Bull. Inst. Zool., Academia Sinica **27**(2): 73-90

SHALLOW WATER CRINOIDS OF KENTING NATIONAL PARK, TAIWAN[1]

JIAN-CHYI CHEN[2], KUN-HSIUNG CHANG*
and CHANG-PO CHEN*

Institute of Marine Biology, National Sun Yat-sen University, Kaoshiung, Taiwan 80424, Republic of China
** Institute of Zoology, Academia Sinica, Nankang, Taipei, Taiwan 11529, Republic of China.*

(Accepted: December 10, 1987)

Jian-Chyi Chen, Hun-Hsiung Chang and Chang-Po Chen (1988) Shallow water crinoids of Kenting National Park, Taiwan. *Bull. Inst. Zool., Academia Sinica* **27**(2): 73-90. A total of 20 species of crinoids, belonging to 16 genera of 5 families have been found in the subtidal zone of Kenting National Park in southern Taiwan. Systematic accounts, spatial distributive characteristics and key based on color, habitat and posture of these fauna are presented.

Key words: Crinoids, Echinoderms, Comatulids, Systematic accounts, Distribution.

There are plenty of macro-benthos in the Kenting National Park, and echinoderms are the dominante one. Echinoderm fauna of Taiwan had been studied by Hayasaka (1948, 1949), Chen and Chang (1981), Wu (1982), Applegate (1984), Chao (1986) and Chen (1986). In order to protect and conserve the natural resources of Kenting National Park, field studies of crinoids have been conducted. This report presents the first attempt to make a comprehensive survey of the composition and ecology of these crinoids inhabiting in the shallow water of southern Taiwan. Species identification of crinoids based on morphological features is not suitable for field researchers, thus a key is compiled based on their colors, habitats and postures.

MATERIALS AND METHODS

The living posture, substratum preference and color variation of crinoids were observed *in situ* from January 1985 to April 1986 by SCUBA diving at 11 locations of the waters of Kenting National Park (Fig. 1). The range

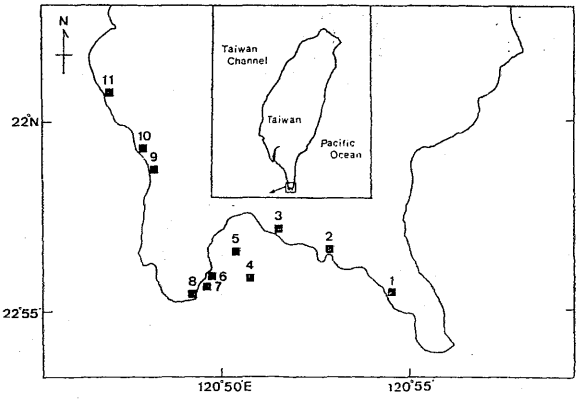

Fig. 1. Map of southern tip of Taiwan showing the study area. 1, Shan-geo-wan; 2, Sheau-wan; 3, Tarn-tzy-wan; 4, Talao-gu; 5, D-station; 6, B-station; 7, A-station; 8, Mau-pi-tou; 9, Horng-chair; 10, Shyun-goang-tzoei; 11, Hsia-shai-ku.

1. Paper No. 304 of the Journal Series of the Institute of Zoology, Academia Sinica.
2. To whom reprint request should be sent.

TABLE 1
Range of water depth at each study site

Locality	Depth (m)
1. Shan-geo-wan (香蕉灣)	2- 8
2. Sheau-wan (小灣)	6-11
3. Tarn-tzy-wan (潭子灣)	4-6
4. Ta-lao-gu (大佬鼓)	15-25
5. D-station (D站)	6-10
6. B-station (B站)	5-10
7. A-station (A站)	7- 9
8. Mau-pi-tou (貓鼻頭)	7-15
9. Horng-chair (紅柴)	10-15
10. Shyun-goan-tzoei (蠢廣嘴)	12-15
11. Hsia-shai-ku (下水堀)	12-20

of water depth observed at each location is listed in Table 1. Specimens were collected, narcotised with 70-75% alcohol, fixed in 10% formalin and then airdired: Specimens were deposited in the Institute of Zoology, Academia Sincica (ASIZ). The identification of species followed Utinomi and Kogo (1965), Clark and Clark (1967), Clark and Rowe (1971), Clark (1972) and Rowe *et al.* (1986). Terminology and the expression of the number of cirrus and segment followed Clark and Rowe (1971).

TERMINOLOGY

(Fig. 2)

Brachial: the calcareous ossicles of the arms

Centrodorsal: the large plate occupying the centre of the dorsal or aboral side.

Cirri: the jointed appendages arising from the centrodorsal. The number of cirri is presented by the Roman figures (I, II...X etc.). The segments of cirrus is presented by Arabic figures (1, 2...10 etc.).

Disivision series: the ossicles between the radials and the first and the first brachials of the undivided arms.

Pinnules: the slender jointed appendages arising from the brachials on alternate sides. The pinnules on the outer side of the arms are designated P_1, P_2, etc. and on the inner side P_a, P_b, etc.

Radials: the five plates from which the division series arise.

Syzygy: a rigid breaking-joint occuring at intervals in division series and arms.

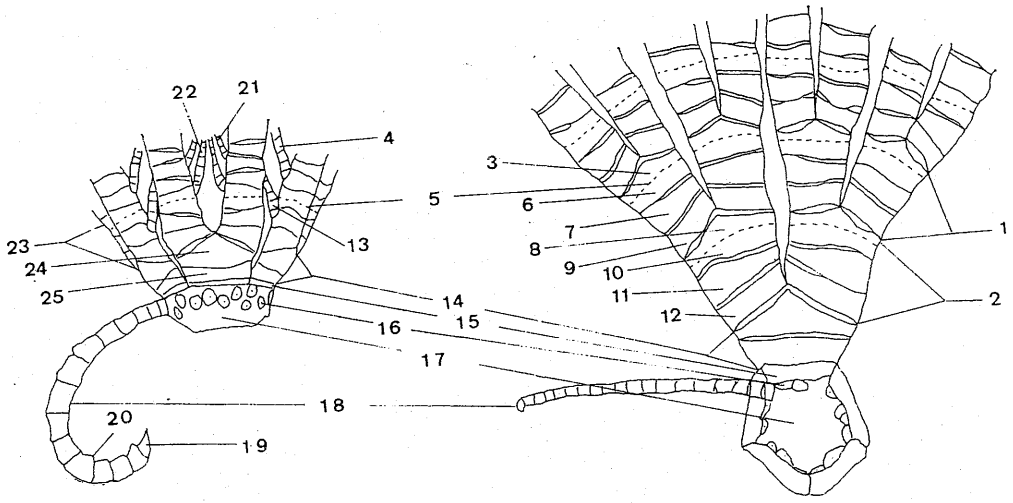

Fig. 2. Introductory figure of crinoid. 1, IIIBr; 2, IIBr; 3, $IIIBr_4$; 4, P_2; 5, syzygy; 6, $IIIBr_3$; 7, $IIIB_2$; 8, $IIBr_4$; 9, $IIIBr_1$; 10, $IIBr_3$; 11, $IIBr_2$; 12, $IIBr_1$; 13, P_1; 14, IBr; 15, radial; 16, cirrus socket; 17, centrodorsal; 18, cirrus; 19, terminal claw; 20, dorsal spine; 21, P_b; 22, P_a; 23, brachials; 24, IBr_2; 25, IBr_1. (Modified from Clark and Rowe, 1971)

