The ophiurans (Echinodermata: Ophiuroidea) of Taiwan

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ABSTRACT

The ophiruan fauna of Taiwan is comprised of 6 families, 8 genera, 13 species. They are: *Amphipholis misera* (Koehler), *Ophiactis savigni* (Müller and Troschel), *Ophiothela danae* Verrill, *Ophiothrix aspidota* Müller and Troschel, *O. hyrida* Clark, *O. propinqua* Lyman, *Ophiomastrix annulosa* (Lamarck), *Ophilocoma brevipes* Peters, *O. erinacea* Müller and Troschel, *O. scolopendrina* (Lamarck), *Ophiarthrum pictum* Müller and Troschel, *Ophiarachna incrassata* (Lamarck) and *Ophioplocus japonicus* Clark. Taxonomic characters, collecting and preserving techniques, glossary, and systematic accounts with distributioual data for Taiwan are included. *Ophiocoma erinacea* and *Ophiarachna incrassata* are reported for the first time from Taiwan.

The ophiurans include those echinoderms known as basket stars and serpent stars or brittle stars. They are not diverse in appearance: a small, flattened disk of rounded, pentagonal or somewhat star-shaped contour is clearly set off by the five (rarely six), long, slender arms (Fig. 11). Although they occur on all bottoms from the littoral to abyssal depths, literature on the Taiwan ophiurans is scanty. Koehler (1922) reported 6 species: *Ophiothrix aspidota, O. hybrida, O. propinqua, Ophiactis savigny, Amphipholis misera, Ophiocoma scolopendrina.* Sato (1936) and Hiro (1939) noted the occurrences of *Ophiomastrix annulosa, Ophiocoma scolopendrina, Ophiarthrum pictum* and *Ophioplocus japonicum*, and Chang & Liao (1958) mentioned the ocurrence of *Ophiothela danae* in Taiwan.

In 1977, Messrs J. Marcus and S.-D. Lai collected 3 lots of the ophiurans for the University of Colorado Museum. They are here identified as *Ophiocoma erinacea, O. scolopendrina* and *Ophiarachna incrassata.*

Mortensen (1934) stated that the Malyan region is the richest area in the whole world with regard to echinoderms. Taiwan is located within the boundary of the Indo-Malayan zoogeographical subregion (Ekman, 1953). Thus, it is to be expected that Taiwan echinoderm fauna must be extraordinarily rich. Unfortunately, an ophiuran faunal study has never been made the object of a special investigation in Taiwan. The 13 species listed here may represent only a small fraction of Taiwan ophiuran fauna. This paper includes taxonomic characters, collecting and preserving techniques, glossary and systematic accounts with distributional data for Taiwan. It is hoped that this report may instigate further ophiuran research in Taiwan.

TAXONOMIC CHARACTERS

The aboral surface of the disk varies from smooth to leathery to granular with small spines or a number of imbedded plates. The primitive plate arrangement, i.e. a central plate surrounded by other plates disposed in concentric circles of five each, can be seen in juveniles

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and some adults (Fig. 1). This arrangement is usually lost by the interpolation of secondary plates (Fig. 2) or the deposition of granules. Thus, the aboral surface often presents a complete coverage of small plates of irregular shapes and sizes. The most conspicuous character is that a pair of radial shields (Fig. 2) is present, although sometimes concealed from view by granules, at the base of each arm (Fig. 15).

In the center of the oral surface of the disk (Fig. 3) is star-shaped aperture which leads to the mouth. The aperture is surrounded by 5 interradial wedge-shaped jaws. Each jaw (Figs. 3, 6-9) composed of 2 halfjaws and is edged by a series of oral papillae (Figs. 3, 8, 9) which may be lacking in some genera. Internal to the jaw tip, maxiller (or jaw plate) and tooth papillae or teeth are seen (Fig. 10), but one or the other may be lacking in some genera. The jaw is bordered by a pair of small adoral shields (Fig. 3) which are bordered by a conspicuous plate, oral or buccal shield (Fig. 3). One of the 5 buccal shields is pierced by one pore and acts as a madreporite. The genital bursae are opened by genital or bursal slits (Fig. 3) on either side of the arm base. The bursal slits are supported on each side by an elongated genital shield, (Fig. 3) which meets the radial shield at its outer end and does not meet the buccal shield at its inner end; the gap is filled by one or more small genital scales.

