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Identification of feather stars (Echinodermata: Crinoidea: Comatulida) at Subic Bay, Zambales, Philippines

Carmen C. Arguelles*, Reynald M. dela Paz[1], and **Florencia G. Claveria***

Biology Department, College of Science, De La Salle University,
2401 Taft Avenue, Manila, Philippines

A taxonomic survey of the feather stars collected from three dive sites, LST Wreck, San Quentin Wreck, and South Reef Canyons Coral Reef at Subic Bay, Zambales during the months of June, July, and October 2007, yielded 15 specimens belonging to four families and eight species. The eight species (order Comatulida) identified and confirmed by Dr. Charles Messing are: *Cenometra bella, Capillaster multiradiatus, Comanthus parvicirrus, Comaster nobilis, Comatella nigra, Himerometra robustipinna, Phanogenia gracilis* and *Stephanometra tenuipinna*. This study represents the first proper documentation of crinoid species in three dive sites at Subic Bay, Zambales, Philippines

Key Words: Comatulida, Crinoidea, San Quentin and LST Wreck, South Reef Canyons Coral Reef, Subic, Zambales, Philippines

INTRODUCTION

Feather stars constitute a group of echinoderms belonging to class Crinoidea and order Comatulida, having five to hundreds of arms surrounding their cup-like bodies (Grzimek 2003; Hyman, 1955). Just like their closest relatives, the sea lilies, feather stars are stalked only in the juvenile stage but detach their cup-like bodies in the adult stage to become freely moving or motile crinoids (Grzimek 2003). Feather stars are regarded as primitive echinoderms and today's living species all belong to the subclass Articulata (Ausich and Messing 1998). Order Comatulida is composed of 18 extant families, with family Comasteridae being the most common in tropical shallow-water in both the Indo-west Pacific and the Western Atlantic (Meyer and Macurda 1980; Messing 1998, 2001, 2003; Kirkendale and Messing 2003). Feather stars are among the least known echinoderms attributable to difficulty in their collection on account of their fragile nature, secretive habits, and distribution in deep waters. Also, their identification requires patience and painstaking attention to morphological details. In the Philippines, although it is believed that shallow waters (<50m deep) are inhabited by at least 60 living species of feather stars (Messing, personal communication 2008), there are no documented studies to warrant this claim. In this paper, we report our findings of eight species of crinoids inhabiting three dive sites at Subic Bay, Zambales, Philippines.

*Corresponding author: florencia.claveria@dlsu.edu.ph
pootsclaveria@yahoo.com

MATERIALS AND METHODS

Collection Site

Subic Bay is located between Zambales and Bataan provinces, Philippines. The three dive sites consisted of the San Quentin and LST wrecks, and the South Reef Canyons (Figure 1). San Quentin is one of the oldest wrecks in Subic Bay and is a vessel 50-60m long, found 12m underwater, with good visibility, and warm water temperature. From the scuba shack and with moderate water current, it takes approximately 5-10 min to get to the wreck. The LST is a landing craft 30 m deep, and has