RESULTS

Key to species of comatulids

1. Proximal pinnules modified to form a comb; mouth near the edge of the disc and anal tube approximately central.
   Proximal pinnules not forming a comb. 13
2. Only 10 arms....3
   More than 10 arms....5
3. The first brachial syzygy at 3+4. .....*Comissia littoralis*
   The first brachial syzygy at 1+2. 4
4. Cirrus segments less than 15. .....*Comatula pectinata*
   Cirrus segments 16–18. ..*Comatula solaris*
5. P_1 arising from the first brachial. .....*Capillaster multiradiatus*
   P_1 not arising from the first brachial. ..6
6. All division series are 2....7
   Some division series are 4....9
7. No IIIBr series; only 20 arms..... .....*Comatella maculata*
   Some IIIBr series; more than 20 arms..8
8. No IVBr series; about 30 arms..... ..... *Comatella stelligera*
   Some IVBr series; about 40 arms. ....*Comatella nigra*
9. Division series often alternating with arms. 10
   Division series no alternating with arms. 11
10. Arms more than 50; with subradial clefts. .....*Comaster multifidus*
    Arms no more than 34; no subradial clefts. .....*Comaster distinctus*
11. The most external IIIBr series usually 2; the internal ones 4..... ..... *Comanthina schlegeli*
    IIIBr series 2 and 4 irregularly arranged. 12
12. 20–40 arms; cirri very reduced. ....*Comanthus parvicirrus*
    More than 60 arms; cirri well developed. .....*Oxycomanthus bennetti*
13. Middle and distal cirrus segments with a pair of dorsal spines. 14
    Only distal cirrius with single spine or tubercle....17
14. Only 10 arms....15
    More than 10 arms. 16
15. Centrodorsal thin and discoidal; 17–24 cirrus segments. ..*Oligometra serripinna*
    Centrodorsal thick and hemispheric; 44–57 cirrus segments. ....*Colobometra perspinosa*
16. P_1 equal length P_2, or longer than P_2; P_3 absent; the division series 2 or 4..... ..... *Basilometra boschmai*
    P_2 longer than P_1; P_2 and P_3 very stout; all division 2.....*Cenometra bella*
17. Only 10 arms; P_3 longer than P_1 and P_2. .....*Toxometra paupera*
    More than 10 arms; P_3 shorter than P_1 and P_2....18
18. About 43 arms; division series consist of 2 or 4; P_1 longer than P_2. ....*Himerometra magnipinna*
    Less than 35 arms; all division series are 2; P_2 long than P_1. 19
19. 19–29 cirrus segments; oral pinnules spike-like.....*Stephanometra spicata*
    38–43 cirrus segments; oral pinnules flexible. .....*Lamprometra palmata*

SYSTEMATIC ACCOUNTS

Order: Articulata
Family: Comasteridae

Capillaster multiradiatus (Linn'e)

(Fig. 3)

Capillaster multiradiatus, Clark, 1913: 5; 1918: 15; Chang and Liao, 1964: 8; Clark and Rowe, 1971: 15; Clark, 1972: 76.

Materials: Two specimens, ASIZ 52001–2, Jun. 14 and Nov. 4 1985, Ta-lao-gu.

Diagnosis: Cirri XV-XXV (usually XX), 20–24 (the longest up to 28); middle segments have well developed dorsal processes. Arms 16–20 in number and 75–140 mm in length. Though IIBr series are usually 4 (3+4), sometime few IIBr series may be of 2 ossicles;

the IBr series fused each other.

Remarks: In some large specimens, arms are white with black articulation.

Comatella maculata (Carpenter)

(Fig. 4)

Comatella maculata, Clark, 1912: 4; 1913: 3; 1918: 4, 7; Clark and Rowe, 1971: 6, 15; Clark, 1972: 84; Liao, 1983: 263.

Materials: Four specimens, ASIZ 52004-7, Oct. 1985, Shan-geo-wan.

Diagnosis: Centrodorsal flattened and discoidal; cirri XXII-XXXI, 17-22, 3.6-3.7 mm in length. Arms usually are 20 in number and 55-105 mm in length. P_1 is longer than P_2.

Comatella nigra (Carpenter)

(Fig. 5)

Comatella nigra, Clark, 1908: 208; 1918: 4; Clark and Rowe, 1971: 15.

Materials: Two specimens, ASIZ 52008-9, Apr. 24 and Oct. 6 1985, Nan-wan. One specimen, ASIZ 52010, Oct. 8 1985, Shan-geo-wan.

Diagnosis: Cirri XXV-XXIX, 21-26; the 14th segment is the transition segment. Arms 40-48 in number and 50-70 mm in length; all division series are 2; the VBr series absent; P_1 presents on 46th-49th segments.

Remarks: Only a single color form of this species has been observed in the Park; arms and pinnules are black.

Comatella stelligera (Carpenter)

(Fig. 6)

Comatella stelligera, Clark, 1912: 3; 1913: 3; 1918: 4; Chang and Liao, 1964: 7; Clark, 1972: 85; Liao, 1983: 263.

Materials: One specimen, ASIZ 52011, Oct. 8 1985, Shan-geo-wan.

Diagnosis: Cirri about XL, 20-23, about 14 mm in length. Arms 30, about 80 mm in length; all division series are 2; there is no IVBr series; P_1 has about 45 segments and is about 20 mm in length.

Comaster multifidus (Müller)

(Fig. 7)

Comaster multifida, Clark, 1918: 35.
Comaster multifidus, Clark and Rowe, 1971: 84.

Materials: One specimen, ASIZ 52012, Jun. 15 1985, Ta-lao-gu; One specimen, ASIZ 52013, Oct. 8 1985, Shan-geo-wan.

Diagnosis: Subradial clefts present around the edge of the centrodorsal; Cirri absent. Arms 50-79 in number and 58-75 mm in length; the IIBr series 2 (1+2) and 4 (3+4), and the following division series all 2(1+2).

Comaster distinctus (Carpenter)

(Fig. 8)

Comaster distincta, Clark, 1913: 13; 1918: 37, 41.
Comaster distinctus, Clark and Rowe, 1971: 16; Clark, 1972: 81.

Materials: One specimen, ASIZ 52017, Dec. 7 1985, Hsia-shai-ku.

Diagnosis: Cirri XXIII, 10-12, and about 7 mm in length. Arms 34 in number, about 75 mm in length; P_1 35 segments, 7-8 mm in length, and each with 11 teeth.

Comanthina schlegeli (Carpenter)

(Fig. 9)

Comanthina schlegeli, Clark and Rowe, 1971: 16; Meyer and Macurda, 1980: 77.

Materials: Two specimens, ASIZ 52052-3, Oct. 1985, Sheau-wan; One specimen, ASIZ 52054, Oct. 28 1985, Shan-geo-wan.

Diagnosis: Centrodorsal discoidal with 6.9 mm in diameter; cirrus sockets arranged in two rows; cirri XV-XXX, 16-17, 12-14 mm in length. Arms 64-80 in number and 140-150 mm in length; the IIIBr series 2 on the outer side and 4 (3+4) on the inner side.

Comanthus parvicirrus (Müller)

(Fig. 10)

Comanthus parvicirra, Utinomi and Kogo, 1965: 270.
Comanthus parvicirrus, Clark and Rowe, 1971: 16; Clark, 1972: 77; Liao, 1983: 264; Rowe *et al.*, 1986: 211.

Materials: One specimen, ASIZ 52021, Oct. 6 1985, B-station; Two specimens, ASIZ 52022-3, Oct. 1985, Shan-geo-wan; One specimen, ASIZ 52024, Jan. 4 1986, Tarn-tzy-wan.

Diagnosis: Centrodorsal pentagonal or discoidal, 2.5-3.7 mm in diameter; cirri V-XIII, 11-15, 7-10 mm in length. Arms 22-40 in number and 55-130 mm in length; P_1 presents 34th 39th segments 9-11 mm in length, and each with 6-10 teeth; the IIBr series almost 4(3+4).

Remarks: Some alpheid shrimps *Synalphaeus* sp. and brittle stars are associated with this species.

Oxycomanthus bennetti (Müller)

(Fig. 11)

Comanthus bennetti, Clark and Rowe, 1971: 6; Meyer and Macurda, 1980: 78.
Oxycomanthus bennetti, Rowe *et al.*, 1986: 259.

Materials: Three specimens, ASIZ 52026-8, Jun. and Nov. 4 1985, Ta-lao-gu.

Diagnosis: Cirri well developed, XXXIII-XLVIII, 22-34, 6.8-8.2 mm in length. Arms 73-109 in number and 120-200 mm in length; the farthest division series is VBr; IIBr and the following division are almost 4 (3+4), and sometime only IIBr series have 2 ossicles.

Remarks: Alpheid shrimps *Synalphaeus* sp. and the galathea anomura *Galathea* sp. are frequently associated with this species and located on the oral disk.

Comissia littoralis Clark

(Fig. 12)

Comissia littoralis, Clark, 1918: 19; Clark and Rowe, 1971: 14.

Materials: One specimen, ASIZ 52031, Oct. 8 1985, Shan-geo-wan.