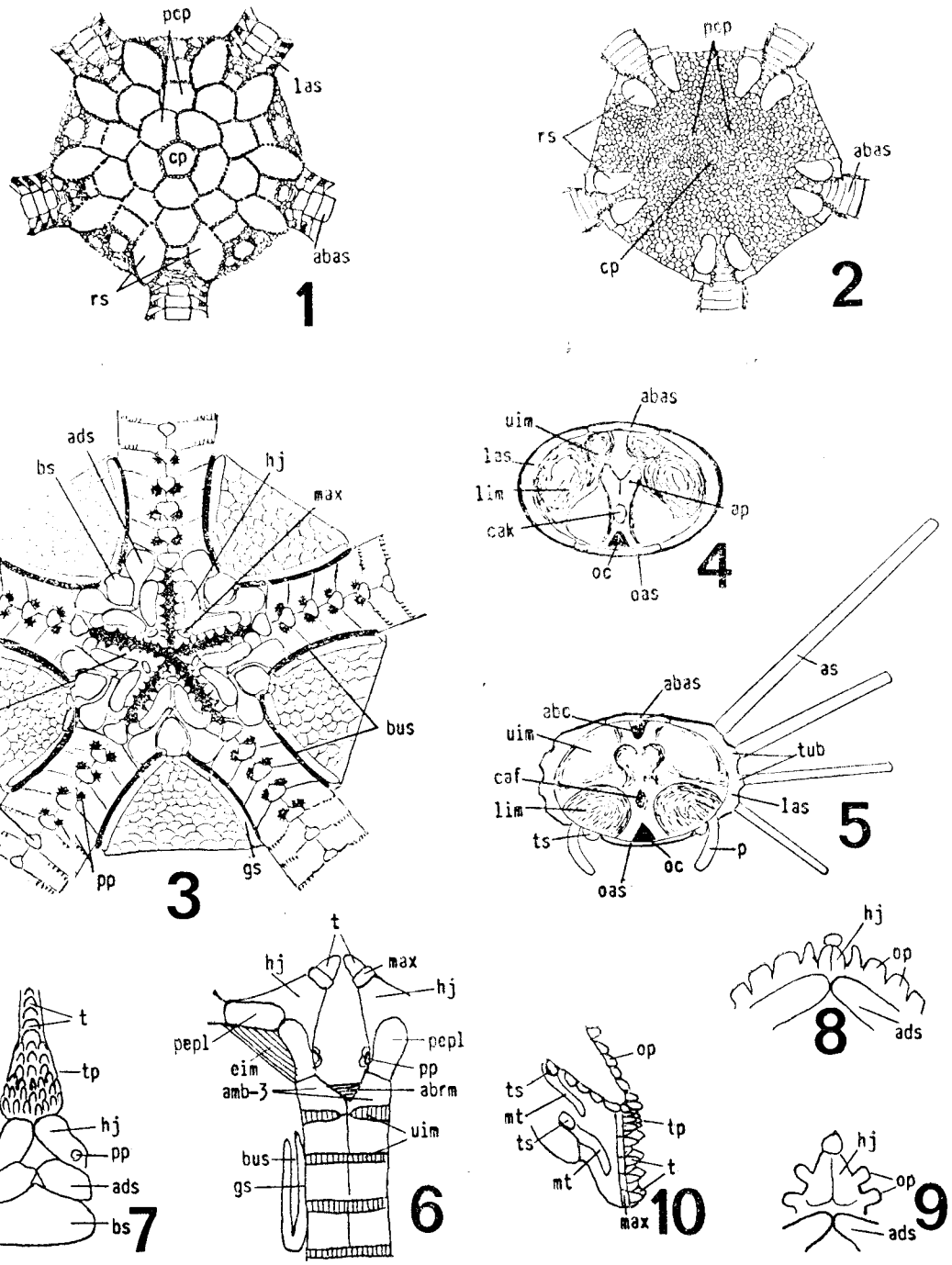
The arms contain a series of jointed vertebrae which are protected by four series of shields: aboral, oral and 2 lateral arm shields (Figs. 4, 5). Each lateral arm shield usually bears 2-15 spines arranged in a vertical row (Fig. 5). Differing arrangements of arm shields and varying degrees of spininess are characteristically found in different species. A pair of podial pores (Fig. 3) is present on each arm joint on its oral surface between the lateral and oral arm shields and is usually protected by one or more tentacle scales (Figs. 13, 16). The arm/disk ratio varies in different species and can be used as a taxonomic character.