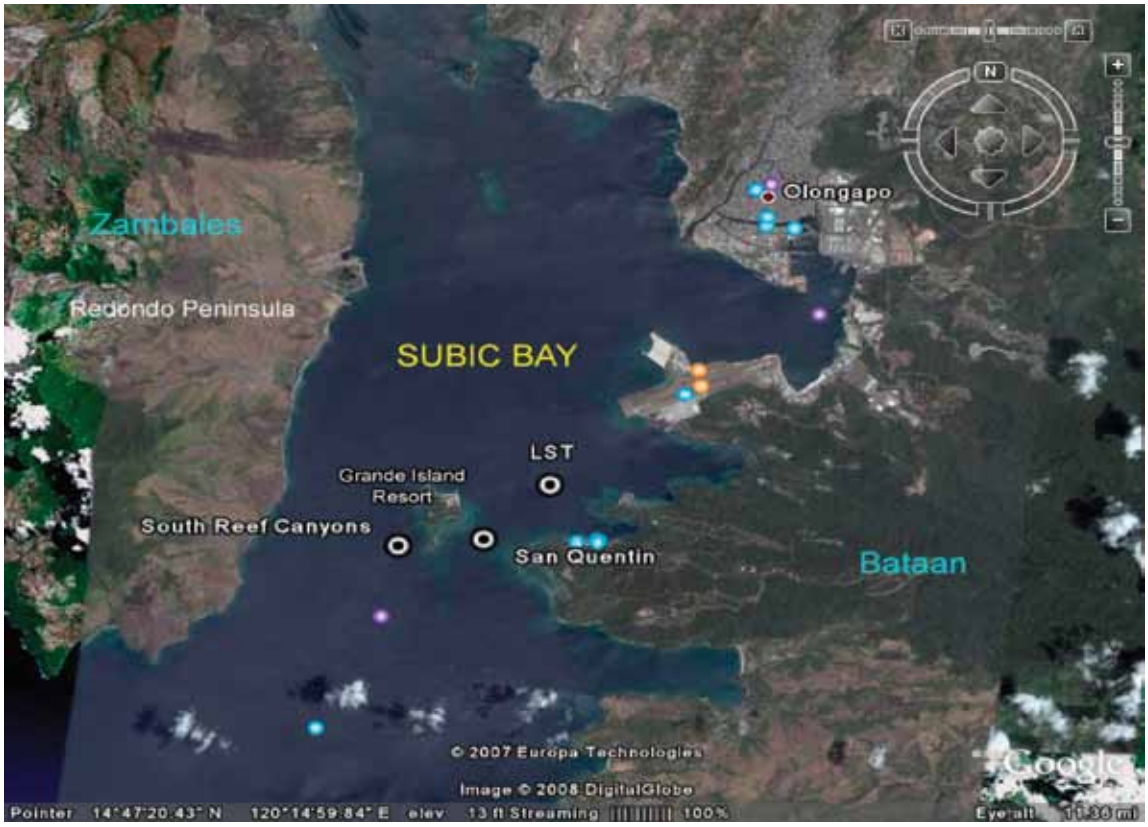

Figure 1. Subic Bay showing three diving sites (San Quentin LST Wrecks, and South Reef Canyons) in the collection of feather stars (Source: Office of Subic Bay National Authority)

15-30 m visibility depending on the water current. San Quentin wreck has more diverse marine life compared with the LST site (Casa Baretto 2006). The South Reef Canyons is situated behind Grande Island and west of Chiquita Island (Davis 2007), and is approximately 12 m deep, with mild currents, and warm temperature. It has the most diverse marine life relative to other dive sites including numerous feather stars clinging to hard corals (personal communication with other regular divers).

Field Collection and Preservation

Prior to diving, sea water-filled containers were placed in a net bag used to carry them underwater. To loosen the animal's grip on the substrate, a small metal bar was inserted between the cirri and the substrate, a technique employed to avoid possible breakage to the fragile arms. The animals were then placed in individual sea-water filled containers and transported back to land. Individual feather stars were transferred into a basin half-filled with seawater, the natural color noted and photographed. Two arms, one cirri, and the diameter of the central disk were measured in cm. To prevent premature killing of specimen, the basin used was washed thoroughly with tap water after every use. The specimen were then carefully lifted and immersed into their respective sea-water-filled containers to which 95% ethanol (3 parts sea water: 1 part 95% ethanol) was added, oral side down with arms spread out. Using the fingers, pressure was gently applied for about 30 sec to restrain and keep the specimen in place and hasten fixation. When the animal became totally immobile, the seawater-95% ethanol solution was replaced with the 70% ethanol, as the final fixative (Hendler 2004; Messing 2006). Collection was done in June, July, and October, 2007. Per dive site, only one specimen of each kind was collected.