Diagnosis: Cirri about X, 14-16, about 7 mm in length; the 10th or 12th and the following segments with dorsal spine. Arms only 10 in number and about 40 mm in length; P_1 with 30 segments, about 6 mm in length, and each with 8-9 teeth.

Comatula pectinata (Linn'e)

(Fig. 13)

Comatula pectinata, Clark, 1908: 202; 1918: 27, 31; Clark, 1972: 85.

Materials: One specimen, ASIZ 52032, Apr. 23 1985, Hsia-shai-ku.

Diagnosis: Centrodorsal discoidal, 3.8 mm in diameter; cirri VII, 13-15, about 11 mm in length; the terminal claw very slender. Arms only 10 in number, about 115 mm in length; the IBr series 2(1+2) being fused each other; the 2nd and 3rd segment of P_2 and P_a with rounded knob-like processes.

Remarks: Only a single color form of this species has been found; the arms and pinnules are red; pinnule tips are yellow. This species like to cling to sea whips.

Comatula solaris Lamarck

(Fig. 14)

Comatula solaris, Clark, 1912: 5; 1918: 26.

Materials: One specimen, ASIZ 52033, Nov. 23 1985, Sheau-wan.

Diagnosis: Cirri XXVI, 16-18, about 16 mm in length. Arms only 10 in number, about 85 mm in length; The IBr series are 2(1+2) and IBr_1 almost fuse each other.

Remarks: This species just curled up beneath hard and soft coral.

Family: Colobometridae

Basilometra boschmai Clark

(Fig. 15)

Basilometra boschmai, Clark and Rowe, 1971: 19.

Materials: One specimen, ASIZ 52034, Nov. 4 1985, Ta-lao-gu; One specimen, ASIZ 52035, Dec. 7 1985, Hsia-shai-ku.

Diagnosis: Centrodorsal low hemispherical; the cirrus sockets irregularly arranged in 2 or 3 rows. Arms 67-90 in number and about 90 mm in length; the division series from IBr to IIIBr with snout-like tubercle.

Cenometra bella (Hartlaub)

(Fig. 16)

Cenometra bella, Clark and Rowe, 1971: 19; Meyer and Macurda, 1980: 88.

Materials: One specimen, ASIZ 52036, Nov. 4, Ta-lao-gu; One specimen, ASIZ 52037, Dec. 7 1985, Hsia-shai-ku.

Diagnosis: Centrodorsal hemispherical and 5.9–6.7 mm in diameter; cirri XXIII-XXVIII, 33–39, 20–21 mm in length. Arms about 27 in number and 110–135 mm in length; the side of ossicles of the division series more or less elongated; P_2 very stiff with 21–25 segments.

Oligometra serripinna (Carpenter)

(Fig. 17)

Oligometra serripinna, Clark, 1912: 27; 1918: 130; Clark, 1972: 129.

Materials: Three specimens, ASIZ 52038–40, Nov. 1985, Sheau-wan.

Diagnosis: Centrodorsal thin discoidal, 2.9–4.0 mm in diameter; cirri XIV–XX, 17–24, 7–10 mm in length. Arms only 10 in number and 35–50 mm in length; P_2 longer than P_1.

Remarks: The dorsal spines of the distal cirrus fused in to a single spine or tubercle.

Colobometra perspinosa (Carpenter)

(Fig. 18)

Colobometra perspinosa, Clark, 1913: 37; 1918: 123.

Materials: One specimen, ASIZ 52041, Jun. 13 1985, Ta-lao-gu; One specimen, ASIZ 52042, Nov. 3 1985, Horng-chair; One specimen, ASIZ 52043, Dec. 7 1985, Hsia-Shai-ku.

Diagnosis: Centrodorsal hemispherical, 5.4 mm in diameter. Cirri XVI-XVIII, 44–57, about 32 mm in length. Arms only 10 in number and 70–100 mm in length; P_2 is the longest pinnule; P_a absent.

Family: Himerometridae
Himerometra magnipinna Clark

(Fig. 19)

Himerometra magnipinna, Clark, 1908: 355; 1918: 73.

Materials: One specimen, ASIZ 52044, Jul. 24 1985, Mau-pi-tou. One specimen, ASIZ 52045, Jun. 14 1985, Ta-lao-gu.

Diagnosis: Centrodorsal hemispherical, 70–9.5 mm in diameter; cirri XXXVI-L, 31–36, 31–32 mm in length; the cirrus scokets arranged in 3 rows. Arms 40–43 in number and 70–95 mm in length; the IIIBr series are 2 on the inner and 4(3+4) on the outer.

Family: Mariametridae
Stephanometra spicata (Carpenter)

(Fig. 20)

Stephanometra spictata, Clark, 1918: 94; Clark, 1972: 108.

Materials: Two specimens, ASIZ 52046–7, Nov. 1985, Sheau-wan.

Diagnosis: Cirri about XXXIX, 21–29, about 29 mm in length. Arms 26 in number and about 85 mm in length; all division series are 2; the IIIBr series are only present on outer; P_2 and P_3 very stiff and spine-like.

Lampometra palmata (Müller)

(Fig. 21)

Lamprometra palmata, Chang and Liao, 1964: 16; Utinomi and Kogo, 1965: 274; Meyer and Macurda, 1980: 84.

Materials: Two specimens, ASIZ 52048–9, Jun. 1985, Ta-lao-gu.

Diagnosis: Cirri XXII-XXIX, 38–43, 26–27 mm in length; the 14th and following cirri with dorsal spines. Arms 30 in number and 100–130 mm in length, all division series are 2; the IIIBr series only present on the outer; P_2 very stiff.

Family: Antedonidae
Toxometra paupera Clark

(Fig. 22)

Toxometra paupera, Clark, 1918: 210; Clark and Clark, 1967: 58.

Materials: One specimen, ASIZ 52050, B-station; One specimen, ASIZ 52051, Tarn-tzy-wan.

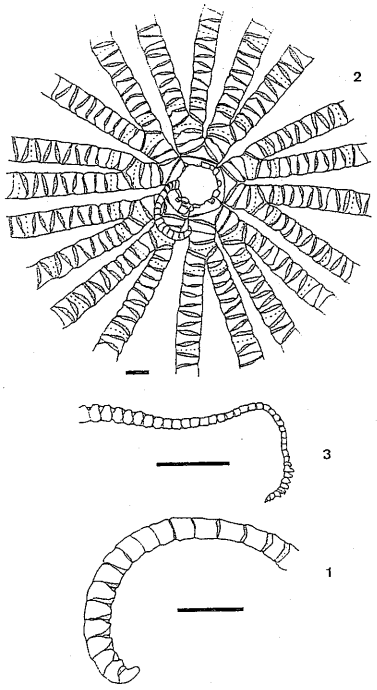

Fig. 3. *Capillaster multiradiatus.* 1, cirrus; 2, dorsal view; 3, first pinnule. (Scale: 2 mm)

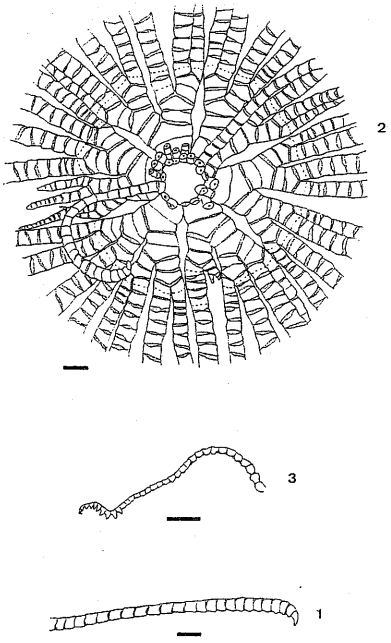

Fig. 5. *Comatella nigra.* 1, cirrus; 2, dorsal view; 3, first pinnule. (Scale: 2 mm)