Color and pigmentation patterns vary and may be a useful trait, to some extent, in distinguishing among many species. Sexes are separate in most species. The dimorphic pigmentation of ripe gonads of some species may allow the sexes to be distinguished.

Captions for Figures

Figs. 1-10. Morphology of the ophiuroids. 1. Aboral view of disk of *Ophiolepis* with concentric arrangement of plates; 2. Aboral vies of disk of *Ophiura* with many small plates; 3. Oral view of the disk of *Ophiomusium*, showing scalation; 4. Distal surface of arm joint of *Ophiocma*, showing surfact shields and vertebal ossicles, spines omitted; 5. Arm joint of *Ophiocoma*, seen from proximal end, showing spine arrangement (one side only) and vertebral articulations; 6. One sector of jaw apparatus and one arm base of *Ophiomusium*, seen from the aboral side, after removal of the aboral disk wall; 7. Jaw and jaw edge of *Ophiothrix*, oral view; 8. Jaw of *Ophiopholis*, oral view; 9. Jaw of *Ophiactis*, oral view (Figs. 1-9, *after* Hyman, 1955); 10. A diagram of one of the five angle of the mouth, seen diagonally from oral side, showing the relations of the chewing apparatus, mouth tentacles and jaw (*after* Lyman, 1874).

Key to the lettering on Figures 1-10: abas, aboral arm shield; abc, aboral canal; abrm, aboral radial muscle; ads, adoral shield; amb-3, third pair of ambulacral; ap, articulating projection; as, arm spine; bs, buccal shield; bus, bursal slit; cak, central articulating knob; caf, ceutral articulating fossa; cp, central plate; ds, disk scale; eim, external interradial muscle; gs, genital shield; hj, half jaw; las, lateral arm shield; lim, lower intervertebral muscles; max, maxiller; mt, mouth tentacle; oas, oral arm shield; oc, oral canal; op, oral papilla; p, podium; pcp, primary concentric plates; pepl, peristomial plate; pp, podial pore; rs, radial shield; t, teeth; tp, tooth papillae; ts, tentacle scale; tub, tubercles of lateral arm shield; uim, upper intervertebral muscle.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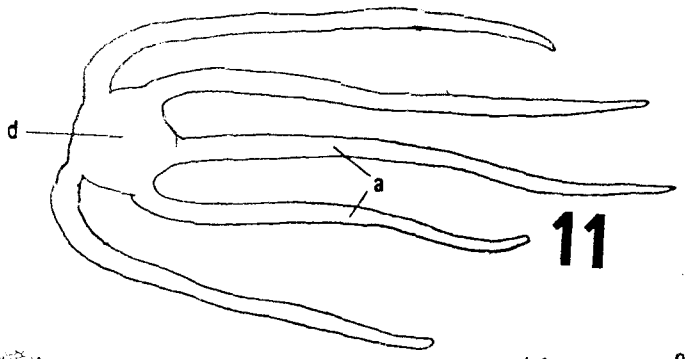

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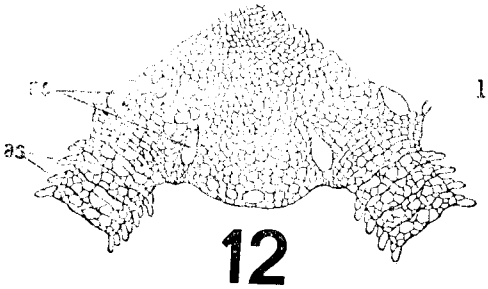

