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SOME SHALLOW-WATER ASTEROIDS (ECHINODERMATA: ASTEROIDEA) FROM TAIWAN[1]

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Shyh-Min Chao and Kung-Hsiung Chang (1989) Some shallow-water asteroids (Echinodermata: Asteroidea) from Taiwan. *Bull. Inst. Zool., Academia Sinica* **28**(3): 215-223. The present paper deals with ten species of shallow water asteroids collected off Taiwan coast by SCUBA diving at the depth of 0-30 meters. The ten species are *Archaster typicus* Müller and Troschel (Archasteridae), *Culcita novaeguineae* Müller and Troschel (Oreasteridae), *Fromia monilis* Perrier, *Linckia laevigata* (Linnaeus), *Nardoa frianti* Livingstone, *Ophidiaster hemprichi* Müller and Troschel (Ophidiasteridae), *Asterina coronata* von Martens, *Patiriella pseudoexigua* Dartnall (Asterinidae), *Acanthaster planci* (Linnaeus) and *Coscinasterias calamaria* (Gray) (Asteriidae). Their systematic accounts and figures are presented in this paper.

Key words: Asteroid, Echinoderms, Systematic account, Taiwan.

The following ten species of asteroids were recorded previously from Taiwan by earlier investigaters (Hayasaka, 1949; Applegate, 1984; Run, 1985; Run *et al.*, 1988). They are *Culcita novaeguineae* Müller and Troschel (Oreasteridae), *Linckia laevigata* (Linnaeus), *Nardoa tumulosa* Fisher, *Leiaster glaber* Peters (Ophidasteridae), *Astropecten ludwigi* (DE Loriol), *Astropecten scoparius* Valencienne, *Craspidaster hesperus* (Müller and Troschel) (Astropectinidae), *Archaster typicus* Müller and Troschel (Archasteridae), *Monachaster sanderi* (Meissner) (Goniasteridae) and *Acanthaster planci* (Linnaeus) (Acanthasteridae). Apart from these records, little attention has been paid to these common coastal animals of Taiwan.

This study based primarily on the marine invertebrate collections made by a joint team from Laboratory of Marine Biology, National Sun Yat-sen University, and the Institute of Zoology, Academia Sinica working along the southern and northern coasts of Taiwan. Among the echinoderm collections, 48 asteroids were collected extensively from intertidal to subtidal waters of almost 30 meters in depth.

Mortensen (1934) and Wu (1982) stated that the Malaysian region is the richest area with echinoderms in the whole world. Since Taiwan is located within the boundary of the Indo-Malay zoogeographical subregion, it is expected that the asteriod fauna of Taiwan would be highly prosperous. Although only 16 species were recorded currently from

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Taiwan, it is believed that more asteroids would be added in the future as the result of intensive collecting.

MATERIALS AND METHODS

Asteroids collected were narcotized in aqueous $MgSO_4$ (80 grams $MgSO_4$ in 1 liter tap water) for about 12 hours (Lincoin and Sheals, 1979; Applegate, 1984). After narcotisation, the animals were fixed in 10% or 15% formalin for two days then air dried. All specimens were deposited in the Marine Invertebrate Laboratory, Institute of Zoology, Academia Sinica (ASIZ).

General accounts of asteriods are given by Hyman (1955). For a taxonomic background the best comprehensive work is that by Clark and Rowe (1971). The measurements of asteroids are: R, from centre of disc to arm tip; r, from centre of disc to interradial edge.

RESULTS

SYSTEMATIC ACCOUNTS

Family Archasteridae

Archaster typicus Müller and Troschel

(Fig. 1A)

Archaster typicus Müller and Troschel, 1840: 104 (not seen); Hayasaka, 1949: 14; Clark and Rowe, 1971: 47.

Materials: ASIZ 50058, 2 specimens; R=7.5 cm, r=1.4 cm; R=6.3 cm, r=1.1 cm; intertidal areas; Pescadores island; Dec. 14, 1985.

Remarks: The species from Taiwan was described firstly by Hayasaka in 1949. He collected 5 specimens around the mouth of Tan-shui River at northern Taiwan. A large population were found by the authors from the intertidal areas of mud substrates at Pescadores Is. The reproductive cycle and mating behavior were studied by Run (1985) and Run *et al.* (1988).