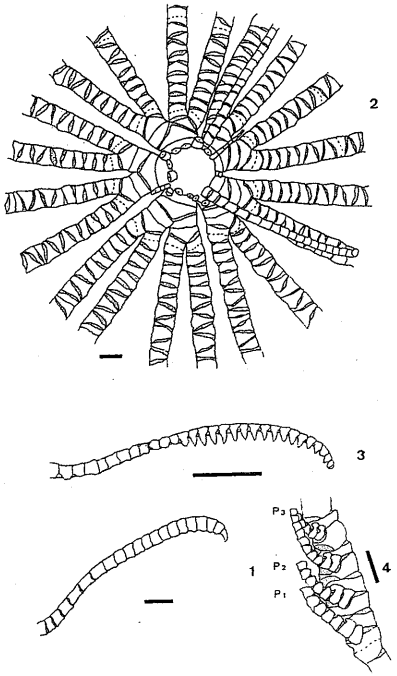

Fig. 4. *Comatella maculata.* 1, cirrus; 2, dorsal view; 3, first pinnule; 4, lateral view of arm and pinnules. (Scale: 2 mm)

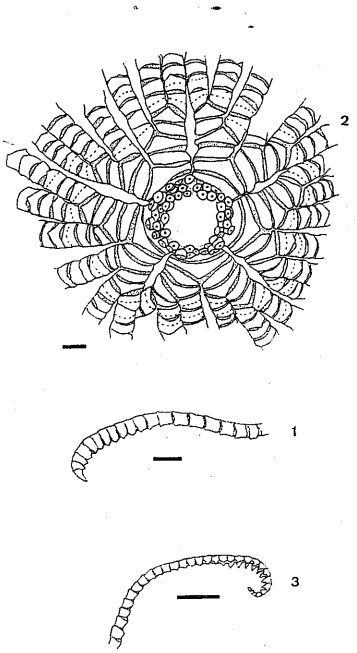

Fig. 6. *Comatella stelligera.* 1, cirrus; 2, dorsal view; 3, first pinnule. (Scale: 2 mm)

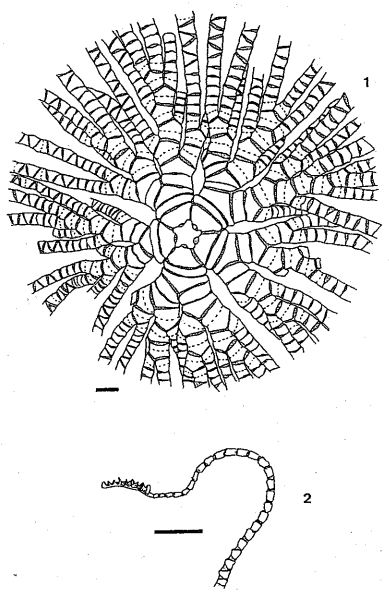

Fig. 7. *Comaster multifidus.* 1, dorsal view; 2, first pinnule. (Scale: 2 mm)

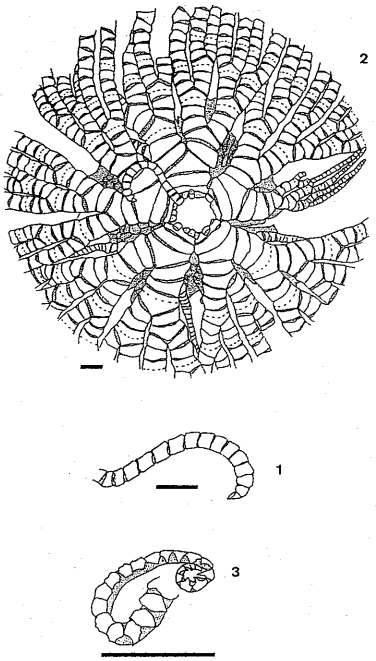

Fig. 9. *Comanthina schlegeli.* 1, cirrus; 2, dorsal view; 3, first pinnule. (Scale: 2 mm)

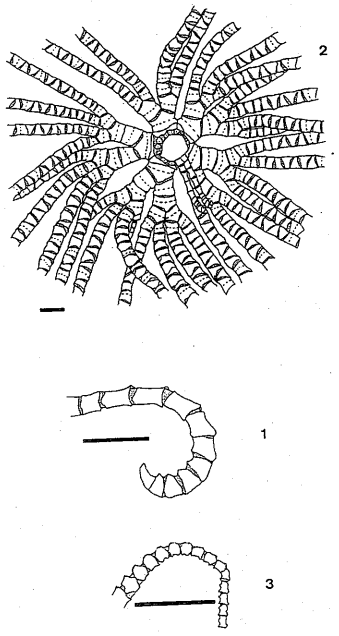

Fig. 8. *Comaster distinctus.* 1, cirrus; 2, dorsal view; 3, first pinnule. (Scale: 2 mm)

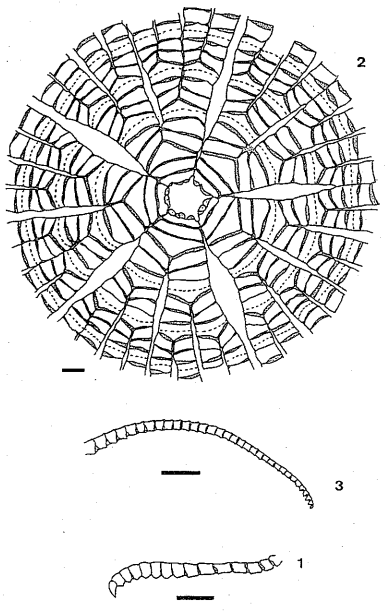

Fig. 10. *Comanthus parvicirrus.* 1, cirrus; 2, dorsal view; 3, first pinnule. (Scale: 2 mm)

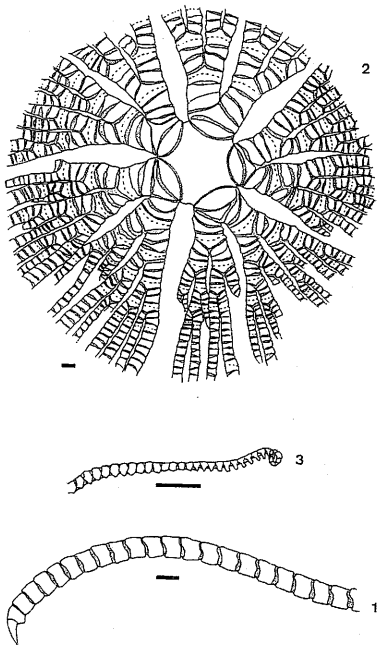

Fig. 11. *Oxycomanthus bennetti.* 1, cirrus; 2, dorsal view; 3, first pinnule. (Scale: 2 mm)

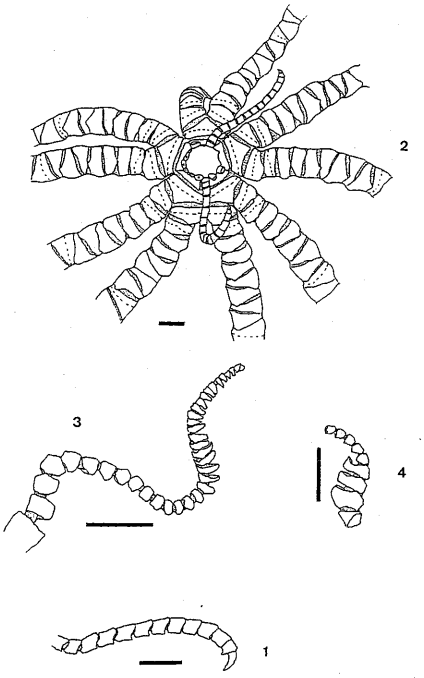

Fig. 13. *Comatula pectinata.* 1, cirrus; 2, dorsal view; 3, first pinnule; 4, lateral side view of 2nd pinnule. (Scale: 2 mm)

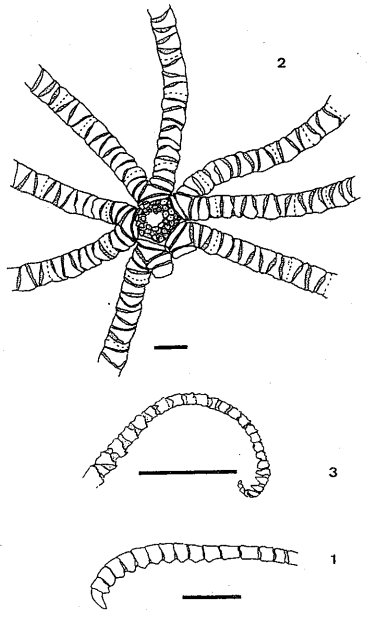

Fig. 12. *Comissia litteralis.* 1, cirrus; 2, dorsal view; 3, first pinnule. (Scale: 2 mm)