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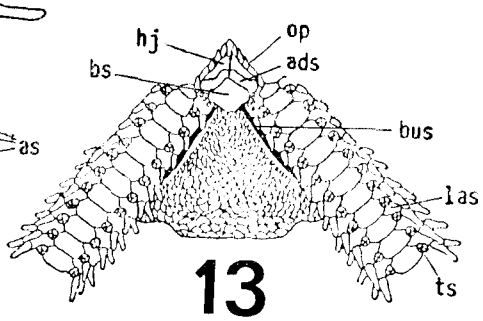

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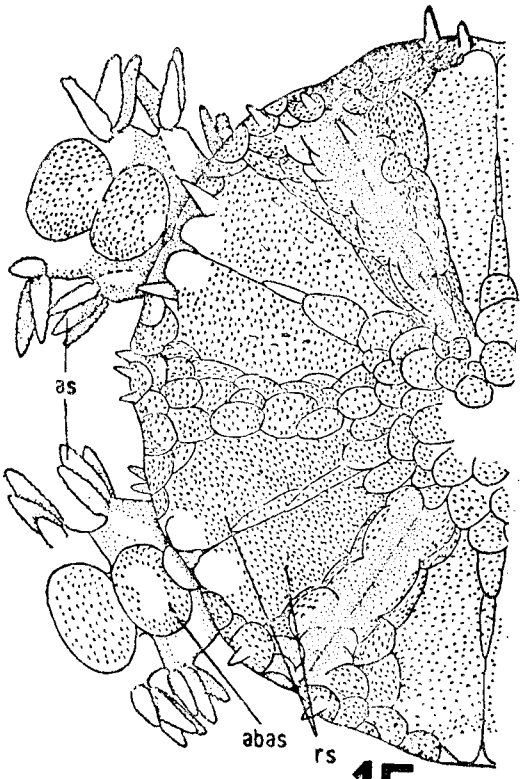

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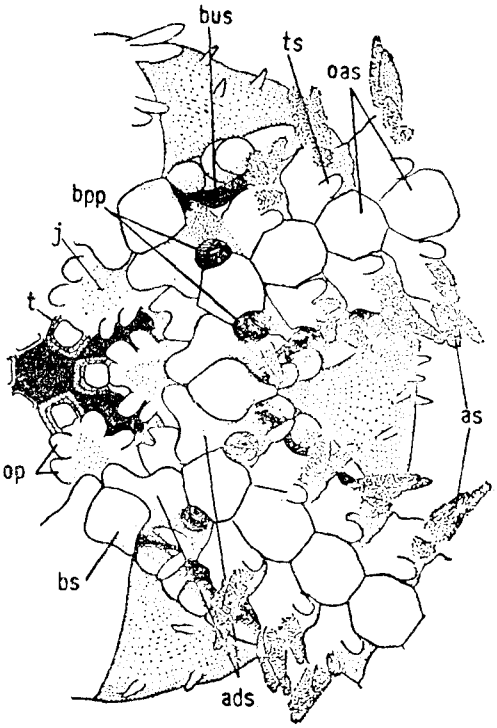

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COLLECTING AND PRESERVING TECHNIQUES

The ophiurans occur on all bottoms from littoral to abyssal depths. For hand-collecting, they are usually found underneath or between rocks. Tidepools along the rocky shore provide many ophiurans. In deeper water with sand, mud, or rock-rubble bottoms, the starfish drag or dredge (see Knudsen, 1966) proves excellent for collecting.

The ophiurans can be effectively narcotized with epsom salts: Place specimens in flat-bottomed container and with just enough sea water to cover them. Add a small amount of epsom salts every hour during the day, and let stand until the specimens are not responding to a gentle probe of a fine tipped object. Then, they are best positioned as shown in Fig. 11 and killed and fixed in 10% neutral formalin for 24 hours. Finally, the specimens may be dried or preserved in 70% Ethyl Alochol.