Morphological Examination and Measurement

Specimen were examined, noting important diagnostic features (Rouse et al. 2001). The body of crinoids (feather stars and sea lilies) is supported by calcium carbonate skeleton covered by a tissue layer (=skin). The central body (=theca) that houses the viscera is composed of a series of articulated ossicles forming the calyx. The theca and pinnule-bearing arms (brachials) of stalked juvenile feather stars make up the crown, while unstalked adult feather stars have cirri characterized as long hook-like structures for attachment. The calyx is composed of five basal ossicles (= basals) which may be absent or reduced, and five radial

ossicles (radials) that support the central disk. Ambulacral grooves extend from the mouth to the arms and pinnules, where food particles are captured. The centrodorsal either discoidal, hemispherical, cylindrical, star- or cone-shaped, is a large ossicle at the center of the aboral side of the body, where there are sockets for cirri attachment.

The works of AH Clark (1931), AM Clark and Rowe (1971), Rowe et al. (1986), and Messing (2001) were used in the identification of the specimen at the family, genus and species level. To ensure accuracy of findings, data were rechecked once or twice, if necessary. All identified species were verified/confirmed by Dr. Charles G. Messing thru email correspondence (messingc@nova.edu).

Curation of Collections

The specimen were kept in individual 13 x 13.5 cm plastic containers with 70% ethanol, labeled with a tag bearing the date and where collected, and collector's name. These were deposited at the Animal Systematics Laboratory, Biology Department, De La Salle University-Manila. Each specimen was assigned a separate number and properly catalogued with the following entries: 1. consecutive collection number: 2. original field number: 3. scientific name or at least the genus prior to verification/ confirmation: 4. exact locality of collection site: 5. date of collection: 6. name of collector; and 7. remarks.

RESULTS AND DISCUSSION

Despite the rich/diverse marine life in the other diving sites, feather stars were absent. A total of 15 specimen of comatulid crinoids were collected from the San Quentin (n=4), South Reef (n=55), and LST Wreck (n=6). The specimen represented eight different species belonging to four families (Table 1). Of the 15 specimen, one specimen each of *Cenometra bella*, *Comanthus parvicirrus* and *Stephanometra tenuipinna* were collected from the LST wreck; one and two specimen of *Comatella nigra* and *Phanogenia gracilis* from the South Reef Canyons, respectively; a total of three specimen of *Comaster nobilis* from the San Quinten and the LST wreck; one specimen each of *Himerometra robustipinnin* from the San Quentin and the LST Wreck; and a total of four *Capillaster multiradiatus* were collected from the three diving sites (Table 2).

Family Colobometridae

Diagnosis: Cirral borne on one or two transverse combs with two or three thorny projections curving inward (Grzimek 1972).

Table 1. Classification of the available genera of Comatulida based on the scheme of AM Clark and Rowe (1971) as emended by Messing (2001).

Family	Subfamily	Species
Colobometridae		*Cenometra bella*
Comasteridae		
	Capillasteriinae	*Capillaster multiradiatus*
	Comasterinae	*Comanthus parvicirrus*
		Comaster nobilis
		Phanogenia gracilis
		Comatella nigra
Himerometridae		*Himerometra robustipinna*
Mariametridae		*Stephanometra tenuipinna*

Table 2. An account of the collection sites of the 15 specimen of comatulid feather stars during the months of June, July and October, 2007.

Species	LST Wreck	South Reef Canyons	San Quentin
Cenometra bella	1	-	-
Comanthus parvicirrus	1	-	-
Stephanometra tenuipinna	1	-	-
Comatella nigra	-	2	-
Phanogenia gracilis	-	1	-
Comaster nobilis	1	-	2
Himerometra robustipinna	1	-	1
Capillaster multiradiatus	1	2	1
Subtotal	6	5	4

Legend: - (not found during collection time)

Genus *Cenometra* A.H. Clark, 1909

Diagnosis: A genus of Colobometridae in which the second oral pinnule (P_2) is very stout and stiff and much longer than the first and third; the segments of P_2 have flared and spinose distal ends; and all have more than 10 arms (Modified from Clark and Rowe 1971).

