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Revision of Taiwan Starfish (Echinodermata: Asteroidea), with Description of Ten New Records

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Shyh-Min Chao (1999) Revision of Taiwan starfish (Echinodermata: Asteroidea), with description of ten new records. *Zoological Studies* **38**(4): 405-415. This paper revises Taiwan's starfish fauna, listing 31 valid species in 10 families. A key to the 31 species is included. In addition, 10 newly recorded asteroids collected by scuba and skin diving in reef areas, and by trawling off the Taiwan coast are described: *Asterina orthodon* Fisher, *Nepanthia belcheri* (Perrier) (Asterinidae), *Asteropsis carinifera* (Lamarck) (Asteropseidae), *Echinaster callosus* von Marenzeller (Echinasteridae), *Anthenea chinensis* (Gray) (Oreasteridae), *Calliaster childreni* Gray, *Stellasteropsis colubrinus* Macan (Goniasteridae), *Cistina columbiae* Gray, *Linckia multifora* (Lamarck) (Linckiidae), and *Neoferdina insolita* Livingstone (Ophidiasteridae). Species accounts and figures of these 10 species are presented.

Key words: Sea stars, Echinoderms, Species account, Taiwan.

Systematic studies on the starfish from the waters of Taiwan have been limited to only 6 papers (Hayasaka 1949, Applegate 1984, Chao and Chang 1989, Chao et al. 1990, Liao and Clark 1995, Chao 1999) in which only 21 species have been recorded. Among these species, 13 were collected by skin and scuba diving from the intertidal zone to a depth of 20 m, and 8 species were dredged from the sandy substrate from 30 to 200 m in depth.

In 1949, Hayasaka listed 8 species of starfish in Taiwan waters: *Acanthaster planci* (Linnaeus), *Archaster typicus* Müller and Troschel, *Astropecten scoparius* Valencinne, *Astropecten ludwigi* (de Loriol), *Craspidaster hesperus* (Müller and Troshel), *Linckia laevigata* Linnaeus, *Nardoa tumulosa* Fisher, and *Culcita novaeguineae* Müller and Troschel. Liao and Clark (1995) determined that all specimens of *Astropecten scoparius* collected from southern China were *A. vappa* Müller and Troschel. I agree with their conclusion. *A. vappa* is common in the Taiwan Strait. As *Ctenopleura ludwigi* has not been collected since Hayasaka (1949), Chao (1999) observed that it probably was a misidentification of *C. sinica*, which is common in waters off Taiwan.

Applegate (1984) collected 4 additional species of starfish (*Monachaster sanderi* [Meissner], *Culcita novaeguineae* Müller and Troschel, *Leiaster glaber* [Peters] and *Linckia laevigata* Linnaeus) from the reef areas of southern Taiwan and Orchid I. All specimens are deposited in the Biology Department, Tunghai Univ., Taichung. I have checked these specimens and confirm that *Leiaster glaber* and *Monachaster sanderi* are misidentifications of *Leiaster speciosus* and juvenile *Culcita novaeguineae*, respectively.

Coscinasterias calamaria (Gray) collected from northern Taiwan by Chao and Chang (1989) is re-identified as *C. acutispina* (Stimpson) in this paper. *C. calamaria* (Gray) has a discontinuous distribution, being known from Mascarene I., East Africa, China, southern Japan, South Pacific islands (Clark and Rowe 1971), and from tropical Australia, (Rowe and Gates 1995, as *Stolasterias calamaria*). *Coscinasterias acutispina* (Stimpson) is a common littoral species from southern China and southern Japan (Imaoka et al. 1991, Liao and Clark 1995). I believe the specimens from the littoral zone of northern Taiwan belong to the *acutispina* group.

From the descriptions of *C. acutispina* and *C. calamaria*, it is hard to distinguish these 2 species.

The illustration of *C. calamaria* by Clark and Rowe 1971 is clearly the same as *C. acutispina*. Clark and Downey (1992) suggest that it is better to treat both *C. calamaria* and *C. acutispina* as subspecies of *C. tenuispina* (Lamarck), which is common in the Atlantic and the Mediterranean. Further study of these 3 species of *Coscinasterias* is needed. Rowe (Rowe and Gates 1995) has referred these species to the genus *Stolasterias* (type species *S. tenuispina* [Lamarck]).

I have collected Taiwanese starfish by both scuba and skin diving off the coast of Taiwan and surrounding islands (Pescadore Is., Green I., and Orchid I.) (Fig. 1) since 1989. Trawls were made at irregular intervals on sandy bottoms off western and northeastern Taiwan to a depth of 200 m. Many starfish were collected including 10 species recorded from Taiwan for the first time.

Of these 10 species, *Anthenea chinensis* and *Calliaster childreni* were dredged from sandy substrates of 50-200 m in depth. *A. chinensis* is abundant in the Taiwan Strait. More than 100 specimens of various sizes were collected from 1995 to 1998. *Calliaster childreni* is rare in waters off Taiwan. Only 2 specimens were trawled in the past decade.

The other 8 species were collected from shallow rocky substrates of less than 20 m in depth by scuba and skin diving. *Nepanthia belcheri* and *Linckia multifora* are abundant on the Pescadore Is. and Orchid I., respectively. Both species undergo frequent fissiparous asexual reproduction. The remaining 6 species are relatively rare in Taiwan; collection is serendipitous. Less than 3 specimens of each species were found in the past 15 yr. I suggest that the occurrence of these rare species in Taiwan may be the result of plantonic larvae drifting from other waters. As these 6 species are common in tropical reef flats, the larvae probably originate in the Indo-Malay region, especially the Philippines.

To date, 31 species in 10 families of starfish have been collected from Taiwan. The starfish fauna from Taiwan is poor compared to that of southern China, the Philippines, and Japan. This may be due to the limited nature of the investigations. Mortensen (1934) and Wu (1982) state that the Malaysian region is the richest area for echinoderms in the world. As Taiwan is located within the boundary of the Indo-Malay zoogeographical subregion, Taiwan should have a prosperous and diverse asteroid fauna. Systematic collection of the echinoderms from Taiwan is currently being conducted by the National Museum of Natural Science. More starfish species are expected to be collected in the near future.