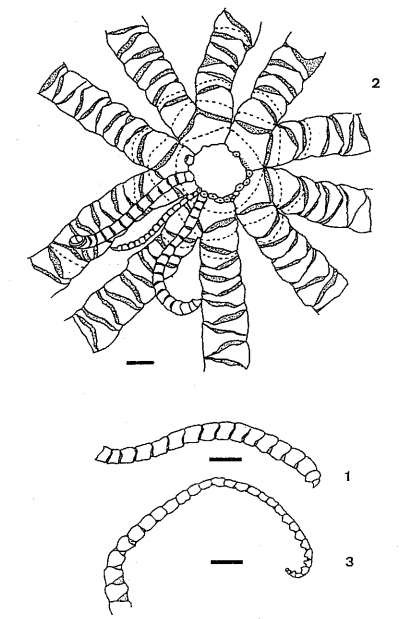

Fig. 14. *Comatula solaris.* 1, cirrus; 2, dorsal view; 3, first pinnule. (Scale: 2 mm)

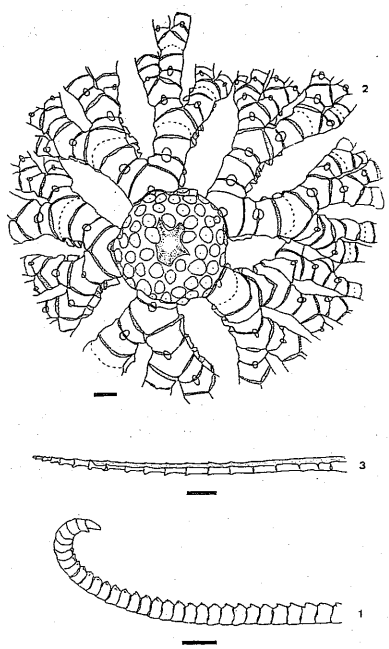

Fig. 15. *Basilometra boschmai.* 1, cirrus; 2, dorsal view; 3, first pinnule. (Scale: 2 mm)

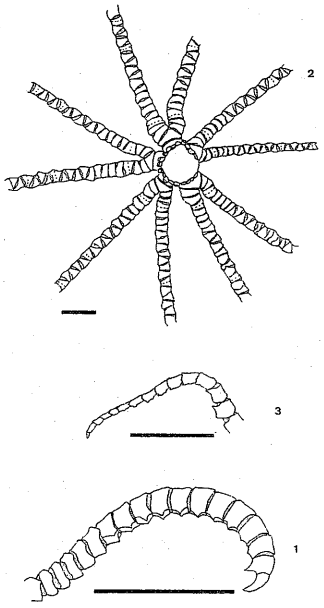

Fig. 17. *Oligometra serripinna.* 1, cirrus; 2, dorsal view; 3, first pinnule. (Scale: 2 mm)

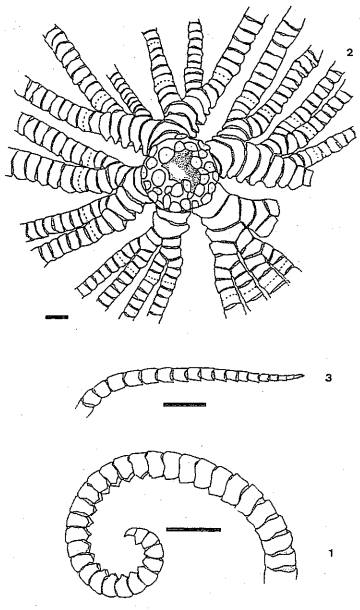

Fig. 16. *Cenometra bella.* 1, cirrus; 2, dorsal view; 3, first pinnule. (Scale: 2 mm)

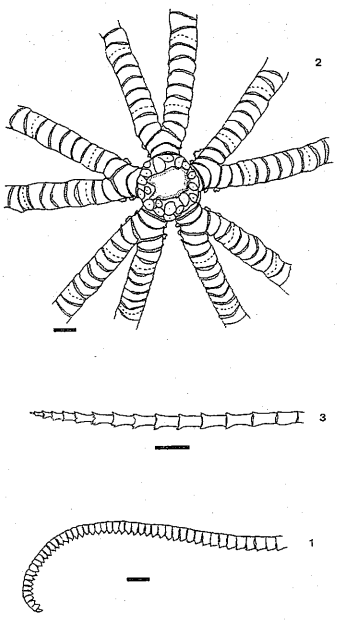

Fig. 18. *Colobometra perspinosa.* 1, cirrus; 2, dorsal view; 3, first pinnule. (Scale: 2 mm)

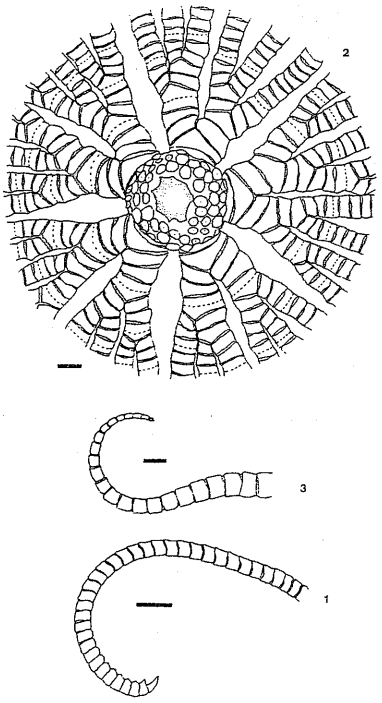

Fig. 19. *Himerometra magnipinna.* 1, cirrus; 2, dorsal view; 3, first pinnule. (Scale: 2 mm)

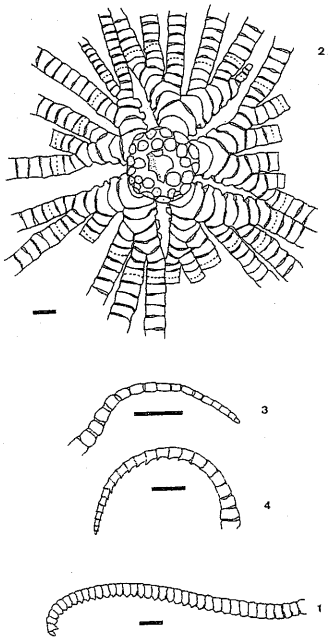

Fig. 21. *Lamprometra palmata.* 1, cirrus; 2, dorsal view; 3, first pinnule; 4, second pinnule. (Scale: 2 mm)

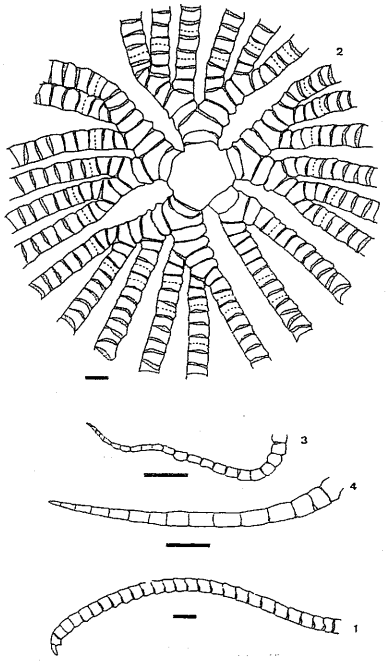

Fig. 20. *Stephanometra spicata.* 1, cirrus; 2, dorsal view; 3, first pinnule; 4, second pinnule. (Scale: 2 mm)

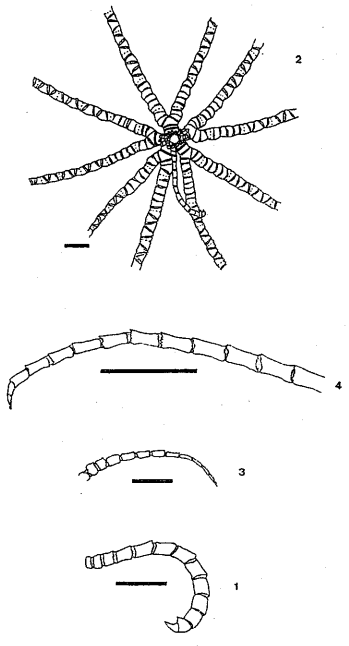

Fig. 22. *Toxometra paupera.* 1, cirrus; 2, dorsal view; 3, first pinnule; 4, third pinnule. (Scale: 2 mm)

