

Astriclypeus and *Echinodiscus* in Japan*

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日本の海胆 *Astriclypeus* と *Echinodiscus* について

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(要 約)

瑞浪層群から産出する化石 *Astriclypeus* とそのもっとも近縁と考えられる *Echinodiscus* の関係について、形態的特徴、生態（古生態）、地質的地理的分布、系統関係、日本における両属の化石種についてのべる。

Introduction

There are many living or fossil species of the so-called key-hole sand dollars (sea-urchins) throughout the world. One of them is the fossil *Astriclypeus* from the Miocene Mizunami group, and it is known from the Miocene formations of various localities in Japan extensively. Fossil *Astriclypeus* is one of the very important index fossils in the Japanese Miocene. On the other hand, fossil *Echinodiscus* which has the familiar relationship with *Astriclypeus*, occurs from only the Oligocene of Southwestern Japan. So far as the living species is concerned, *Astriclypeus* are widely distributing in the adjacent seas of Japan, but *Echinodiscus* are unknown.

In the present paper several problems of these two genera are mentioned, namely on their morphological feature, their geological and geographical distributions, their ecology and their phylogenetic relation.

Morphological features

All the sand dollars including *Astriclypeus* and *Echinodiscus* have quite flat test, as the name shows. It is really characteristic features that there are five ambulacral furrows to the central peristome on the oral surface, and that *Astriclypeus* and *Echinodiscus* have some lunules or slits at the extremities of ambulacral areas, as well as the genera *Mellita* or *Encope* in the western hemisphere. *Astriclypeus* is very similar with *Echinodiscus* as follows: the shape of test is flat and discoidal; the size is 100-180 mm in diameter; the apical system is in the

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central part of aboral surface; the number of genital pores is four; the ambulacral furrows with twigs bifurcating near the peristome; the position of periproct is intermediate between the peristome and the posterior margin on the oral surface.

However, *Astriclypeus* differs from *Echinodiscus* in the following features, that is, the former is rather round outline of the test and the ambulacral petal opens at the extremities, but the latter is somewhat pentagonal outline and the petal rather closes at the extremities. Especially the most remarkable difference of these two genera is the five lunules at the extremities of the ambulacral petals in the genus *Astriclypeus* and the two slits at the extremities of the posterior paired petals in the genus *Echinodiscus*.

Ecological note

In the present time these two genera *Astriclypeus* and *Echinodiscus* are living on the sandy or stony bottoms of the shallow sea (about 2 to 30 m in depth), being covered with some sands or gravels on their aboral surface alike. The fossil species of these two genera are unexceptionally found in the matrices of sandstone or conglomerate, so their palaeoecological circumstances seem to be about same with the present ecological state.

The most important feature to be divided these two genera is lunules or slits, as mentioned above. It is quite interesting problem to observe how their lunules or slits are useful ecologically, and some zoologists had reported about it.

The genus *Mellita* with five lunules in the Ambulacra I, II, IV, V and in the Interambulacrum V is one of the representative key-hole sand dollars in America.

R. KENK (1944) of Department of Biology, University of Puerto Rico in the coast of Puerto Rico and L. H. HYMAN (1958) of American Museum of Natural History in the coast of North Carolina had observed *Mellita*. And also H. IKEDA (1941) of Department of Zoology, University of Kyushu had observed *Astriclypeus* in the coast of Kyushu, Japan. Their opinions or conclusions on account of function of lunules are about same, but it is not so clear in detail. The lunules seem to be very important on the locomotion and on the stability of test. It might indicate some specialization by De BEER which appears at the last stage on their evolutionary trends.

Geological and geographical distribution

Astriclypeus is known to exist from the middle Miocene Epoch down to Recent in the neighbouring areas of Japan and *Echinodiscus* ranges from the Oligocene Epoch to Recent in the Indo-Pacific regions.