Family Oreasteridae

Culcita novaeguineae Müller and Troschel

(Figs. 1B, 1C)

Culcita novaeguineae Müller and Troschel, 1842: 38 (not seen); Chang and Liao, 1964: 74; Clark and Rowe, 1971: 54; Marsh, 1974: 77; Okada and Ogida, 1981: 55.

Material: ASIZ 50057, 1 specimen; R=12 cm, r=10 cm; 6 meters depth; Nan-wang, southern Taiwan; Dec. 4, 1985.

Remarks: Hayasaka (1949) described 2 specimens from a shallow bay of Su-ao (N. E. Taiwan) where the bottom covered partly by the coral reefs. Although this species was recorded previously from Liu-chiu-yu (Applegate, 1984), and northern and southern Taiwan, but is rare in Taiwan. During this two years of collections, only three specimens were found on the exposed surface of rocks of platform up to the depth of 3-8 meters. This animal eat living tissues of coral colony.

Family Ophidiasteridae

Fromia monilis Perrier

(Fig. 1D, 2A)

Fromia monilis Perrier, 1875: 443 (not seen); Clark and Rowe, 1971: 62; Marsh, 1977: 258.

Materials: ASIZ 50051, 4 specimens; R=3.3-4.9 cm, r=0.7-1.1 cm; 5-15 meters depth; Nan-wang and Wan-li-tung, southern Taiwan; Nov. 14, 1985.

Diagnosis: Tube feet with terminal discs; five or six arms (usually 5); abactinal plates crowned by granules; marginal plates conspicuous; interradial arcs angular; armament predominantly continuous granuliform, modified into tubereles at the end of arms; adambulacral armament spiniform; papular pore single, actinal pores few or absent on the disc; abactinal granulation fine; color of

supermarginal and proximal abactinal plates orange, the disc orange-red.

Remarks: Animals were found on the exposed surface of rock, extending to the depth of 5-15 meters at reef flat. This species occurred occasionally from northern and southern Taiwan, and Pescadores Is.

Linckia laevigata Linnaeus

(Fig. 1E)

Linckia laevigata Linnaeus, 1758: 662 (not seen); Chang and Liao, 1964: 62; Clark and Rowe, 1971: 62.

Materials: ASIZ 50060, 2 specimens; R=8 cm, r=1.3 cm; R=13 cm, r=2.2 cm; 10 meters depth; Wan-li-tung, southern Taiwan; June. 11, 1985.

Remarks: Linckia laevigata is a common asteriod of Taiwan. They were found on the exposed surface of rock to the depth of 10 meters. Although Applegate (1984) stated that *Linckia laevigata* is the commonest asteriods in Taiwan, however, it is rare during the period from June to November.

Nardoa frianti Koehler

(Figs. 1F, 1B, 2C)

Nardoa frianti Koehler, 1910 (not seen); Clark and Rowe, 1971: 63.

Nardoa mamillifera Livingstone, 1930 (not seen); Clark and Rowe, 1971: 63.

Materials: ASIZ 50054, 1 specimen; R=10 cm, r=1.3 cm; 15 meters depth; Nan-wang, southern Taiwan; Dec. 14, 1985.

Diagnosis: Tube-feet with terminal discs; abactinal plates crowned by granules; five arms; adambulacral armament spiniform; papular pores in groups, present on the oral and aboral sides; a number of isolated abactinal plates abruptly more convex and projecting than the rest, often hemispherical; some of the supero-marginal plates hemispherical as well as some abactinal plates, the height of these often equal to the basal diameter.

Remarks: Only one specimen was found exposed on rock at the depth of 15 meters of reef flat. This species is rare in Taiwan.

Ophidiaster hemprichi Müller and Troschel

(Figs. 2D, 2E)

Ophidiaster hemprichi Müller and Troschel, 1842 (not seen); Clark and Rowe, 1971: 61.

Material: ASIZ 50055, 1 specimen; R=5.5 cm, r=0.7 cm; 4 meters depth; Nan-wang, southern Taiwan; Oct. 9, 1985.