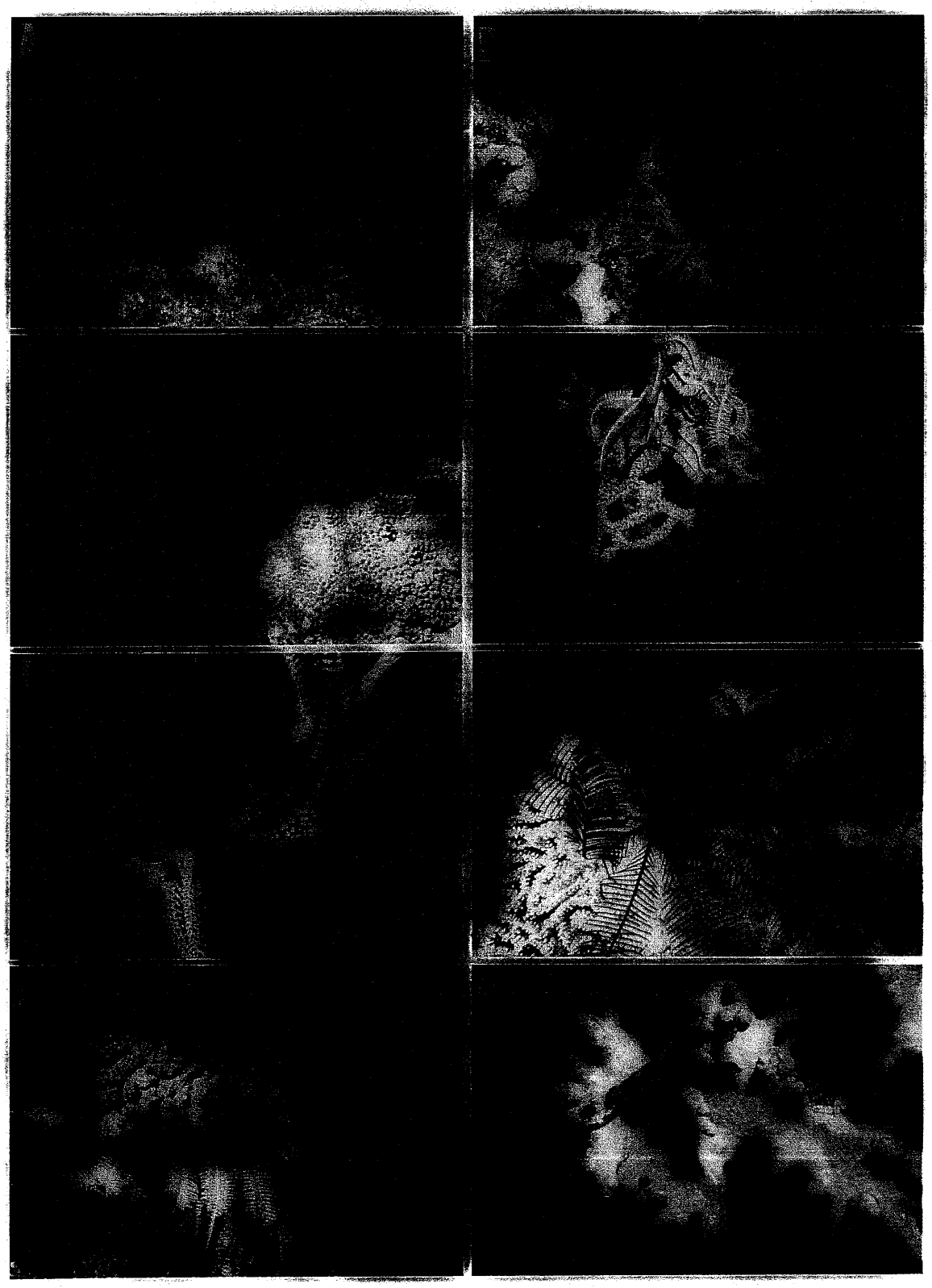

Fig. 23

Diagnosis: Centrodorsal thick and discoidal, 3.9 mm in diameter; the cirrus sockets arranged 3 rows in the slope; cirri about XLIII, 12-16, about 12 mm in length; Arms only 10 in number, 45-67 mm in length; P_3 is the longest pinnule.

ECOLOGY

Distribution of crinoids

A total of 20 species belonging to 16 genera in 5 families of comatulid crinoids were found in the shallow water of the Park (Table 2). The dominate species belonging to comasterids, were *Comatella maculata, Comastar multifidus, Comanthus parvicirrus* and *Oxycomanthus bennetti;* especially, *C. parvicirrus* and *C. maculata* were easily found in every sampling areas. Among these four dominant species, only did *O. bennetti* expose its body in water column, while the others lived within infrastructure of the corals.

TABLE 2
A list of comatulids at Kenting National Park, Taiwan

Species	Locality (*)										
	1	2	3	4	5	6	7	8	9	10	11
Capillaster multiradiatus	+			+	+		+				
Comatella maculata	+	+	+	+	+	+	+	+	+	+	+
Comatella nigra	+						+	+			
Comatella stelligera	+										
Comaster distinctus									+		+
Comaster multifidus	+		+	+	+		+		+	+	+
Comanthina schlegeli	+	+	+						+		
Comanthus parvicirrus	+	+	+	+	+	+	+	+	+	+	+
Oxycomanthus bennetti		+		+	+			+	+		+
Comissia littoralis	+										
Comatula pectinata											+
Comatula solaris		+						+			
Basilometra boschmai				+							+
Cenometra bella				+							+
Oligometra serripinna		+		+							
Colobometra perspinosa				+					+		+
Himerometra magnipinna		+	+	+	+			+			
Stephanometra spicata		+									
Lamprometra palmata				+				+			
Toxometra paupera			+		+						
Total species	8	8	6	11	7	2	5	7	7	3	9

* See Fig. 1 and Table 1.

Fig. 23A. *Oxycomanthus bennetti*, showing three color varieties. D-station, depth 10 m. Arm length 15-20 cm.

23B. *Oxycomanthus bennetti*, showing cirri and proximal arms. Hsia-shai-ku, depth 12-15 m. Arm length 15-20 cm.

23C. *Himerometra magnipinna*, D-station, depth 10 m. Arm length about 8 cm.

23D. *Capillaster multiradiatus*, clinging to *Subergogia suberosa.* Ta-lao-gu, depth 20-25 m. Arm length about 14 cm.

23E. *Cenometra bella*, clinging to Ellisellidae. Mau-pi-tou, depth 12-15 m. Arm length 11-13.5 cm.

23F. *Colobometra perspinosa*, clinging to *Subergorgia mollis.* Ta-lao-gu, depth about 20 m. Arm length 9 cm.

23G. *Comanthina schlegeli*, under *Acropoda* sp. Hsia-shai-ku, depth 12-15 m. Arm length 15 cm.

23H. *Oligometra serripinna*, perching on *Sinularia* sp. Ta-lao-gu, depth about 15 m. Arm length 3.5-5 cm.