GLOSSARY

The following are adopted from Spencer & Wright's (1966) "glossary of morphological terms applied to asterozoans", and the text of Hyman (1955).

aboral—applied to surface opposite that bearing mouth (syn., dorsal).

aboral arm shield—ossicles of series along midline of aboral surface of arm (syn., dorsal shield).

abradial—directed away from axis of ray.

adoral—directed toward mouth.

ambulacral—ossicle of axial skeleton, one of double series of opposite or alternate ossicles formed along axis of arm.

buccal shield—large ossicle in interradial position adjoining mouth (syn., buccal plate, mouth shield, oral shield).

bursa—internal gill pouch, entered by gill slit.

central plate—prominent plate at center of aboral surface of disk.

dental papilla—scalelike ossicle projecting from jaw.

disk—central part of body, distinctly separable from arms.

fossa—a shallow depression on a vertebra to receive articulating knob on another vertebra.

genital shield—elongate ossicle along oral edge of gill slit at the base of arm (syn., genital plate).

genital slit—fissure along side of base of arm, leading into bursa (syn., bursal slit).

granules—minute, more or less skeletal elements situated on surface of ossicles, generally in pits or distributed in covering skin.

interadial—indicating position midway between axis of adjacent rays or area between such rays.

jaw—compound ossicle projecting into the mouth cavity. Each half jaw consists of the second ambulacral ossicle (a larger piece) and the first adambulacral osscicle (a smaller piece) (see Hyman, 1955, Fig. 2504).

lateral arm shield—ossicles of a series along the side of the arm (syn., side shield).

Captions for Figures

Fig. 11. Aboral view of a brittle star.

Figs. 12-14. *Ophioplocus japonicus* Clark. 12. Aboral view; 13, Oral view; 14. Lateral view of three arm joints near disk (*after* Clark, 1911).

Figs. 15-16. *Ophiactis savigny* (Müller and Troschel). 15. Aboral view; 16. Oral view (*after* Hyman, 1955).

Key to the lettering on Figures 11-16: a, arm; abas, aboral arm shield; ads, adoral shield; as, arm spine; bpp, buccal podial pore; bs, buccal shield; bus, bursal slit; d, disk; hj, half jaw; j, jaw; las, lateral arm shield; oas, oral arm shield; op, oral papillae; rs, radial shield; t teeth; ts, tentacle scale.

madreporite—sievelike ossicle that serves as inlet to the water vascular system; it is located on the oral surface of the disk.

maxiller—a narrow elongated vertical ossicle at the jaw tip (syn., jaw plate).

mouth frame—consists of five wedge-shaped pieces or jaws that are compounded of the first two ambulacrals, the first two ad-ambulacral, and surface shield (syn., oral frame).

oral—aplied to surface of animal that contains mouth.

oral arm shield—ossicles of series along mid-line of oral side of arm (syn., ventral shield).

oral canal—canal to accomodate radial nerve and water vessel on the oral side of arm.

oral papillae—minute scalelike projection near mouth.

ossicle—any individual calcified element of skeleton.

papillae—scalelike minute ossicle.

peristomial plate—first pair of ambulacrals is formed into tow elongated pieces that occupy the aboral surface of the jaws (see Fig. 6 and Hyman, 1955, Fig. 250A)

podial pore—passage for emergence of tentacle (syn., tentacle pore).

primary plates—ring of prominent ossicles on aboral surface, typically consisting of five radials and five interradials surrounding central plate.

radial shield—relatively large ossicle comprising one of pair adjacent to base of arm on aboral surface of disk.

spicule—very minute irregular, cylindrical or radiale skeletal element.

spine—sharp or blunt, short or long skeletal element, attached to ossicle by muscle.

streptospondyline—type of articulation between vertebrae with simple ball-and-socket joint which permits the arms to coil and entwine around objects.

tentacle—may be used for tube feet in general or specialized one (syn., podium).

tooth papillae—scalelike ossicles projecting from jaw (syn., dental papilla).

vertebra—fused pair of opposite ambulacrals, articulating with neighboring.

vertebrae by ball-and-socket joints.

zygospondyline—type of articulation between vertebrae with several peg-and-socket joint that limit movement of arms, in horizontal plane.

