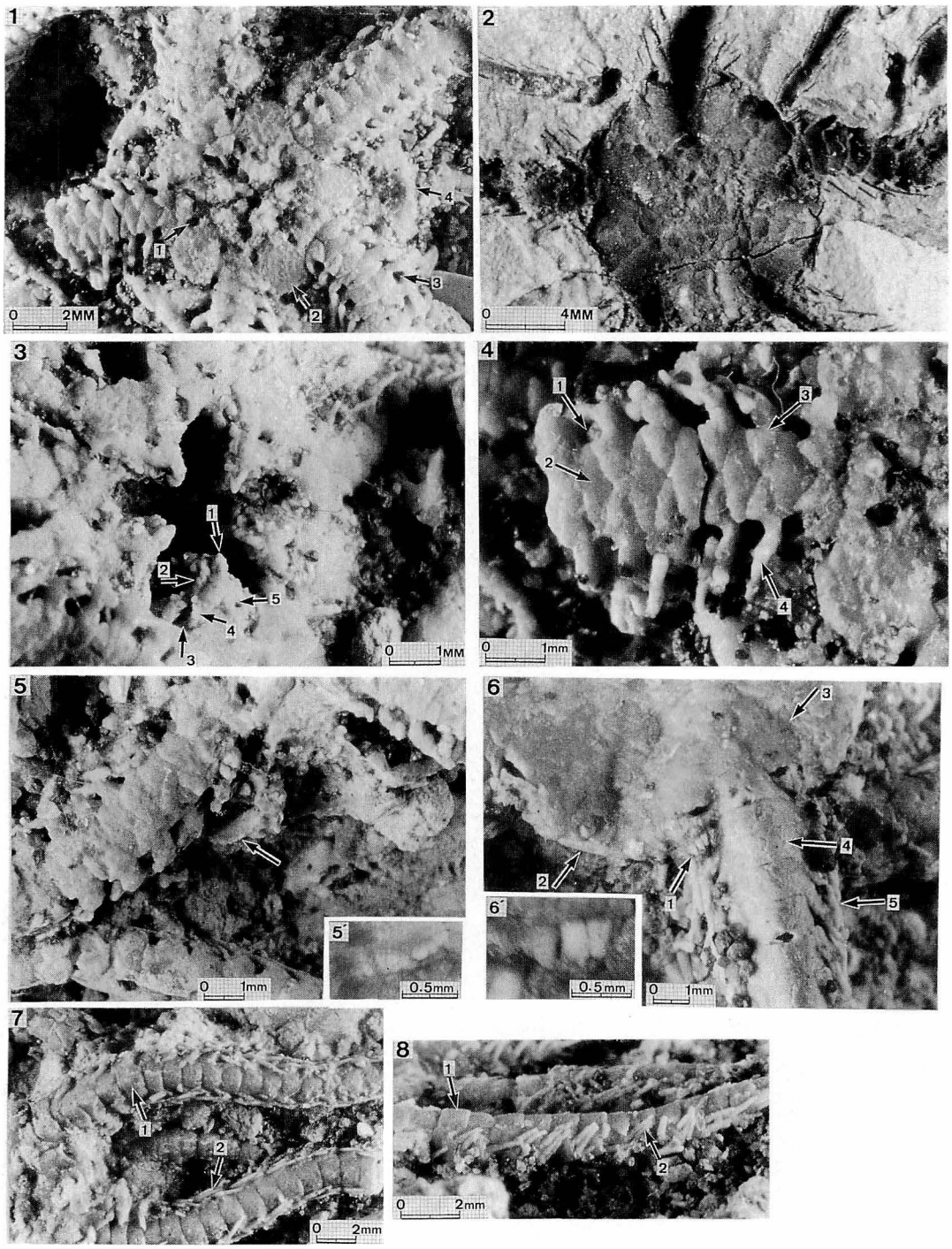
1
0 2MM
2
0 4MM
3
0 1MM
4
0 1mm
5
0 1mm
5´
0.5mm
6
6´
0.5mm
0 1mm
7
0 2mm
8
0 2mm

Plate III