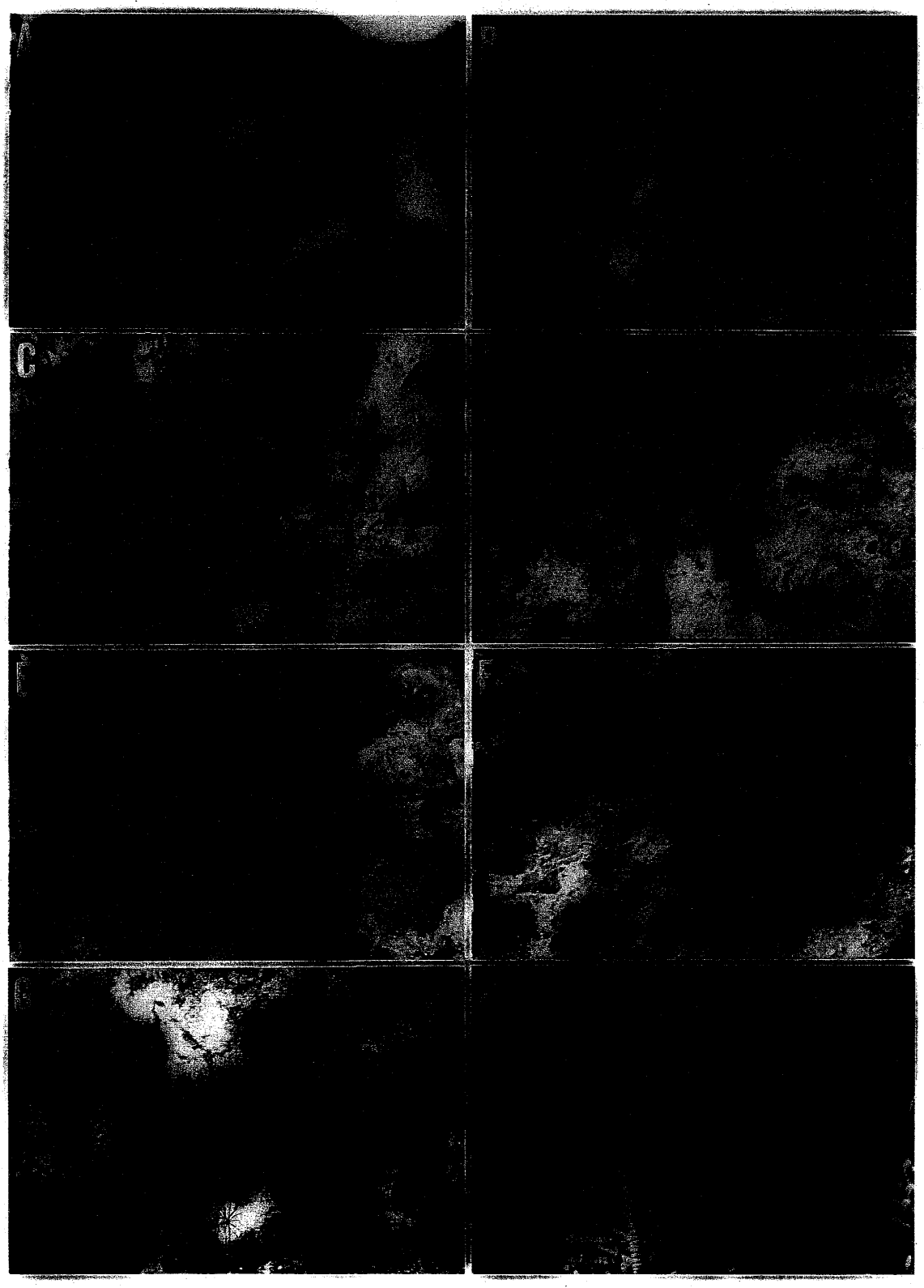

Fig. 24

Habitats and arms form

Habitat and posture of the crinoids occurred in the Park are listed in Table 3. *Oxycomanthus bennetti* (Fig. 23A, B) and *Himerometra magnipinna* (Fig. 23C) perched on the top of coral heads or rock pinnacles. *Capillaster multiradiatus* (Fig. 23C), *Basilometra palmata, Cenometra bella* (Fig. 23E) and *Colobometra perspinosa* (Fig. 23F) clinged to gorgonian and exposed their arms completely. *Comanthina schlegeli* (Fig. 23G), *Oligometra serripinna* (Fig. 23H) and *Comatula pectinata* (Fig. 24A) dwelt under the reef. *Comatula solaris* (Fig. 24B) curled up under the colony of hard or soft coral, and its arms were not exposed by day. *Comatella maculata* (Fig. 24C, D), *C. nigra, C. stelligera, Comaster multifidus* (Fig. 24E), *C. distinctus*

TABLE 3

Habits, posture and depth of comatulid crinoids at Kenting National Park

Species	Relation to Substratum	Exposure during the day	Depth (m)
Capillaster multiradiatus	Clings to gorgonian (fans) or attaches in recesses of coral or rock	Complete or arms only	3-25
Comatella maculata	Attaches in recesses of coral or rock	Arms only	2-15
Comatella nigra	Attaches in recesses of coral	Arms only	4-11
Comatella stelligera	Attaches in recesses of coral or rock	Arms only	4- 8
Comaster multifidus	Attaches in crevices of coral or rock	Arms only	4-25
Comaster distinctus	Attaches in recesses of coral	Arms only	12-25
Comanthina schlegeli	Perches on coral or rock attaches in recesses of coral or rock	Complete or arms only	4-15
Comanthus parvicirrus	Attaches in recesses or crevices of coral of rock	Arms only	2-18
Oxycomanthus benntti	Perches on coral or rock	Complete	10-25
Comissia littoralis	Attaches in recesses of coral	Arms only	6- 8
Comatula pectinata	Clings to gorgonian (whips) or attaches in recesses of soft coral	Complete or arms only	10-19
Comatula solaris	Curles up beneath coral	No	10-15
Basilometra boschmai	Clings to gorgonian (fans)	Complete	12-15
Cenometra bella	Clings to gorgonian (fans or whips) or Antipathidae	Complete	12-15
Oligometra serripinna	Clings to gorgonian (fans) or attaches in crevices, or perches on soft coral	Complete or arms only	10-25
Colobometra perspinosa	Clings to gorgonian (fans)	Complete	10-25
Himerometra magnipinna	Perches on coral rock	Complete	10-15
Stephanometra spicata	Attaches in recesses of coral	Arms only	10-12
Lamprometra palmata	Clings to gorgonian (fans)	Complete	15-20
Toxometra paupera	Attaches in recesses of coral	Arms only	4-12

Fig. 24A. *Comatula pectinata*, under *Sarcaphyton* sp. D-station, depth about 10 m. Arm length 8.5 cm.
24B. *Comatula solaris*. Mau-pi-tou, depth 12-15 m. Arm length 8.5 cm.
24C. *Comatella maculata*. Ta-lao-gu, depth about 15 m. Arm length about 8.5 cm.
24D. *Comatella maculata*. D-station, depth 10 m. Arm length 10 cm.
24E. *Comaster multifidus*. Horng-chair, depth 10-15 m. Arm. length 12 cm.
24F. *Comaster distinctus*. Hsia-shai-ku, depth 12-15 m. Arm length about 7.5 cm.
24G. *Comanthus parvicirrus*. D-station, depth 8-10 m. Arm length about 10 cm.
24H. *Comanthus parvicirrus*, showing section of one arm with offset pattern of pinnules. D-station, depth 10 m. Arm length 10 cm.

(Fig. 24F), *Comanthus parvicirrus* (Fig. 24G, H), *Comissia littoralis*, *Stephanometra spicata* and *Toxometra paupera* extended their arms from crevices in the reef framework.

Because it is difficult for SCUBA divers to use systematic key to distinguish the crinoids, a key based on the ecological data is necessary and important.