SYSTEMATIC ACCOUNTS

Class Ophiuroidea

Order Gnathophiurida

Radial shield and genital plate articulate by means of a conspicuous socket, in the former and of a large, ball-like condyle on the latter. Genital plates, as a rule, firmly fixed to the basal vertebrae. Genital scales short, very wide, flattened, leaf-like. On abradial side of innermost part of each genital slit occurs another short, wide, flattened, leaf-like scale, which is firmly attached to oral shield. Peristomal plates small, or rarely large, usually entire, but sometimes double. Oral frames, as a rule, with well-developed lateral wings (Matsmoto, 1915).

Family Amphiuridae

Teeth quadrangular, with wide ends, very stout; oral papillae present; dental papillae wanting; peristomal plate small; oral frames very stout with well-developed lateral wings; genital scales short, leaf-like; genital plate firmly fixed to basal vertebrae; dorsal side of vertebrae rhomboidal, not U-shpaed (Matsumoto, 1915).

Genus *Amphipholis*

1. *Amphipholis misera* (Koehler)

See Koehler, 1922: 165-166, pl. 70, figs.

4-8.

Distribution in Taiwan: Nan Wan (Koehler, 1922)

Family Ophiactidae

Same as Amphiuridae except no paired infradental papillae (Matsumoto, 1915).

Genus *Ophiactis*

2. *Ophiactis savigni* (Müller & Troschel) Figs. 15-16

See Koehler, 1922: 193-195, pl. 64, figs. 5-6; pl. 96, fig. 2.

Distribution in Taiwan: China Sea, in the vicinity of Taiwan, Latitude 20°19′30″N, Longitude 121°51′15″E (Koehler, 1922).

Family Ophiotrichidae

Same as Amphiuridae, except dental papillae well-developed, forming a vertical clamp at apex of each jaw; dorsal side of vertebrae U-shaped (Matsumoto, 1915).

Genus *Ophiothela*

3. *Ophiothela daena* Verrill

See Koehler, 1922: 297-298; pl. 59, figs. 1-3; pl. 103, fig. 1.

Distribution in Taiwan: Taiwan (Chang & Liao, 1958).

Genus *Ophiothrix*

4. *Ophiothrix aspidota* Müller & Troschel

See Koehler, 1922: 209-211, pl. 32, figs. 1-5; pl. 33, fig. 7; pl. 97, fig. 3.

Distribution in Taiwan: China Sea, in the vicinity of Formosa (Koehler, 1922).

5. *Ophiothrix hybrida* Clark

See Koehler, 1922: 239-240, pl. 46, figs. 4-6; pl. 99, fig. 3.

Distribution in Taiwan; China Sea, in the vicinity of Formosa (Koehler, 1922).

6. *Ophiothrix propinqua* Lyman

See Koehler, 1922: 256-257, pl. 38, figs. 1-2; pl. 101, fig. 4.

Distribution in Taiwan: China Sea, in the vicinity of Formosa (Koeqler, 1922).

Order Chilophiurida

Radial shield and genital plate articulate with each other by means of two condyles and one pit on either plate. Genital plates and scales bar-like. Peristomal plates small, or sometimes moderately large, usually double or triple. Oral frames with or without well-developed lateral wings. Oral papillae very well developed, close set; the outermost one usually pointing inwards and stretching above the next papilla, which is the largest as a rule (Matsumoto, 1915).

Family Ophiocomidae

Dental papillae (Fig. 7) well developed, forming a vertical clamp at apex of each jaw; disk often covered with granules; arms stout, stoutest at a distance from base; arm spine long, not appressed.

Genus *Ophiomastrix*

Disk with more or less evident spinelets, in some species with granules also; some upper arm spines more or less claviform.

7. *Ophiomastrix annulosa* (Lamarck)

See Clark, 1921: 135-136, pl. 14, fig. 6; Koehler, 1922: 329, pl. 72, figs. 4-5.