Fossil *Astriclypeus* in Japan occurs only in the middle Miocene formations of various districts from the southern part of Hokkaido in the north to the Ryukyu in the south. They have never been found in the other horizons except only one case of the Pliocene (Nobori Formation) and the Alluvium. According to S.

NISIIYAMA (1968), *Astriclypeus mannii ambigenus*, *A. mannii minoensis*, *A. mannii integer* are known as the Miocene species and *A. mannii* as the Pliocene or Recent species.

The Recent species of *Astriclypeus* is confined in the sea around Japan, from about E-130° to E-140° and from about N-30° to N-40°, with exceptional report coming from Cambodia. About fossil species besides Japan, *A. mannii integer* of the Miocene and *A. mannii* of the Pliocene are known from Taiwan.

Recent species of *Echinodiscus* covers an area, extending roughly from E-35° to E-125°, and from N-35° to S-15°, including the Red Sea, the Indian Ocean, the east coast of Africa, the Malay region, the north-western part of Australia, the Philippines and Taiwan. Fossil species of *Echinodiscus* in Japan are *E. chikuzenensis* and *E. transiens* from the Oligocene (Ashiya and Nichinan groups) of Fukuoka, Miyazaki and Yamaguchi Prefectures. Fossil *Echinodiscus* are known from the Miocene formations of India and Indonesia, from the Pliocene formations of the Persian Gulf, the Aru Archipelago and Indonesia, and from the Pleistocene formations of Amboina and Egypt, respectively.

Phylogenic relation

Among the key-hole sand dollars *Astriclypeus* and *Echinodiscus* are the most familiar genera undoubtedly. At first they are almost same in the morphological features except lunules or slits as stated above. Secondly, judging from their geographical distributions, they are limited in the Eastern Hemisphere together and quite similar in their ecological conditions. Thirdly, their lunules and slits show the familiar relation between these two genera. For example, some fossil species (*Amphiope*) with three small lunules in the anterior three ambulacra and two large lunules in the posterior two ambulacra, which is known from the Miocene formations of Taiwan, means the intermediate type between *Astriclypeus* and *Echinodiscus*. Again, the young species of *Astriclypeus* from the Alluvium of Nagoya Harbour has not necessarily five lunules, but five slits.

According to Th. MORTENSEN the small species of 9 mm in diameter is without lunules and the species of 13 mm in diameter has two lunules only in the posterior paired ambulacra, in the case of *Astriclypeus*. These facts seem to be a quite familiar relation between two genera, ontogenically and phylogenically.

Judging from their geological distributions, the genus *Scutella* appeared in the Eastern Hemisphere at the Eocene Epoch, and *Echinodiscus* originated from *Scutella* at the Oligocene Epoch, and then *Astriclypeus* succeeded at the Miocene Epoch at last. It should be considered that the branch of their phylogenic tree is in the nearest position.

Fossil species of *Astriclypeus* and *Echinodiscus* in Japan

Astriclypeus mannii integer YOSHIWARA 1899

- 1899 *A. integris*: S. YOSHIWARA, Jour. Geol. Tokyo, 6, p. 1, pls.1-2
 1903 *A. integer*: S. YOSHIWARA, Jour. Coll. Sci., Imp. Univ., Tokyo, 17, p. 15, pl. 1, figs. 3-4,
 pl. 2, figs. 3-4
 1935 *A. integer*: S. NISIYAMA, Saito Ho-on Kai Mus., Res. Bull., 5, p. 141
 1947 *A. integer*: I. HAYASAKA, Acta Geol. Taiwanica, 1, p. 115, pl. 15, fig. 2, pl. 16, figs. 1-2
 1960 *A. integer*: A. MORISHITA, Jour. Earth Sci., Nagoya Univ., 8(1), p. 60
 1963 *A. integer*: A. MORISHITA, op. cit., 11(2), p. 138, pl. 5, fig. 1
 1965 *A. mannii integer*: S. NISIYAMA, Bull. Shimane Univ. (Nat. Sci.), 15, p. 79
 1968 *A. mannii integer*: S. NISIYAMA, Palaeont. Soc., Japan, Spec. Paper, 13, p. 139