Key to species of crinoids based on their ecological data

1. Attaches in recesses of coral or rock during the day.....2
   Fully or partly visible by day.....11
2. Arms completely hidden in the shelter; arms brown with white bands, pinnules umber; only 10 arms..... .....*Comatula solaris*
   Arms not completely hidden, being partly exposed in the water column. 3
3. Only 10 arms.....4
   More than 10 arms.....5
4. Cirri more than xxv; arms brown to black proximally....*Toxometra paupera*
   Cirri less than XX; arms yellow ocher, not black. .....*Commissia littoralis*
5. Only 20 arms; scarlet with golden yellow spots; light green with black spots; or arms umber, pinnules brown. .... *Comatella maculata*
   More than 20 arms. 6
6. Cirri more than XXXV.....7
   Cirri less than XXX. 8
7. Arms, pinnules and cirri scarlet to dark red.....*Comatella stelligera*
   Arms usually brown with black bands... .....*Stephanometra spicata*
8. Arms black; 40–48 arms. ....*Comatella nigra*
   Color not as above. 9
9. Arms and pinnules silver gray or green, pinnules tips gold yellow to light green; or arms are green or brown, pinnule dark blue with brown tips or dark green with light green tips. ....*Comanthus parvicirrus*
   Arms and pinnules orange-yellow; arms very slender and delicate.....10
10. Cirri well developed; about 34 arms..... ..... *Comaster distinctus*
    Cirri absent; more than 40 arms..... ..... *Comaster multifidus*
11. Perches on the surface of coral or rock. 12
    Clings to gorgonacean (whips and fans). 14
12. Pinnules scarlet; arms usually white..... .....*Himerometra magnipinna*
    Color not as above.....13
13. Short and weak cirri; arms and pinnules dark green, pinnule tips lemon yellow. ..... *Comanthina schlegeli*
    Long and stout cirri; arms canary to gold, pinnules black with lime green or white tips; arms dark green with light green band, pinnules most black; arms brown, pinnules black with light green tips.....*Oxycomanthus bennetti*
14. Only 10 arms.....15
    More than 10 arms. 17
15. Clings to sea whips; arms and pinnules red to scarlet, pinnule tips yellow..... .....*Comatula pectinata*
    Clings to sea fans; color not as above. 16
16. Arms 7–10 cm in length; form radial fans; arms and pinnules brown (sometime with white bands), ambulacra groove black....*Colobometra perspinosa*
    Arms 3.5–5cm in length; not form radial fans; arms and pinnules brown (sometime with white bands)..... .....*Oligometra serripinna*
17. 16–20 arms; arms and pinnules gray with black articulations..... .....*Capillaster multiradiatus*
    More than 20 arms. 18
18. More than 60 arms; arms and pinnules brown to black proximally..... ..... *Basilometra boschmai*
    Less than 30 arms. 19
19. Arms khaki with brown spots; pinnules brown with white bands or white with black bands, pinnule tips white..... .....*Cenometra bella*
    Arms brown with white bands; pinnules khaki. .....*Lamprometra palmata*

DISCUSSION

Meyer and Macurda (1980) described that *Capillaster multiradiatus* is a nocturnal crionid. However, we found that this species is also visible in day time. Basically, the diurnal behavior of *C. multiradiatus* seems to depend on where the animal inhabits. For instance, at Ta-lao-gu (about 15–25 m deep) two individuals of *C. multiradiatus* clinged to gorgonian and completely exposed their arms by day; whereas, in other areas this animal attached in recesses of coral or rock with arms partly hidden (Table 3). Therefore, *C. multiradiatus* may have different habits at different areas, which may be related to different depth, habitats, light intensity or current (La Touche, 1978; Byrne and Fortain, 1981; Meyer *et al.*, 1984).

Generally, comasterids live within infrastructure of the reef, while non-comasterids live in exposed habit (Meyer, 1979). For instance, most comasterids observed in this study attach in recesses or crevices of coral colony or rock with their arms exposed by day. However, *Oxycomanthus bennetti* completely exposes its arms in the water column. On the other hand, non-comasterids, especially Colobomtridae, cling to gorgonian or perch on the surface of corals or rocks during day time (Table 3).

Since color variation is common by seen in crinoids (Meyer and Macurda, 1980; Zmarzly, 1984), thus the color prttern is not an unreliable character for species identification. To ensure the key presented here to be valid, we have taken carefully the color variation into account. Some rules on the color variation are tentatively made. Briefly, the more cryptic the species is, the less variation in its color patterns. As to those species exposed their bodies by day, there is not any common trend in their color variation. It's worthy to note that the color of *Oxycomanthus bennetti* vary amazingly: like arms canary to gold, pinnules black with lime green or white tips; arms olive green with green band, pinnules alomst black; arms brown, pinnules black with lime green tips.

REFERENCE

APPLEGATE, A. L. (1984) Echinoderms of southern Taiwan. *Bull. Inst. Zool., Academia Sinica* **23**: 93-118.

BYANE, M. and A. R. FONTAINE (1981) The feeding behaviour of *Florometra serratissma* (Echinodermata: Crinoidea). *Can. J. Zool.* **59**: 11-18.

CHANG, F. Y. and Y. L. LIAO (1964) Echinodermata. In *Illustrated fauna of China* (P. C. Wu and L. J. Cheng, eds.). Science Press, Beijing, 142 pp.

CHAO, S. M. (1986) *Holothuroids of southern Taiwan.* M. S. Thesis. Natl. Sun Yat-sen Univ., Kaohsiung, 110 pp.

CHEN, C. P. and K. H. CHANG (1981) The regular sea urchins of Taiwan. *Bull. Inst. Zool., Academia Sinica* **20**: 78-86.

CHEN, J. C. (1986) *The shallow-water crinoids (Echinodermata: Crinoidea) of Kenting National Park, Taiwan.* M. S. Thesis. Natl Sun Yat-sen Univ., Kaohsiung, 112 pp.

CLARK, A. H. (1908) Preliminary notice of a collection of recent crinoids from the Philippine Islands. *Smithson. Misc. Coll.* **52**: 199-234.

CLARK, A. H. (1912) The crinoids of the Natural History Museum at Hamburg. *Smithson. Misc. Coll.* **60**: 1-33.

CLARK, A. H. (1913) Notes on the recent crinoids in the British Museum. *Smithson. Misc. Coll.* **61**: 1-89.

CLARK, A. H. (1918) The unstalked crinoids of the Siboga expedition. *Siboga Exped.* **42b**: 1-300.

CLARK, A. H. and A. M. CLARK (1967) A monograph of the existing crinoids. I(5). Suborders Oligophreata (concluded) and Macrophreata. *Bull. U. S. Natl. Mus.* **82**: 1-860.

CLARK, A. M. (1972) Some crinoids from the Indian Ocean. *Bull. Brit. Mus. (Nat. Hist.) Zool.* **24**: 75-156.

CLARK, A. M. and F. R. E. ROWE (1971) Monograph of shallow-water Indo-West Pacific echinoderms. *Brit. Mus. (Nat. Hist.). Publ.* **690**: 1-238.

HAYASAKA, I. (1948) Notes on the echinoids of Taiwan. *Bull. Oceanogr. Inst. Taiwan* **4**: 1-35.

HAYASAKA, I. (1949) On some starfishes from Taiwan. *Bull. Oceanogr. Inst. Taiwan* **5**: 11-19.

LA TOUCHE, R. W. (1978) The feeding behavior of the feather star *Antedon bifida* (Echinodermata: Crionidea). *J. Mar. Biol. Ass. U. K.* **588**: 877-890.

LAIO, Y. L. (1983) The echinoderms of Xisha Island, Guangdong Province China. V. Crinoidea. *Inst. Oceanology, Academic Sinica* **605**: 263-277.

MEYER, D. L. (1979) Length and spacing of the tube feet in suspension-feeding. *Mar. Biol.* **51**: 361-369

MEYER, D. L. and D. B. MACURDA, Jr. (1980) Ecology and distribution of the shallow-water crinoids of Palau and Guam. *Micronesica* **16**: 59-99.

MEYER, D. L., C. A. LAHAYE, N. D. HOLLAND, A. C. ARNESON and J. R. STRICKLER (1984) Time-lapse cinematography of feather stars (Echinodermata: Crionidea) on the Great Barrier Reef, Australia: demonstrations of posture changes, locomotion, spawning and possible predation by the fish. *Mar. Biol.* **78**: 179-184.

ROWE, F. R. E., A. K. HOGGETT, R. A. BIRTLES and L. L. VAIL (1986) Revision of some comasterid genera from Australia (Echinodermata: Crionidea), with descriptions of two new genera and nine new species. *Zool. J. Lin. Soc.* **86**: 197-277.

UTINOMI, H. and I. KOGO (1965) On some comatulids from the coastal sea of KII Peninsula. *Publ. Seto. Mar. Biol. Lab.* **8**: 263-286.

WU, S. K. (1982) The Ophiurans (Echinodermata: Ophiuroidea) of Taiwan. *Biol. Bull. Taiwan Normal Univ.* **17**: 15-23.

ZMARZLY, D. L. (1984) Distribution and ecology of shallow-water crionid at Enewetak Atoll, Marshall Island. With an annotated checklist of their symbionts. *Paci. Sci.* **38**: 105-122.

南臺灣墾丁國家公園海域海百合之研究

陳 健 祺　張 崑 雄　陳 章 波

南臺灣墾丁國家公園海域亞潮帶的海百合類，共計有 5 科 16 屬 20 種。本文中在分類上包括這 20 種海百合外部形質的檢索及特徵的描述。在生態上則有墾丁海域海百合的分佈及以棲息場所和個體顏色爲基礎的生態檢索。