The object of this study is to present species accounts and figures of the 10 newly recorded species. A synoptic list of the 31 species and 10 families of starfish from Taiwan is included. A key to all 31 recorded starfish is presented. Specimens are deposited in the National Museum of Natural Science (NMNS), Taichung, Taiwan. The following abbreviations are used in the text: R = the length from disc center to ray tip; r = the length from disc center to interradial edge.

Synopsis of Asteroidea from Taiwan

Asteroid species found in Taiwan are based on Hayasaka (1949), Applegate (1984), Chao and Chang, (1989), Chao et al. (1990), Lee and Chen (1994), Liao and Clark (1995), Chao (1999), and this study. The mark " ※ " represents new record in this paper.

ACANTHASTERIDAE
Acanthaster planci (Linnaeus)
ARCHASTERIDAE
Archaster typicus Müller and Troschel
ASTERIIDAE
Coscinasterias acutispina (Stimpson)

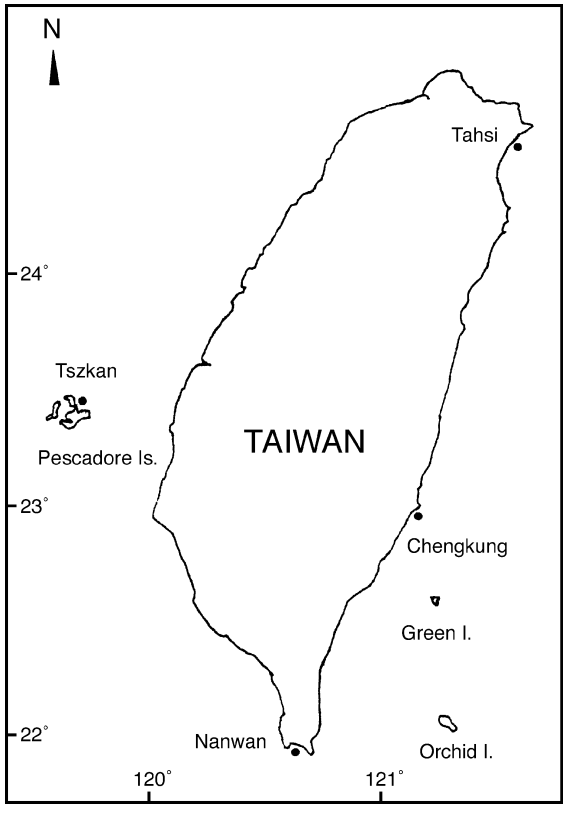


Fig. 1. Map of Taiwan.

ASTERINIDAE
- *Asterina coronata* von Martens
- ※ *A. orthodon* Fisher
- ※ *Nepanthia belcheri* (Perrier)
- *Patiriella pseudoexigua* Dartnall

ASTEROPSEIDAE
- ※ *Asteropsis carinifera* (Lamarck)

ASTROPECTINIDAE
- *Astropecten polyacanthus* Müller and Troschel
- *A. vappa* Müller and Troschel
- *Astropecten velitaris* von Martens
- *Craspidaster hesperus* (Müller and Troshel)
- *Ctenopleura sinica* (Döderlein)
- *Dipsacaster pretiosus* (Döderlein)
- *Tethyaster aulophorus* (Fisher)

ECHINASTERIDAE
- ※ *Echinaster callosus* von Marenzeller
- *E. luzonicus* (Gray)

GONIASTERIDAE
- ※ *Calliaster childreni* Gray
- ※ *Stellasteropsis colubrinus* Macan

OPHIDIASTERIDAE
- ※ *Cistina columbiae* Gray
- *Fromia monilis* Perrier
- *Leiaster speciosus* von Martens
- *Linckia laevigata* Linnaeus
- ※ *L. multifora* (Lamarck)
- *Nardoa frianti* Koehler
- *N. tumulosa* Fisher
- ※ *Neoferdina insolita* Livingstone
- *Ophidiaster hemprichi* Müller and Troschel

OREASTERIDAE
- ※ *Anthenea chinensis* (Gray)
- *Culcita novaeguineae* Müller and Troschel
- *Pentaceraster westermanni* von Martens

Key to species of starfish from Taiwan

This key is adapted from Clark and Rowe (1971), Guille et al. (1986), and Liao and Clark (1995).

1. Podia with rounded or conical knob (no “sucker”); edge of body defined by 2 rows of conspicuous marginal plates .. 2
   Podia with a terminal disc (“sucker”) 8
2. Actinal plates extending to the rays, usually more than 2 rows 3
   Actinal plates restricted to disc, usually only 1 row, not more than 2 4
3. Madreporite completely covered by paxillae ..... *Dipsacaster pretiosus*
   Madreporite not covered by paxillae ..... *Tethyaster aulophorus*
4. Periphery fringed with large conspicuous spines, at least on infero-marginal plates 5
   Periphery of body appearing smooth, spines at upper end of infero-marginal plates appressed and inconspicuous .... *Craspidaster hesperus*
5. At least 1 large spine projecting horizontally from upper end of each infero-marginal plate; adambulacral plate with 3 furrow spines 6
   Infero-marginal spines appressed; adambulacral plate with about 5 furrow spines ..... *Ctenopleura sinica*
6. Size small, R usually < 3 cm; large spine on 1st supero-marginal plate only ..... *Astropecten velitaris*
   R usually > 4 cm; most supero-marginal plates armed with spines 7
7. A large, erect, conical spine on upper end of each supero-marginal plate ..... *Astropecten polyacanthus*
   Usually 1 short blunt spine in middle of some supero-marginal plates ..... *Astropecten vappa*
8. Abactinal plates bearing paxillae; median row of paxillae clearly larger than lateral rows; ray flattened; marginal plates conspicuous; large compressed spines fringing upper end of infero-marginal plates ..... *Archaster typicus*
   Abactinal plates of various aspects but lacking paxillae .. 9
9. Abactinal surface flat; prominent marginal plates forming conspicuous side-wall 10
   Abactinal surface slightly convex; marginal plates well developed, reduced, or inconspicuous; no conspicuous side-wall 12
10. Marginal plates with fine granules; pores in groups; 5 abactinal plates convex in a conical form on disc forming a pentagon; ray tip with short conical tubercles .... *Stellasteropsis colubrinus*
    Marginal plates with coarse granules or short conical tubercles 11
11. Marginal plates with 2-3 short conical tubercles; a longitudinal series of conical tubercles on carinal plates .... *Calliaster childreni*
    Marginal plates with numerous coarse granules; abactinal plates with coarse granules; infero-marginal plates and actinal plates with numerous valvate pedicellariae .... *Anthenea chinensis*
12. Marginal plates well developed, sometimes concealed by thickened skin 13
    Marginal plates reduced and inconspicuous 23
13. Relatively slender asteroids with reduced interradial areas; abactinal skeleton compact; papulae single or in groups; marginal plates reduced but still visible 14
    Usually massive asteroids, R > 100 mm, with enlarged interradial areas; abactinal skeleton reticulate, usually bearing strong tubercles; papulae in groups; marginal plates more or less concealed by skin 22
14. Abactinal plates in regular longitudinal series 15
    Abactinal plates irregular in arrangement 17
15. Skin thin; granules present on all plates; papular areas in 8 longitudinal series; with a large, convex terminal plate ... . *Ophidiaster hemprichi*
    Skin thick; no granules or tubercles except on adambulacral plates 16
16. Skin perfectly smooth; color uniformly crimson .... *Leiaster speciosus* von Martens
    Skin penetrated by a few spines; spines and plates in 7 longitudinal series; each plate with a short spine; usually 5 rays ..... *Cistina columbiae*
17. Adambulacral armature granuliform; rays cylindrical, disc narrow 18
    Adambulacral armature spiniform; rays cylindrical or flattened 19
18. Fissiparous species, usually 5 rays of different sizes; small size, R usually < 3 cm ..... *Linckia multifora*
    Not fissiparous; large size, R usually > 10 cm; color blue or bluish-green ..... *Linckia laevigata*
19. Papulae present below infero-marginal plates 20