Diagnosis: Tube-feet with terminal discs; body form stellate, five arms; abactinal plates crowned by granules of markedly uneven in size, some granules distinctly flattened and more or less equaliform; marginal plates inconspicuous; arm cylindrical and interradial area small; skeleton fairly solid; armament predominantly granulated; only eight serties of pore-areas; one or more granules developed between the consecutive furrow spines, though sometimes only between alternate pairs; madreporite single; one series of elongated subambulacral spines; longitudinal arrangement of plates fairly regular; arm's tip with a large, convex and denuded terminal ossicle.

Remarks: Only one specimen was found on the exposed surface of rock at the depth of 4 meters at reef flat.

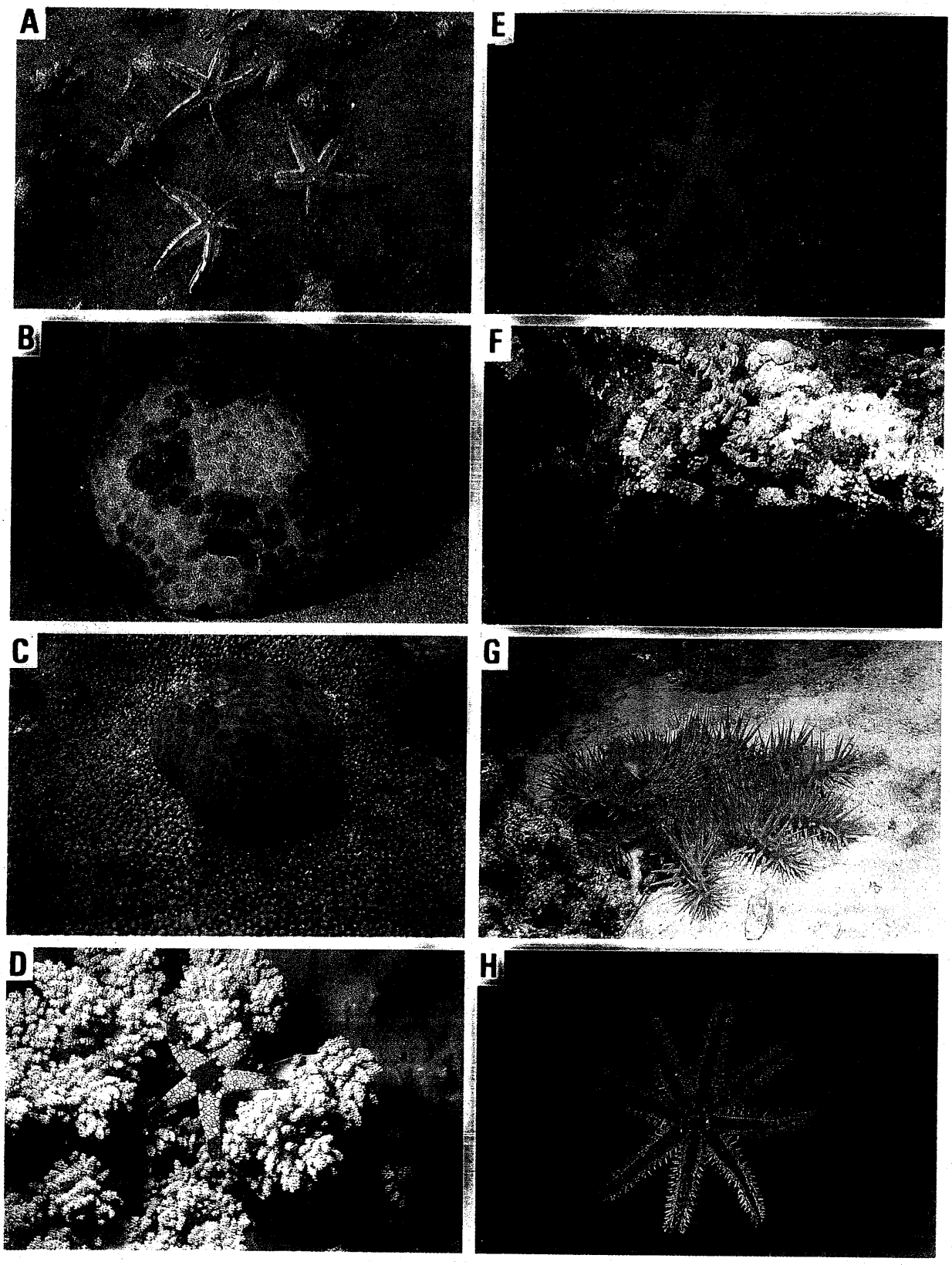
Family Asterinidae

Asterina coronata von Martens

(Fig. 2F)

Asterina coronata von Martens, 1866 (not seen); Clark and Rowe, 1971: 68.