Distribution in Taiwan: Taiwan coast (Sato, 1936).

Genus *Ophiocoma*

Disk covered with granules (normally concealed underlying scales); no true disk spinelets; uppermost arm spines often considerably enlarged.

8. *Ophiocoma brevipes* Peters

Disk with fine granules; disk and arms variegated. See also Koehler, 1922: 319-322, pl. 72, figs. 6-9.

Distribution in Taiwan: Nan Wan (Koehler, 1922).

9. *Ophiocoma erinacea* Müller & Troschel
   Arm/disk ratio, 4-5; disk with rather coarse granules; color quite uniformly black. See also Koehler, 1922: 322-324, pl. 73, fig. 7.
   Distribution in Taiwan: Keng-ting (1 specimen, UCM No. 821; this paper).
10. *Ophiocoma scolopendrina* (Lamarck)
   Arm/disk ratio, 4.5-7.5; disk with rather coarse granules; color variable. See also Koehler, 1922: 322-325, pl. 73, fig. 5, pl. 74, figs. 1-4.
   Distribution in Taiwan: Nan Wan (2 specimens, USNM E207; Koehler, 1922); Koshun, Botel Tobago (Sato, 1936), Lambay Island (=Liu Chiu Hsu)) (Hiro, 1939), Keng-ting (1 specimen, UCM No. 832; this paper).

Genus *Ophioarthrum*

Disk covered with a smooth, naked skin, bearing neither granules nor spinelets.

11. *Ophioarthrum pictum* Müller & Troschel
   Disk ornamented with meandrine brown lines; a dark line along the aboral side of arm; arm spines, 3, ringed, the upper one longest (Lyman, 1874). See also Lyman, 1874: 225-226, pl. 7, figs. 2-4; Clark, 1921: 140, pl. 12, fig. 1.
   Distribution in Taiwan: Taiwan Coast (Hiro, 1939).

Family Ophiodermatidae

No vertical clamps of dental papillae; disk closely covered with granules; arms stout, stoutest at base, inserted laterally to disk; numerous arm spines; shout or long, appressed or not appressed; oral papillae thin.

Genus *Ophiarachna*

12. *Ophiarachna incrassata* Lamarck
   See Clark, 1921: 140-141, pl. 34, figs. 1-2.
   Distribution in Taiwan: Keng-ting (1 specimen, UCM No. 822; this paper).

Family Ophiolepidiae

Disk squammated or tessellated, usually free of granules; oral papillae thick; arm stout, stoutest at base, inserted laterally to disk; arm spines short, appressed.

Genus *Ophioplocus*

13. *Ophioplocus japonicus* Clark Figs. 11-14.
   Disk closely covered with small scales; radial shields bare; aboral arm plate broken up into a considerable number of plates; oral papillae 5; teeth 5; arm spines 3, short, thick and blunt; tentacle scales 2 on proximal side and 2 on distal side. See also Clark, 1911: 30-31, figs. 5 a-c.
   Distribution in Taiwan: Milun, Sinko, Daihanratsu, Daizubo, Nekobana (Sato, 1936).

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臺灣產之陽燧足

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摘 要

臺灣產棘皮動物之陽燧足，計有六科八屬十三種；牠們分別爲：*Amphipholis misera* (Koehler), *Ophiactis savigni* (Müller and Troschel), *Ophiothela danae* Verrill, *Ophiothrix aspidota* Müller and Troschel, *O. hybrida* Clark, *O. propinqua* Lyman, *Ophiomastrix annulosa* (Lamarck), *Ophilocoma brevipes* Peters, *O. crinacea* Müller and Troschel, *O. scolopendrina* (Lamarck), *Ophiarthrum pictum* Müller and Troschel, *Ophiarachna incrassata* (Lamarck) and *Ophioplocus japonicus* Clarko 分類特徵、標本之採集、保存、和在臺灣之分布情況，文中都討論到。*Ophiocoma erinacea* 和 *Ophiarachna incrassata* 在臺灣首次發現。