No papulae below infero-marginal plates; abactinal plates with granules, some marginal and/or abactinal plates conspicuously bare and convex; papulae single; occurrence of convex medioabactinal plates forming a conspicuous carinal row ..... *Neoferdina insolita*

20. Papulae single; rays and disc relatively flattened; color of disc and ray tip orange-red, other parts orange ..... *Fromia monilis*
Papulae in a group; ray cylindrical, disc relatively convex .. 21
21. Sparse hemispherical plates, height of these plates often equal to basal diameter, measuring less than 3 mm ..... *Nardoa frianti*
Hemispherical plates low, broad and dense, measuring 4-5 mm in diameter ..... *Nardoa tumulosa*
22. Body pentagonal or almost circular in outline; form massive, R often > 6 cm; actinal plates covered by coarse granules, often in groups and with some finer granules among the coarse ones ..... *Culcita novaeguineae*
Body stellate with well-developed rays; large spines in 7 longitudinal rows on abactinal and supero-marginal plates; R up to 20 cm ..... *Pentaceraster westermanni*
23. Podia arranged in 4 rows; occurrence of rosettes of crossed pedicellariae associated with marginal and abactinal spines; 3-4 madreporites; 6-8 rays; fissiparous species ..... *Coscinasterias acutispina*
Podia arranged in 2 rows; no crossed pedicellariae associated with marginal or abactinal spines 24
24. Body flat below; ray section triangular or more or less elliptical in shape; abactinal skeleton compact 25
Body round below; ray section circular in shape; abactinal skeleton reticulate 29
25. Body covered by smooth skin obscuring most plates; carinal and supero-marginal plates bearing series of conical spines ..... *Asteropsis carinifera*
Skin thin, skeletal plates distinct and overlapping (at least the abactinal plates); abactinal, marginal, and actinal plates with single or grouped spinelets or short spines 26
26. Ray well developed, fingerlike, R/r > 3/1; usually 6-7 rays; fissiparous species; small size, R usually < 2 cm ..... *Nepanthia belcheri*
Body pentagonal or stellate with short rays, R/r usually 1.5-2.5/1; usually 5 rays; no fissiparity 27
27. Body form almost or quite pentagonal, R/r < 1.5/1; abactinal plates crowned by firm granules; each actinal plate with single spinelet; 2-3 furrow spines per set; intertidal species ..... *Patiriella pseudoexigua*
Stellate body form, R/r > 1.5/1 28
28. Body markedly flattened, R/r usually < 1.7/1; abactinal armament consisting of fine minute hyaline spinelets, easily dislodged ..... *Asterina orthodon*
Body always thick midradially, R/r often > 2/1; several abactinal plates convex and bearing enlarged spinelets .... *Asterina coronata*
29. More than 10 rays and several madreporic plates ..... *Acanthaster planci*
Five rays and 1 madreporic plate; marginal and abactinal plates irregularly arranged, single spine on some plates ... 30
30. Abactinal spines small, usually 1.0-1.5 mm long and fairly numerous ..... *Echinaster luzonicus*
Abactinal spines large and conspicuous, often 4-5 mm long and well spaced ..... *Echinaster callosus*

SPECIES ACCOUNTS

Followings are species accounts of the 10 new records. Descriptions and figures of the other 21 species are published in recent papers (Applegate 1984, Chao and Chang 1989, Chao et al. 1990, Chao 1999).

Family Asterinidae
Asterina orthodon Fisher
(Figs. 2A, 5, 6)

Asterina orthodon Fisher 1922: 415-418, figs. 1, 2, pl. 10 (type locality: Hong Kong); Clark and Rowe 1971: 67; Liao and Clark 1995: 131; Rowe and Gates 1995: 35.

Materials: NMNS2318-159, 1 specimen, R/r = 14 mm/10 mm; NMNS2318-160, 1 specimen, 9 mm/8 mm, Chengkung.

Diagnosis: Body small and flat. Five rays indistinct. Abactinal plate bearing 10-15 minute hyaline spinelets that dislodge easily. Dry specimens usually with bare abactinal plates, imbricating in the proximal direction. Anus at center of disc and surrounded by 6-12 hyaline spinelets. Madreporite single, near anus, and with numerous fine pores. Papulae not in groups and on abactinal surface only. Small terminal plate conspicuous and slightly convex. Actinal plates in regular series, each plate with 3-5 hyaline webbed spinelets. Furrow spines webbed, 6-8 per set (Fig. 2A). Oral armature consisting of 7 webbed marginal spines and 3 webbed suboral spines.