Materials: ASIZ 50052, 2 specimens; R=1.5 cm, r=0.8 cm; R=1.5 cm, r=0.7 cm;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intertidal areas; Dan-shiau, northern Taiwan; Sept. 29, 1984.

Diagnosis: Tube feet with terminal discs; abactinal plates convex, tabulate (with a broad elevation crowned by short spinelets) forming a reticulated pattern; pores separated; marginal plates inconspicuous; body form stellate with flat and aboral convex, edge thin; scattered abactinal plates usually convex and bearing a cluster of markedly enlarged spinelets.

Remarks: *Asterina coronata* was found on the undersurfaces of pebbles and rocks at intertidal areas of northern Taiwan.

Patiriella pseudoexigua Dartnall

(Fig. 2G)

Patiriella pseudoexigua Dartnall, 1971: 43-45; Marsh, 1977: 275.

Materials: ASIZ 50050, 31 specimens; R=0.3-1.3 cm, r=0.2-1.0 cm; R:r=1.2-1.5; intertidal areas; Wan-li-tung, southern Taiwan; Oct. 14, 1985.

Diagnosis: Tube feet with terminal discs; body being small, form pentagonal, edge thin and five arms inconspicuous; abactinal plates convex, tabulate (with a broad elevation crowned by short granules) and imbricated in proximal direction forming a reticulated pattern; marginal plates inconspicuous; oral side flat, aboral side more or less convex; actinal plates with single spinelet, these are larger near the mouth; two or three furrow spines in each set; papular pore separated clearly and distributed uniformly on dorsal side, absent of pore on oral side; color dark green.

Remarks: The range of animals were limited in tidal pools of reef platform, with the highest density of 43 per square meter in July. They were found on the undersurfaces of pebbles and rocks, or at the edge of pools.

Family Acanthasteridae

Acanthaster planci (Linnaeus)

(Fig. 1G)

Asterias planci Linnaeus, 1758: 823 (not seen).
Acanthaster planci: Chang and Liao, 1964: 56; Clark and Rowe, 1971: 71; Marsh, 1977: 275; Okada and Ugida, 1981: 58.

Materials: ASIZ 50059, 2 specimens; R=10 cm, r=5 cm; R=7 cm, r=3.3 cm; 4 meters depth; Wan-li-tung, southern Taiwan; Mar. 28, 1986.

Remarks: These specimens were found on the exposed surface of stony corals at the depth of 4 meters. Both *Acanthaster planci* (Linnaeus) and *Culcita novaeguineae* Müller and Troschel are coral eaters. This species is rare in Taiwan, thus the coral destruction by these animals are not serious.