Cenometra bella (Figure 2)

Materials examined: Annotations: Single specimen, DLSU Z.C. 001, LST Wreck, Subic Bay, June 10, 2007; collected by C. Argüelles.

Diagnosis: Whole aboral side including brachials and cirri dark brown; pinnules cream, with dark brown spots, their proximal segments also colored dark brown; mouth located at the center of the central disc; each of the IIBr series of the arms composed of two brachials; each segment from the middle and distal areas of the cirri with

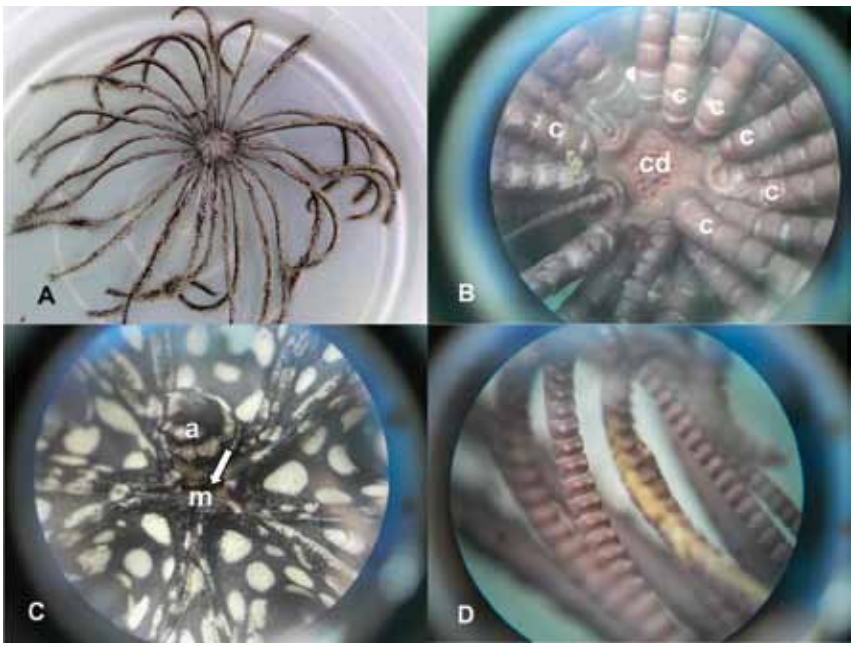

Figure 2. *Cenometra bella*. A. Whole specimen showing aboral surface with cirri and arms with brownish cream colored pinnules; B. Centrodorsal surrounded by cirri; C. Oral surface showing the mouth (arrow) adjacent to anus; D. Middle and distal segments of cirri with paired tubercles, one on each side of midline.

Legends: mouth (m); anus (a); centrodorsal (cd); cirri (c).

a pair of tubercles, one on each side of the midline; P_2 stout and stiff and largest among all the pinnules (personal observation).

Family Comasteridae

Diagnosis: With disc-shaped centrodorsal and mouth usually positioned toward the central disc margin; anus usually found central; cirri present only in juveniles, absent or reduced in the adults; shorter arms used for attachment and usually without ambulacral grooves though may still house the gonads (Modified from Grzimek 1972).

Genus *Capillaster* A.H. Clark, 1909

Diagnosis: Of the subfamily Capillasteriinae with oblong brachials much wider than long and strongly spinose medial brachials (Messing 2001); comb teeth of oral pinnules confluent (Rowe et al. 1986). Species of *Capillaster* are usually found either fully or semi-exposed on hard or soft corals, some may even be on sea whips (Rouse et al. 2001).

Capillaster multiradiatus (Figure 3)

Materials examined: Annotations: Four specimen collected. Photos shown DLSU Z.C. 002, San Quentin, Subic Bay, July 21, 2007, and three others; DLSU Z.C. 003, South Reef Canyons, Subic Bay, July 21, 2007; DLSU Z.C. 004, South Reef Canyons, Subic Bay, July 21, 2007; DLSU Z.C. 005, LST, Subic Bay, October 12, 2007; collected by C. Argüelles.