Distribution: Southern China (Liao and Clark 1995) and Taiwan (this report).

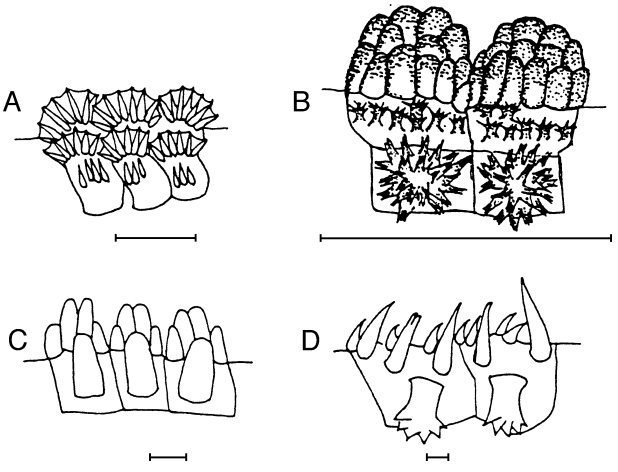


Fig. 2. Ambulacral armature of (A) *Asterina orthodon* Fisher. (B) *Nepanthia belcheri* (Perrier). (C) *Asteropsis carinifera* (Lamarck). (D) *Echinaster callosus* von Marenzeller. Proximal direction is the left side. Scale is 1 mm.

Remarks: This species was collected from the base of dead branching corals (*Pocillopora verrucosa*) at 8 m in depth. Rowe (Rowe and Gates 1995) includes *A. orthodon* in the synonymy of *A. sarasini* (de Lorial), though Liao and Clark (1995) comment that synonmy with *sarasina* requires further investigation. If the view of Rowe (Rowe and Gates 1995) is accepted, then the distribution extends between Sri Lanka, tropical Australia, and Taiwan.

***Nepanthia belcheri* (Perrier)**
(Figs. 2B, 7, 8)

Asterina (*Nepanthia*) *belcheri* Perrier, 1875: 320 (type locality: uncertain, see Rowe and Marsh 1982: 103).
Nepanthia belcheri: Rowe and Marsh 1982: 99-103, fig. 3, d-e (complete synonymy); Liao and Clark 1995: 133; Rowe and Gates 1995: 37.

Materials: NMNS2318-145, 2 specimens, R/r = 13 mm/4 mm, 12 mm/3 mm, Tszkan, Pescadore Is.; NMNS2318-144, 3 specimens, R/r = 14 mm/4 mm, 8 mm/3 mm, 8 mm/3 mm, Tszkan.

Diagnosis: Size small, R usually < 20 mm. Animals usually with 6-7 rays. One to 3 rays always larger than the rest, indicating fissiparous asexual reproduction. Cross section of ray more or less circular. Abactinal and actinal plates covered with fine firm hyaline-tipped spinelets, giving a velvety texture. Papulae usually not in groups and found on abactinal surface only. One to 5 madreporites; number usually equal to number of rays. Terminal plate conspicuous. Adambulacral armature including 6-8 furrow spines, 4-8 subambulacral spines, and 6-14 additional hyaline-tipped spinelets (Fig. 2B).

Distribution: Indo-Malay region to northern Australia (Rowe and Marsh 1982), southernmost China (Liao and Clark 1995), and Taiwan (this report).

Remarks: This species was collected from the undersides of rocks, or was found attached to the broken skeletons of branching corals, *Acropora*, near the low tide mark. The color of the abactinal surface is similar to the substrate, while the actinal surface is light brownish yellow to pink. Abundant fissiparous individuals were collected from the Pescadore Is.

Family Asteropseidae
***Asteropsis carinifera* (Lamarck)**
(Figs. 2C, 9, 10)

Asterias carinifera Lamarck, 1816: 556 (type locality: 'Les mers australes').
Asterope carinifera: Chang et al. 1964: 61; Okada and Ugida 1981: 57.
Asteropsis carinifera: Clark and Rowe 1971: 38, pl. 9, fig. 9; Marsh 1974: 91; Price 1982: 7 (table 1); Guille et al. 1986: 142-143; Liao and Clark 1995: 125, fig. 52, pl. 16, fig. 7; Rowe and Gates 1995: 44-45; Moosleitner 1997: 12, fig. 12a, b.

Materials: NMNS2318-168, 1 specimen, R/r = 68 mm/25 mm, Nanwan; NMNS2318-169, 1 specimen, R/r = 65 mm/22 mm, Pescadore Is.

Diagnosis: Animals with 5 equal rays. Cross section of ray triangular. Actinal surface flat, while abactinal surface convex. Body surface covered with thick epidermis. Anus at center of disc, surrounded by 15-20 elongate granules. Madreporite single, oval, convex, 2.5 mm in transverse diameter, and with numerous radiating striations. Abactinal and actinal plates oval in shape and arranged in longitudinal series. Carinal and supero-marginal plates bearing prominent conical spines. Adambulacral armature with 4 furrow spines and 1 large spatulate subambulacral spine (Fig. 2C). In life, animal dark green, mottled with pale gray. Dry specimens pale brown.

Distribution: Throughout the Indo-West Pacific area (Clark and Rowe 1971, Price 1982, Liao and Clark 1995, Moosleitner 1997) and Taiwan (this report).

Remarks: This species is nocturnal in habit, oc-

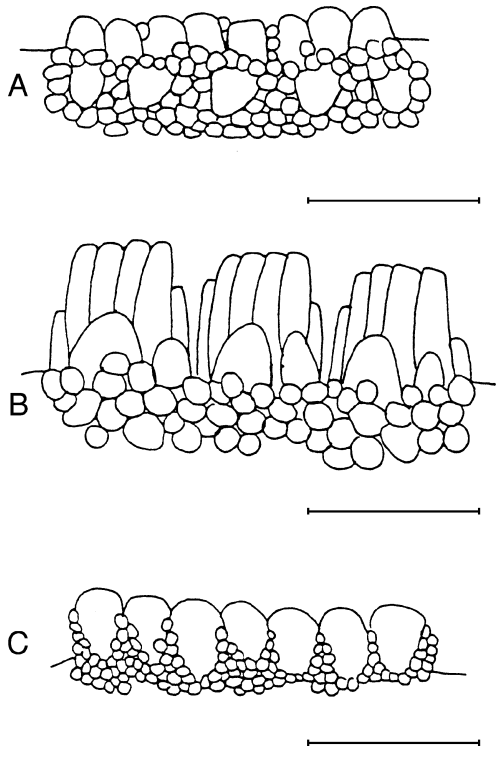


Fig. 3. Ambulacral armature of (A) *Linckia multifora* (Lamarck). (B) *Stellasteropsis colubrinus* Macan. (C) *Neoferdina insolita* Livingstone. Proximal direction is the left side. Scale is 1 mm.

curring at 0-3 m in depth in rocky areas. It is rare in Taiwan. Only 3 individuals were collected during the past 15 yr.