Family Asteriidae

Coscinasterias calamaria Gray

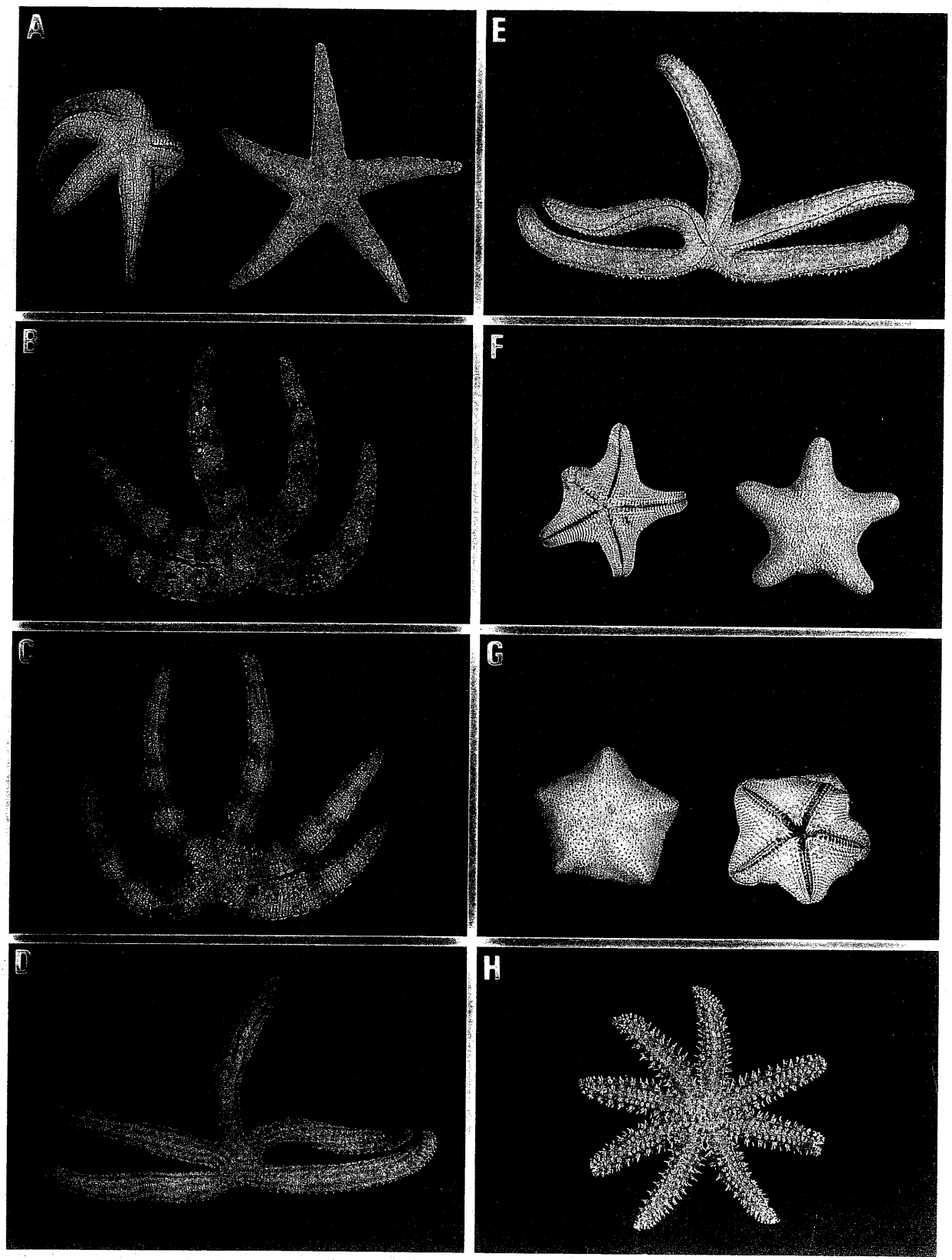
(Figs. 1H, 2H)

Coscinasterias calamaria Gray, 1840 (not seen); Clark and Rowe, 1971: 71.

Materials: ASIZ 50056, 2 specimens; R=2.5 cm, r=0.5 cm; R=1.8 cm, r=0.3 cm; 5 meters depth; Lung-dong, northern Taiwan; Apr. 9, 1985.

Diagnosis: Tube feet with terminal

Fig. 1A. *Archaster typicus* Müller and Troschel.
Figs. 1B, 1C. *Culcita novaeguineae* Müller and Troschel.
Fig. 1D, *Fromia monilis* Perrier.
Fig. 1E. *Linckia laevigata* Linnaeus.
Fig. 1F. *Nardoa frianti* Koehler.
Fig. 1G. *Acanthaster planci* (Linnaeus).
Fig. 1H. *Coscinasterias calamaria* Gray, dried specimen; R=2.5 cm.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discs; body form stellated with 8 arms; ambulacral groove wide, tube feet in four rows; 4 madreporites; 3-4 papular pores in a group; each supero-marginal plate with a long spine, several pedicellariae encircle the base of each spine (i.e. straight pedicellariae); each inframarginal plate with two spines; crossed and straight pedicellariae present.

Remarks: Animals were found from intertidal pool to a depth of 5 meters on northern coast of Taiwan. They were found on undersurfaces of pebbles and rocks.