Diagnosis: Body nearly all white, with small patches of dark brown in some of the pinnules; brachials white, while the dark brown ligaments dividing them; mouth located marginal to the central disc; IIBr series of arms all composed of 4(3+4) brachials; first syzygy arising from IIBr and following brachitaxes located at br_{2+3}; with single tubercle on each cirrus; confluent terminal comb teeth on oral pinnules (personal observation).

Genus *Comanthus* A. H. Clark, 1908

Diagnosis: A genus of subfamily Comasterinae in which the arms arising from IIBr and following brachitaxes have the first syzygy at br_{3+4}; mouth marginal (Modified from Messing 2001).

Comanthus parvicirrus (Figure 4)

Materials examined: Annotations: Single specimen, DLSU Z.C. 006, LST, Subic Bay, October 12, 2007; collected by C. Argüelles.

Diagnosis: Aboral side bears the centrodorsal, cirri, and dark green brachials; pinnules all blue; mouth located

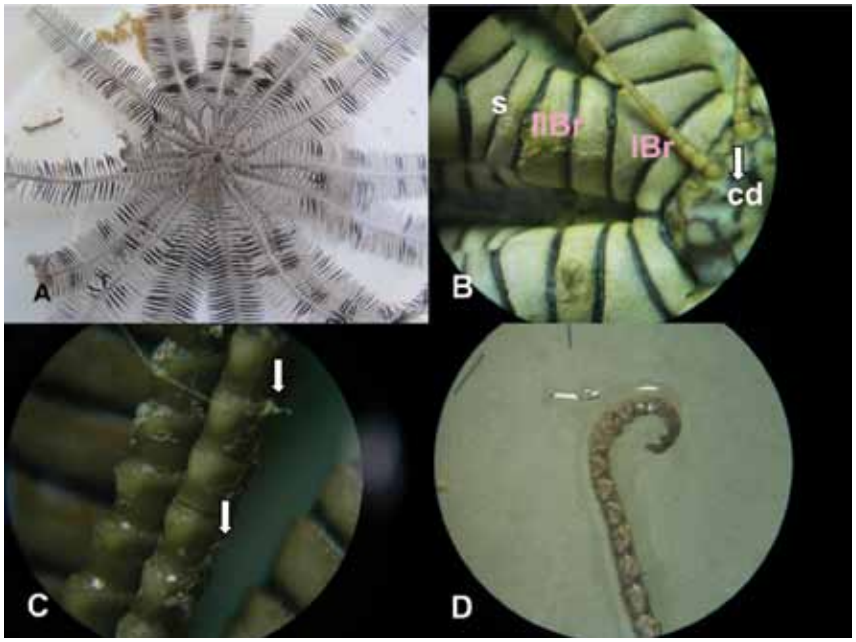

Figure 3. *Capillaster multiradiatus.* A. Whole specimen showing aboral surface and some pinnules bearing dark brown patches; B. White to creamy brachials with dark brown ligament/suture between them, and mouth (arrow) located marginal to the centrodorsal; C. Cirrals each bearing a single tubercle (arrows); D. Confluent terminal comb teeth on oral pinnules.

Legends: suture/ligament (s); centrodorsal (cd); brachial (br).