Family Echinasteridae
Echinaster callosus Marenzeller
(Figs. 2D, 13, 14)

Echinaster callosus Marenzeller, 1895: 531, pl. 1 (type locality: Solomon Is.); Fisher 1919: 428-429, pl. 112, fig. 2, pl. 122, figs. 4, 5, pl. 132, fig. 5a-5e; Clark and Rowe 1971: 72; Marsh 1977: 277-278; Price 1982: 7; Guille et al. 1986: 150-151; Rowe and Albertson 1987: 197; Rowe and Gates 1995: 59.

Material: NMNS2318-164, 1 specimen, R/r = 130 mm/12 mm, Green I.

Diagnosis: Disc small. Animals with 5 rays tapering and curving toward ray tip. Cross section of ray more or less circular. Body surface covered with thick skin. Madreporite single and convex, 2 mm in diameter, and with numerous radiating striations. Skeletal plates in an open meshwork with large papular areas. Pointed spines measuring 3-4 mm occurring at angles of meshes. Every 4th or 5th inferomarginal plate with an expanded large spine with 3-8 forked tips. The furrow armature with 1-2 curved spines deep in the furrow and a large spine, 3-4 mm long, on furrow edge (Fig. 2D). Dry specimen dark brown.

Distribution: Islands of the West Indian Ocean, East Africa, and Madagascar (Clark and Rowe 1971), Gulf of Aqaba (Price 1982), NE Australia (Rowe and Albertson 1987, Rowe and Gates 1995), and Taiwan (this report).

Remarks: This specimen was collected from a reef area at 6 m in depth.

Family Goniasteridae
Calliaster childreni Gray
(Figs. 4B, 19, 20)

Calliaster childreni Gray, 1840: 280 (type locality: Japan); Clark and Rowe 1971: 47; Imaoka et al. 1991: 56-59; Liao and Clark 1995: 92; Rowe and Gates 1995: 64.

Material: NMNS2318-171, 1 specimen, R/r = 50 mm/20 mm, Tahsi.

Diagnosis: Animal with 5 flat rays. Body rigid. Marginal plates large, forming a conspicuous side-wall. Abactinal plates naked, no granules or spines on surface except on midradial plates (carinal plates). Some midradial plates bearing high conical tubercles which are arranged in a longitudinal series. Abactinal plate surrounded by 15-25 coarse angular granules (Fig. 4B). Single madreporite 3 mm in diameter, convex and with numerous radiating striations. Each supero- or infero-marginal plate bearing 2-3 short conical tubercles which dislodge easily. Several actinal plates bearing short conical tubercles which dislodge easily. Adambulacral armature with 6-8 furrow spines and 2 enlarged subambulacral spines.

Distribution: China, southern Japan (Clark and Rowe 1971), and northern Taiwan (this report).

Remarks: This specimen was trawled from sandy substrate at about 100 m in depth.

Stellasteropsis colubrinus Macan
(Figs. 3B, 21, 22)

Stellasteropsis colubrinus Macan, 1938: 395 (type locality: SE Arabia); Clark and Rowe 1971: 48.

Material: NMNS2318-173, 1 specimen, R/r = 25 mm/11 mm, Nanwan, southern Taiwan.

Diagnosis: Animal with 5 rays. Body rigid. Actinal surface flat. Marginal plates conspicuous, forming a side-wall. Abactinal and actinal plates covered with small dense granules. Five abactinal plates protruding on disc, arranged in a pentagonal shape. Granules on primary plates usually dislodged. Center of abactinal interradial area conspicuously concave. Anus at center of disc and surrounded by about 10 enlarged granules. Madreporite absent. Without pedicellaria. Papular pores on abactinal surface, 2-5 in a group. The distalmost marginal plates and terminal plate bearing 1-2 short tubercles. Adambulacral armature with 6-7 furrow spines (usually 6) and 2 stout subambulacral spines (Fig. 3B). Ambulacral groove narrow in both living and dry specimens. Animal in life black on abactinal

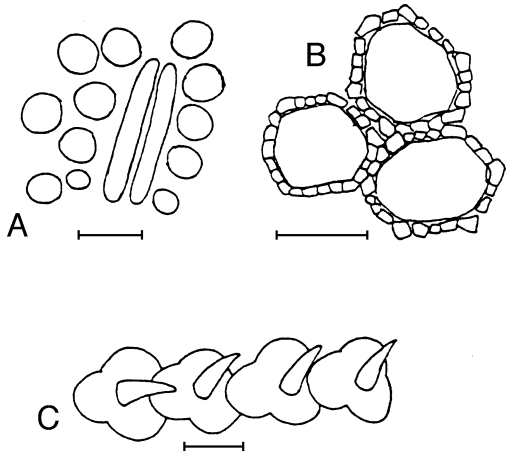


Fig. 4. (A) Actinal granules and valvate pedicellariae of *Anthenea chinensis* (Gray). (B) Abactinal plates and surrounding granules of *Calliaster childreni* Gray. (C) Abactinal plates and spines of *Cistina columbiae* Gray. Proximal direction is the left side. Scale is 1 mm.

surface and light brown on actinal surface. Dry specimen grayish white.

Distribution: NE Africa, SE Arabia (Clark 1993), and Taiwan (this report).

Remarks: It was found on the underside of a rock, 4 m deep in a coral reef. Only 1 individual was collected from Taiwan during the past 15 yr. It is worth noting that this species was previously found only from the western Indian Ocean (Clark and Rowe 1971, Clark 1993). This is the first report of its occurrence in the western Pacific.