Geological horizon and locality: Middle Miocene; Nishi-Katsura group (Mizuho-mura, Minami-Tsuru-gun, Yamanashi Prefecture)

Astriclypeus mannii ambigenus NISIYAMA 1935

- 1935 *A. manni ambigenus*: S. NISIYAMA, Saito Ho-on Kai Mus., Res. Bull., 5, p. 140, pl. 8,
 figs. 1-3, text-figs. 3a-c
 1955 *A. manni ambigenus*: J. W. DURHAM, Univ. California, Publ., 31(4), p. 176
 1960 *A. manni ambigenus*: A. MORISHITA, Jour. Earth Sci., Nagoya Univ., 8(1), p. 60
 1963 *A. manni ambigenus*: A. MORISHITA, op. cit., 11(2), p. 138
 1965 *A. mannii ambigenus*: S. NISIYAMA, Bull. Shimane Univ. (Nat. Sci.), 15, p. 79
 1968 *A. mannii ambigenus*: S. NISIYAMA, Palaeont. Soc. Japan, Spec. Paper, 13, p. 140

Geological horizons and localities: Middle Miocene; Tanosawa formation (Tanosawa, Odose-mura and Hotatezawa, Iwasaki-mura, Nishi-Tsugaru-gun, Aomori Prefecture), Tsugawa formation (Kamagui, Takekoshi-mura, Iwafune-gun, Niigata Prefecture), Hatatate formation (Kagitori, Sendai City, Miyagi Prefecture), Nishikurosawa formation (Nishikurosawa and Hirasawa, Kitaura-machi, Minami-Akita-gun, Akita Prefecture), Kadonosawa formation (Nisatai, Nisatai-mura, Ninohe-gun, Iwate Prefecture), Kunnui formation (Oanzai River, Kaminokuni-mura, Hiyama-gun, Shiribeshi, Hokkaido)

Astriclypeus mannii minoensis MORISHITA 1952

- 1952 *A. manni minoensis*: A. MORISHITA, Mem. Coll. Sci., Kyoto Univ., B, 20(2), p. 113, pl.
 11, fig. 1
 1953 *A. manni minoensis*: A. MORISHITA, Trans. Proc. Palaeont. Soc., Japan, N. S., 10, p. 63,
 pl. 6, figs. 1-2
 1954 *A. manni minoensis*: A. MORISHITA, Mem. Coll. Sci., Kyoto Univ., B, 21(2), p. 227
 1960 *A. manni minoensis*: A. MORISHITA, Jour. Earth Sci., Nagoya Univ., 8(1), p. 60
 1963 *A. manni minoensis*: A. MORISHITA, op. cit., 11(2), p. 138
 1965 *A. mannii minoensis*: S. NISIYAMA, Bull. Shimane Univ., (Nat. Sci.), 15, p. 79
 1968 *A. mannii minoensis*: S. NISIYAMA, Palaeont. Soc. Japan, Spec. Paper, 13, p. 142
 1971 *A. mannii minoensis*: A. MORISHITA, Atlas Jap. Fossils, 15, fig. 5
 1974 *A. mannii minoensis*: A. MORISHITA, Bull. Mizunami Fossil Mus., 1, p. 210, pl. 65, fig. 8

Geological horizons and localities: Middle Miocene; Mizunami group (Shukuno-

hora, Hiyoshi-cho, Mizunami City Gifu Prefecture), Togane formation (Toganeura, Kokubu-mura, Naka-gun, Shimane Prefecture)