DISCUSSION

The three species including *Astropecten ludwigi* (de Loriol), *Astropecten scoparius* Valencienne and *Craspidaster hesperus* (Müller and Troschel) recorded by Hayasaka in 1949 were trawled from the sandy ground of deeper than 20 meters on western coast of Taiwan. The former two species were not included in the echinoderm-fauna of Indo-West Pacific by Clack and Rowe (1971). Although only single specimen for both species were collected in Taiwan, it seems that

Table 1
Records of Asteroidea from Taiwan

Taxa	Relation to Substratum	Depth (m)
Astropectinidae		
Astropecten ludwigi (de Loriol)	Sandy bottom	20-50
Astropecten scoparius Valencienne	Sandy bottom	20-50
Craspidaster hesperus (Müller & Troschel)	Sandy bottom	30-100
Archasteridae		
Archaster typicus Müller & Troschel	Sandy bottom	0-3
Goniasteridae		
Monachaster sanderi (Meissner)	limestone rock	1
Oreasteridae		
Culcita novaeguineae Müller & Troschel	limestone rock	5-10
Ophidiasteridae		
Fromia monilis Perrier	limestone rock	5-15
Leiaster glaber Peters	limestone cave	10-15
Linckia laevigata Linnaeus	limestone rock	1-10
Nardoa frianti Koehler	limestone rock	10
Nardoa tumulosa Fisher	limestone rock	5
Ophidiaster hemprichi Müller & Troschel	limestone rock	8
Asterinidae		
Asterina coronata von Martens	limestone rock	8
Patiriella pseudoexigua Dartnall	limestone rock	0
Acanthasteridae		
Acanthaster planci (Linnaeus)	coral and limestone rock	3-7
Asteriidae		
Coscinasterias calamaria Gray	pebbles	2-5

Fig. 2A. *Fromia monilis* Perrier, dried specimen; R=3.7 cm.
Figs. 2B. 2C. *Nardoa frianti* Koehler, dorsal and ventral ventral view; dried specimen; R=10 cm.
Figs. 2D, 2E. *Ophidiaster hemprichi* Müller and Troschel, dorsal and ventral view; dried specimen; R=5.5 cm.
Fig. 2F. *Asterina coronata* von Martens, dried specimen; R=1.5 cm.
Fig. 2G. *Patiriella pseudoexigua* Dartnall, dried specimen; R=1.1 cm.
Fig. 2H. *Coscinasterias calamaria* Gray, dried specimen; R=2.5 cm.

these two commonly known Japanese species may distribute extensively to the Indo-West Pacific area.

The species obtained from trawlers have not yet been thoroughly investigated. *Craspidaster hesperus* (Müller and Troschel) is the most abundant species collected from deep water by trawlers. It needs further investigation on these deep water species to understand the zoogeographical distribution of these animals.

The record of asteroids in Taiwan is shown in Table 1. In general, the fauna of shallow-water asteroid of Taiwan is relatively poor compared with those of Philippine Is. Aside from the three more abundant intertidal species: *Archaster typicus* Müller and Troschel, *Asterina coronata* von Martens and *Patiriella pseudoexigus* Dartnall, the other 7 species were collected occasionally in shallow waters. It is unexpectable to collect these uncommon species at any time everywhere. It is worth to notice that during our two years of collections only few specimens of the above 7 species have been collected. Therefore, the authors suggest that the occurrence of these rare species in Taiwan may be the result of the drift of plantonic larvae from other waters. According to the surface current patterns in the vicinity seas of Taiwan studied by Fan (1982a, b), it is suggested that South China, Philippine islands or the S. W. Pacific Islands may be the most possible places where these larvae came from. Also, regeneration may be the other means to increase the number of these uncommon species, since the animals with incomplete or newly regenerated arms are usually seen in the fields.

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部份臺灣產海星

趙世民　張崑雄

本文記述潛水於臺灣海域水深 0～30 公尺所採集之十種海星，分別是：*Archaster typicus* Müller and Troschel (Archasteridae), *Culcita novaguineae* Müller and Troschel (Oreasteridae), *Fromia monilis* Perrier, *Linckia laevigata* Linnaeus, *Nardoa frianti* Koehler *Ophidiaster hemprichi* Müller and Troschel (Ophidiasteridae), *Asterina coronata* von Martens, *Patiriella pseudoexigua* Dartnall (Asterinidae), *Acanthaster planci* (Linnaeus) and *Coscinasterias calamaria* Gray (Asteriidae)，種的分類說明，圖片均含於文中。