Family Ophidasteridae
Cistina columbiae Gray
(Figs. 4C, 11, 12)

Cistina columbiae Gray, 1840: 283 (type locality: west coast of Columbia); Clark and Rowe 1971: 72 (complete synonymy, with discussion of type locality); Blake 1978: 239-241; Guille et al. 1986: 128-129; Rowe and Gates 1995: 80-81.

Materials: NMNS2318-147, 1 specimen, R/r = 18 mm/3 mm, Nanwan; NMNS2318146, 1 specimen, R/r = 50 mm/5 mm, southern Taiwan.

Diagnosis: Animal with 5 rays. Disc small. Cross section of ray more or less circular. Madreporite single, 1 mm in diameter and with numerous radiating striations. Papupar pores not grouped. Anus at center of disc, surrounded by 5 spinelets. Skeletal plates imbricating in 7 longitudinal series on each ray. Each plate bearing a conical spine arranged in 7 longitudinal series (Fig. 4C). Adambulacral armature with 2 webbed furrow spines and 1 webbed subambulacral spine.

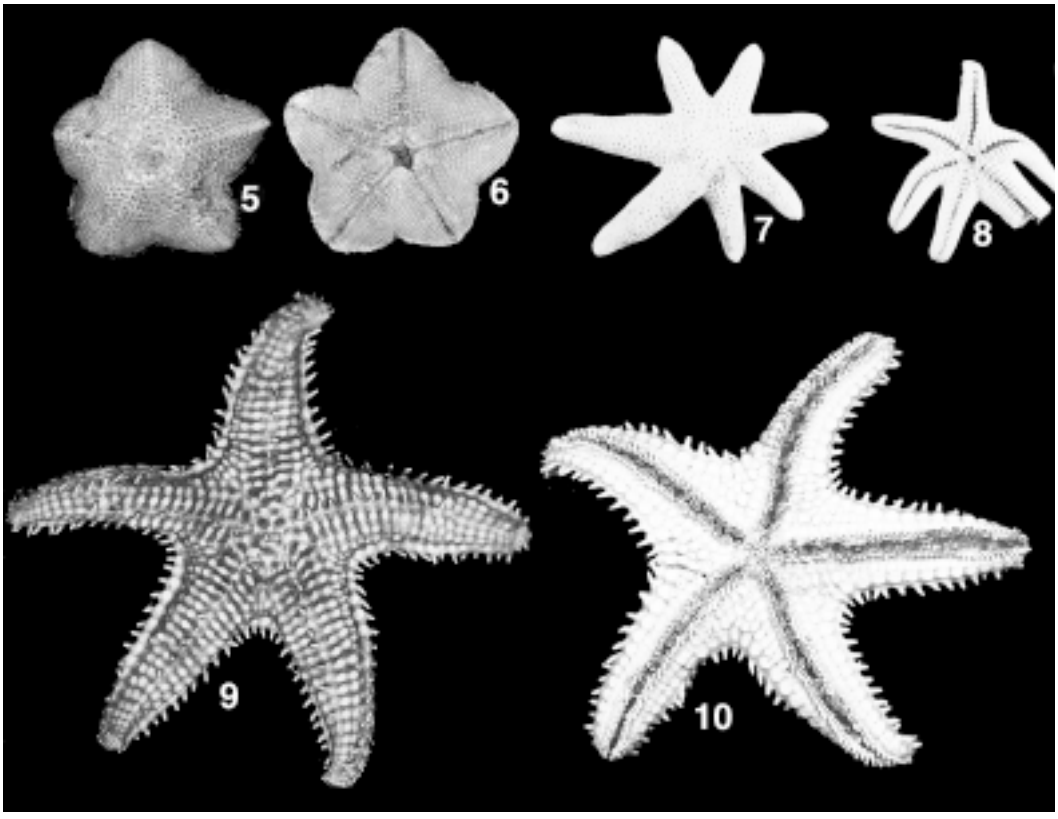
Distribution: Mauritius, Chagos Archipelago, Laccadive Is. (Indian Ocean), New Caledonia (West Pacific), northern coast of Australia (Clark 1993, Rowe and Gates 1995), and Taiwan (this report).

Remarks: This specimen was found at 3-10 m in depth on rocky substrate.

Linckia multifora (Lamarck)
(Figs. 3A, 15, 16)

Asterias multifora Lamarck, 1816: 565 (type locality: unknown 'European Seas').

Linckia multifora Clark and Rowe, 1971: 62; Marsh 1974: 86; Clark and Courtman-Stock 1976: 72; Guille et al. 1986: 138-139;