Astriclypeus manni VERRILL 1867

- 1867 *A. manni*: A. VERRILL, Trans. Connecticut Acad., Arts & Sci., 1, p. 311
 1872 *A. manni*: A. AGASSIZ, Mem. Mus. Comp. Zool., 3, p. 93, 529, pl. 13d. figs. 2-4
 1900 *A. manni*: S. YOSHIWARA, Zool. Mag., 12, p. 393
 1907 *A. manni*: S. YOSHIWARA, Zool. Mag., 19, pl. 10, figs. 11-12
 1914 *A. manni*: H. L. CLARK, Mem. Mus. Comp. Zool., 46(1), p. 72, pl. 125, figs. 13-15
 1925 *A. manni*: H. L. CLARK, Catalogue, Rec. Sea-Urchins, Brit. Mus. (Nat. Hist.), p. 171
 1935 *A. manni*: S. NISIYAMA, Saito Ho-on Kai Mus., Res. Bull., 5, p. 134, text-figs. 1a-b
 1939 *A. manni*: H. IKEDA, Jour. Dept. Agr., Kyushu Imp. Univ., 6(2), pl. 2, figs. 8-11, pl. 3, figs. 6-7, pl. 12, fig. 9, pl. 13, figs. 4-6
 1947 *A. manni*: I. HAYASAKA, Acta Geol. Taiwanica, 1, p. 116, pl. 12, fig. 2, pl. 13, fig. 1, pl. 14, fig. 1, pl. 15, fig. 1
 1948 *A. manni*: Th. MORTENSEN, Monogr., IV₂, p. 416, pl. 50, figs. 1-3, pl. 62, fig. 1, pl. 72, figs. 17-18, 20-21, text-figs. 219c, 221, 244a
 1954 *A. manni*: H. UTINOMI, Publ. Seto Mar. Biol. Labor., 3(3), p. 355
 1955 *A. manni*: J. W. DURHAM, Univ. California, Publ., 31(4), p. 175, text-figs. 1m, 32d
 1963 *A. manni*: A. MORISHITA, Jour. Earth Sci., Nagoya Univ., 11(2), p. 138, pl. 4, figs. 1a-b
 1965 *A. manni*: S. NISIYAMA, Bull. Shimane Univ. (Nat. Sci.), 15, pp. 79, 85
 1968 *A. manni*: S. NISIYAMA, Palaeont. Soc. Japan, Spec. Paper, 13, p. 143, pl. 17, fig. 4, text-fig. 53

Geological horizons and localities: Pliocene; Ananai formation (Tonohama, Yasuda-machi, Aki-gun, Kochi Prefecture) Pleistocene; Ryukyu Limestone (Okinawa Island, precise locality unknown)

Many other fossil specimens of *Astriclypeus manni* from various localities are under the re-examination by the author.

Echinodiscus chikuzenensis NAGAO 1928

- 1928 *E. chikuzenensis*: T. NAGAO, Sci. Rep. Tohoku Imp. Univ., Fac. Sci., 12, p. 17, pl. 1, figs. 15-17
 1956 *E. chikuzenensis*: A. MORISHITA, Mem. Coll. Sci., Univ. Kyoto, B, 23, p. 194
 1960 *E. chikuzenensis*: A. MORISHITA, Jour. Earth Sci., Nagoya Univ., 8(1), p. 59
 1965 *E. chikuzenensis*: S. NISIYAMA, Bull. Shimane Univ. (Nat. Sci.), 15, p. 79
 1968 *E. chikuzenensis*: S. NISIYAMA, Palaeont. Soc. Japan, Spec. Paper, 13, p. 132

Geological horizons and localities: Oligocene; Wakita formation (Wakita, Shimago-mura, Onga-gun, Fukuoka Prefecture), Yamaga formation (Iwaya, Ashiya-machi, Onga-gun, Fukuoka Prefecture), Nichinan group (Nango-mura, Minami-Naka-gun, Miyazaki Prefecture)

Echinodiscus transiens NISIYAMA 1968

1968 *E. transiens*: S. NISIYAMA, Palaeont. Soc., Japan, Spec. Paper, 13, p. 133, pl. 17, fig. 1
 Geological horizon and locality: Oligocene; Yamaga formation (Nishiyama, Hikoshima, Shimonoseki City, Yamaguchi Prefecture)