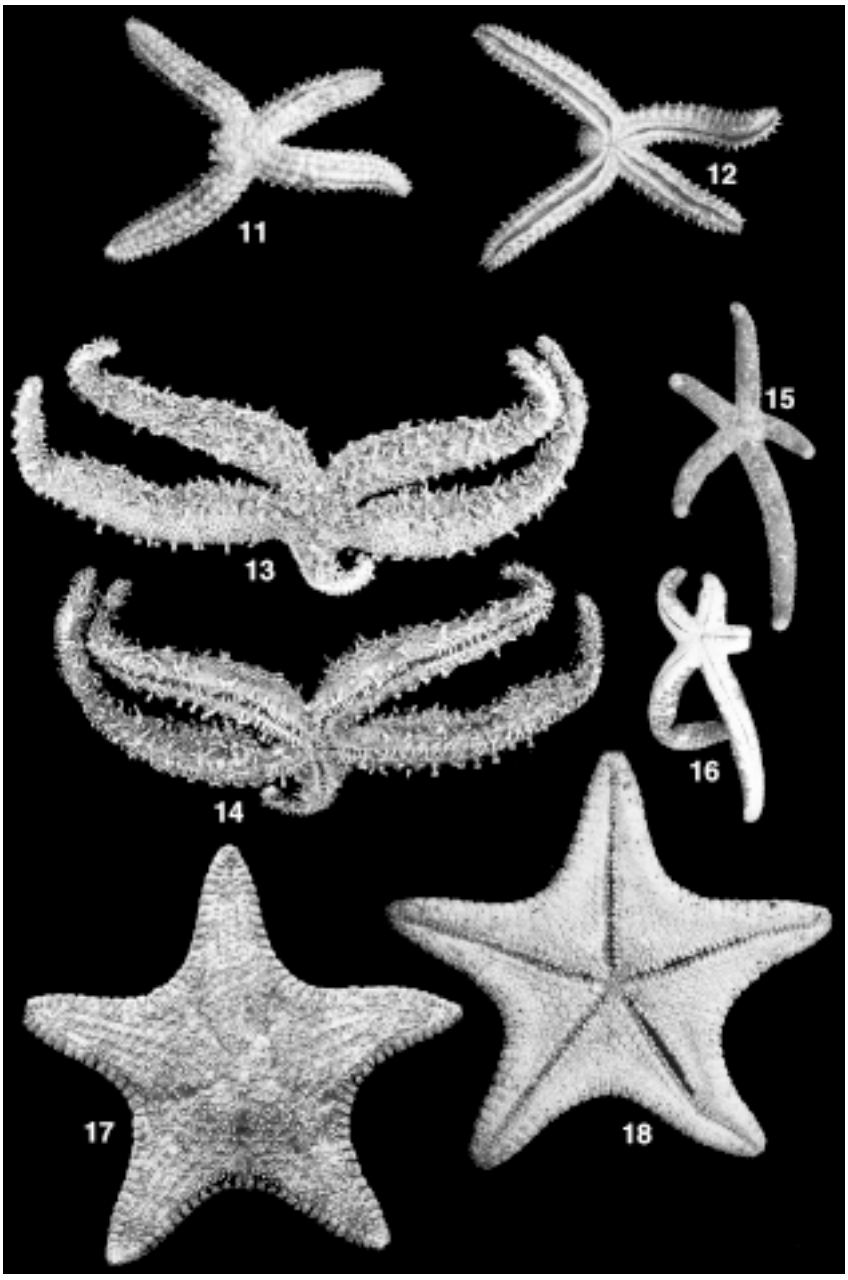


Figs. 5, 6. *Asterina orthodon*, R = 14 mm.
Figs. 7, 8. *Nepanthia belcheri*, R = 14 mm, 12 mm.
Figs. 9, 10. *Asteropsis carinifera*, R = 65 mm.

Walenkamp 1990: 61; Coleman 1994: 26; Liao and Clark 1995: 117; Rowe and Gates 1995: 87; Gosliner et al. 1996: 260.

Materials: NMNS2318-156, 1 specimen, R/r = 25 mm/4 mm, Orchid I.; NMNS2504-17, 7 specimens, R/r = 20-30 mm/3-5 mm. Orchid I.

Diagnosis: Size small. Animal with 5 rays, rarely 6. Rays of different lengths due to fissiparous asexual reproduction. Cross section of ray more or less circular. Both actinal and abactinal plates covered with dense granules. Papular pores 3-5 in a group on abactinal surface. Few papular pores on actinal plates, especially near disc. Madreporites 1-2 in number, with several radiating striations. Furrow spines flat and blunt, more or less in granular form, 2 per set (Fig. 3A). One to 3 granules sometimes



Figs. 11, 12. *Cistina columbiae*, R = 18 mm.
Figs. 13, 14. *Echinaster callosus*, R = 130 mm.
Figs. 15, 16. *Linckia multifora*, R = 25 mm.
Figs. 17, 18. *Anthenea chinensis*, R = 85 mm.

found between furrow spines (Fig. 3A). With a flat and blunt subambulacral spine which is separated from furrow spines by 3-8 granules. Color in life variegated, with purple or red spots on rays. Tip of ray blue.

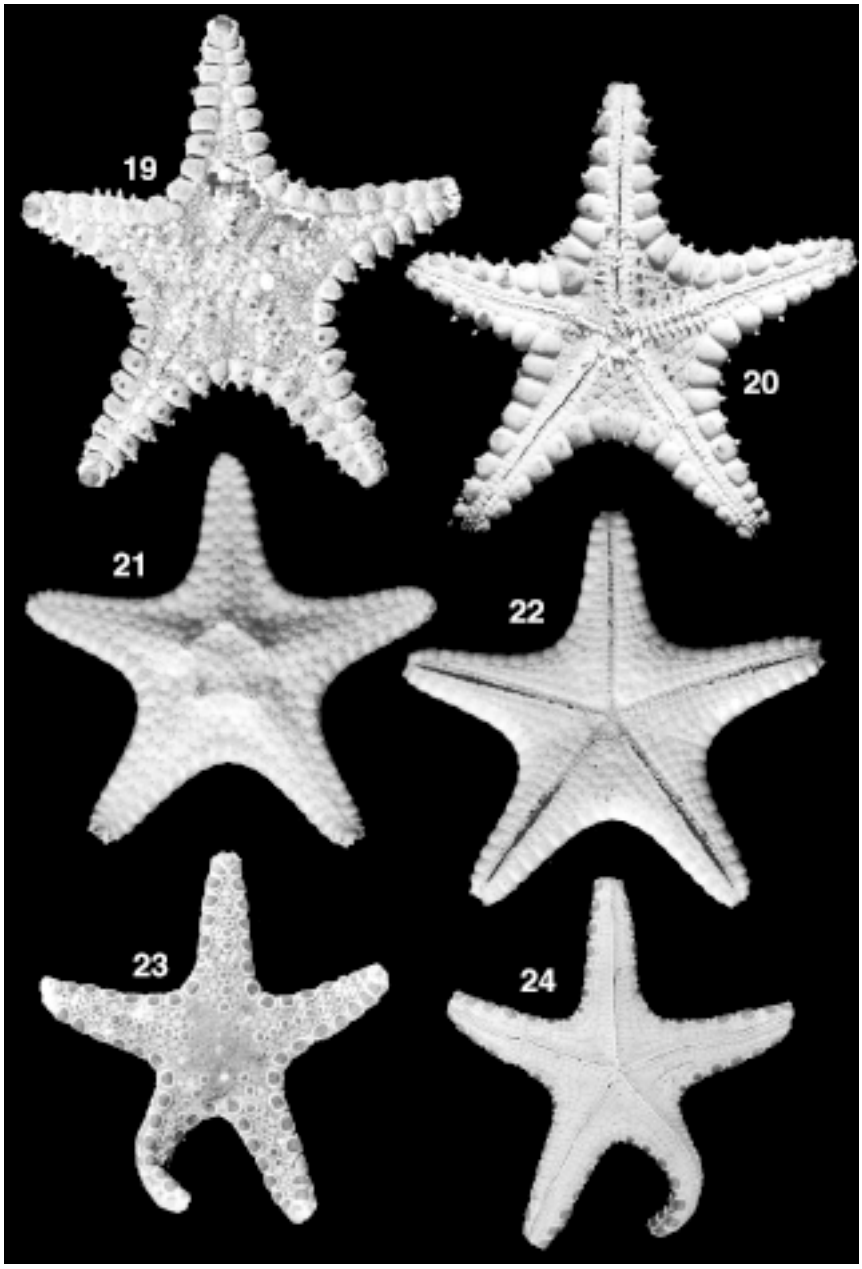
Distribution: Throughout the tropical Indo-West Pacific area (Clark and Rowe 1971), and Taiwan (this report).