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- (1953), Neogene echinoids from Gifu Prefecture, Japan. *Trans. Proc. Palaeont. Soc. Japan, N. S.*, No. 11.
- (1954), Tertiary echinoids from the environs of the Ise-Bay. *Mem. Coll. Sci., Univ. Kyoto, B*, vol. 21, no. 2.
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- (1960), Biostratigraphical studies of Japanese Tertiary echinoids. *Jour. Earth Sci., Nagoya Univ.*, vol. 8, no. 1.
- (1963), On the lunuled Scutellidae (key-hole sea-urchins). *op. cit.*, vol. 11, no. 2.
- (1971), Miocene echinoids from Mizunami district, Gifu Prefecture. Atlas of Japanese fossils, No. 15, Tsukiji-Shokan, Tokyo.
- (1974), Fossil echinoids from Mizunami District. *Bull. Mizunami Fossil Mus.*, No. 1.
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- (1965), The echinoid fauna from Japan and adjacent regions (Abstract). *Bull. Shimane Univ. (Nat. Sci.)*, vol. 15.
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- (1900), Japanese echini (Text). *Zool. Mag. Tokyo*, vol. 12.
- (1903), On some fossil echinoids of Japan. *Jour. Coll. Sci., Imp. Univ. Tokyo*, vol. 17.
- (1907), Japanese echini (Plate). *Zool. Mag. Tokyo*, vol. 19.

Fig. 1. *Astriclypeus manni minoensis* MORISHITA $\times 0.7$

Mid. Miocene. Mizunami Group. Shukubora, Hiyoshi-cho,
Mizunami City, Gifu Prefecture. Abactinal side.

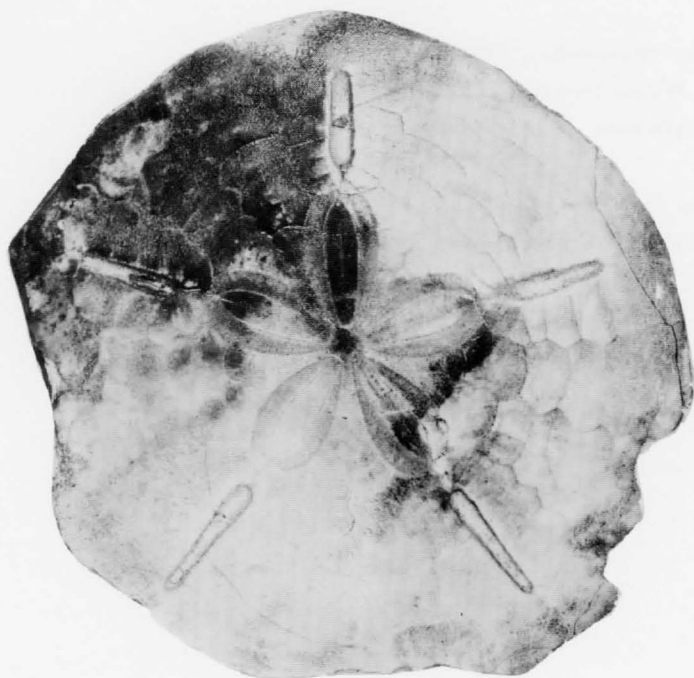
(MORISHITA 1952, Holotype. JC750001 deposited in Kyoto Univ.)

Fig. 2. *Astriclypeus manni minoensis* MORISHITA $\times 1$

Same locality with Fig. 1. Abactinal side.

(MORISHITA 1953)

1



2



Plate 32

Fig. 1. *Echinodiscus chikuzenensis* NAGAO ×1

Oligocene. Wakita formation. Wakita, Shimago-mura, Onga-gun,
Fukuoka Prefecture. Abactinal side.

(NAGAO 1928)

Fig. 2. *Echinodiscus formosus* YOSHIWARA (*Amphiope?*) ×1

Miocene. Taiwan. Abactinal side.

(NISUYAMA 1935)