Remarks: This specimen was collected from reef area at 4 m in depth. It is common at Orchid I.

Neoferdina insolita **Livingstone**
(Figs. 3C, 23, 24)

Neoferdina insolita Livingstone, 1936: 384, pl. 28, figs. 2, 4, 6 (type locality: Papua-New Guinea); Clark and Rowe 1971: 65; Rowe and Gates 1995: 89; Gosliner et al. 1996: 262, fig. 961.

Materials: NMNS2318-141, 1 specimen, R/r =



Figs. 19, 20. *Calliaster childreni*, R = 50 mm.
Figs. 21, 22. *Stellasteropsis colubrinus*, R = 25 mm.
Figs. 23, 24. *Neoferdina insolita*, R = 23 mm.

23 mm/7 mm, Nanwan; NMNS2318-140, 1 specimen, R/r = 21 mm/6 mm, Orchid I.; NMNS2318-143, 1 specimen, R/r = 23 mm/8 mm, Orchid I.

Diagnosis: Animals normally with 5 rays. Body flat. Abactinal and actinal plates covered with fine granules, while the superomarginals, inferomarginals, and carinal plates enlarged and bare. These bare plates slightly convex but not hemispherical. With no bare plates on disc. With 8 superomarginals and 8 inferomarginals. Terminal plate conspicuous and concave. The distalmost inferomarginals and terminal plate bearing 1-2 tubercles. Madreporite circular, with pores and short slits. Anus at center of disc and surrounded by 7 flat granules. Solitary papular pores on abactinal surface. Furrow spines short spatulate, 2 per plate (Fig. 3C). Dense granules sandwiched between furrow spines (Fig. 3C). Abactinal surface of disc usually red in life. Marginal and carinal plates distinct dark brown color. Colors preserved in dry specimens.

Distribution: Papua-New Guinea (East Indies) (Clark and Rowe 1971), tropical Australian coast (Rowe and Gates 1995), and Taiwan (this report).

Remarks: Animals were collected from rocky substrate at 3-10 m in depth. It is rare in Taiwan. All of the specimens from Taiwan have only 8 superomarginals and inferomarginal plates, while *Neoferdina offreti* (Koehler) has 10-12 superomarginals and 15 inferomarginals (Marsh 1977). In addition, *N. offreti* bears coarser granulation in the centers of the granulated abactinal plates than between the plates, while *N. insolita* has coarser granulation interstitially than in the centers of the abactinal plates (Clark and Rowe 1971). *N. insolita* differs from *N. cumingi* by lacking the alternation of large bare and small granule-covered superomarginals and in lacking a distinct transverse row of plates across the rays. Jangoux (1973) doubted the validity of this species.

Family Oreasteridae
Anthenea chinensis Gray
(Figs. 4A, 17, 18)

Anthenea chinensis Gray, 1840: 279 (type locality: China); Liao and Clark 1995: 98.

Anthenea pentagonula Chang et al., 1964: 58; Clark and Rowe 1971: 52.

Materials: NMNS2318-185, 4 specimens, R/r = 52-85 mm/27-40 mm, Tszkan, Pescadore Is.; NMNS2318-186, 1 specimen, R/r = 64 mm/31 mm, Tahsi.

Diagnosis: Animals always with 5 short rays. Body rigid. Abactinal plates convex, covered by sparse short conical tubercles and dense minute spinelets. Each interradial surface bearing a narrow concave ridge. Papular pores present in groups on abactinal surface, but not on actinal surface. Abactinal plates bearing sparse small valvate pedicellariae. Madreporite single, with numerous radiating striations. Anus at center of disc, surrounded by about 10 short spinelets. Conspicuous marginal plates forming a side-wall of body; plates covered with coarse granules. With 2-3 valvate pedicellariae on each infero-marginal plate, but 1 or none on each supero-marginal plate. Pedicellaria on actinal plates about 3 mm long, surrounded by 8-20 coarse granules (Fig. 4A). Furrow spines 7-9 per set, usually 8. With 2-3 stout truncate subambulacral spines. Animals reddish brown in life. Color preserved in dry specimens.

Distribution: Gulf of Tonkin to southern China (Liao and Clark 1995), and Taiwan (this report).

Remarks: This species was trawled from sandy substrate of 30-60 m in depth. It is common in western Taiwan.

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臺灣海星之訂正及十種新記錄海星(棘皮動物門：海星綱)

趙世民[1]

本文回顧及訂正臺灣產海星，並增列 10 種新記錄種海星，共列出 10 科 31 種，這 31 種的檢索表包括在本文中。這 10 種新記錄種海星為：*Asterina orthodon* Fisher 直齒海燕， *Nepanthia belcheri* (Perrier) 刺腕蠍海燕， *Asteropsis carinifera* (Lamarck) 脊鋸腕海星， *Echinaster callosus* von Marenzeller 赤麗棘海星， *Anthenea chinensis* Gray 中華五角海星， *Calliaster childreni* Gray 玉緣棘角海星， *Stellasteropsis colubrinus* Macan 鼠李角海星， *Cistina columbiae* Gray 哥倫比亞蛇星， *Linckia multifora* (Lamarck)多篩指蛇星及 *Neoferdina insolita* Livingstone 棕緣蛇星。這十種的描述及標本照均在文中。

關鍵詞：海星，棘皮動物，種的說明，臺灣。

[1] 國立自然科學博物館