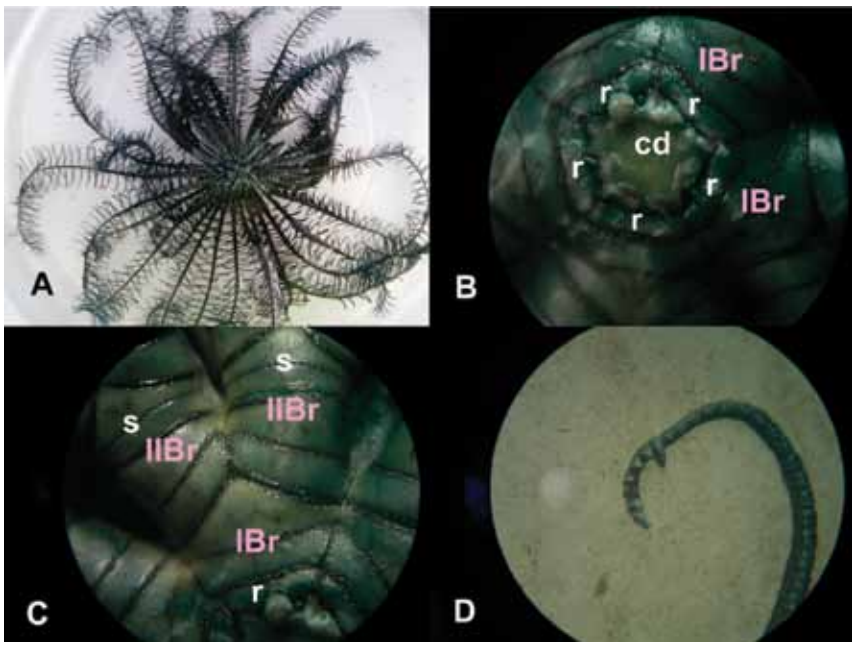

Figure 4. *Comanthus parvicirrus.* A. Whole specimen showing aboral side with cirri and arms with blue pinnules; B. centrodorsal surrounded by radial ossicles; C. Endoskeletal elements or brachial (IIBr series) delineated by brown sutures/ligaments; D. Oral pinnules formed into confluent spoon- or saucer-like terminal combs.

Legends: radial ossicles (r); suture/ligament (s); centrodorsal (cd); brachial (br).

marginal to central disc; arms arranged flatly on one plane; IIBr series composed of 4(3+4) brachials; IIIBr series composed mostly of 4(3+4) brachials as well, but some with two brachials only; oral pinnules have a confluent terminal comb, the most proximal comb tooth having a spoon- or saucer-like appearance; halfway through the arm, pinnules begin to alternate between uncombed and combed pinnules (personal observation).

Genus *Comaster* Agassiz, 1830 (Syn. *Comanthina* Clark):

Diagnosis: Of the subfamily Comasterinae with IIBr usually 4(3+4); IIIBr usually of 2 ossicles exteriorly and 4(3+4) interiorly; combs present at least to P_3, sometimes at intervals to P_{14}; on pinnules arising from arms (except sometimes P_1), comb teeth paired, straight or gently curved, confluent with sides of pinnulars; each tooth of a pair of same size or nearly so; paired teeth sometimes joined to form a transverse bar or filled arch; teeth on adjacent segments not in contact basally; terminal tooth discrete or last few pinnules tapering to a sharp point; aboral interradial surface of disk paved with irregular plates, especially in larger specimen; mouth eccentric [Messing 2001, as emended from Rowe et al. (1986) and Hoggett and Rowe (1986) for *Comanthina* and Messing (1998)].

Comaster nobilis (Figure 5)

Materials examined: Annotations: Three specimen collected. Photos shown DLSU Z.C. 007, LST, Subic Bay, October 12, 2007; DLSU Z.C. 008, San Quentin, Subic Bay, July 21, 2007; DLSU Z.C. 009, San Quentin, Subic Bay, July 21, 2007; collected by C. Argüelles.

Diagnosis: Whole body cream in color but central disc and proximal portions of arms with black spots; some distal parts of arms also with black spots but fewer; tips of pinnules yellow; mouth located marginal to central disc; IIBr series with 4(3+4) brachials; exterior IIIBr series composed of only two brachials, while interior portion composed of 4(3+4) brachials; bases of rays with a pavement of small plates separating them, making the aboral surface look very solid; cirral ornamentation absent; first oral pinnules with terminal comb, each tooth transversely oriented with each segment; pinnules beyond P_1 with pairs of teeth of equal size per segment.

Genus *Comatella* A. H. Clark, 1908

Diagnosis: Belongs to subfamily Phanogeniiae characterized as having thin, rounded keels at the basal few segments of oral pinnules; comb teeth of the oral pinnules confluent with the margin of the pinnulars closest to the arm (Modified from Messing 2001).

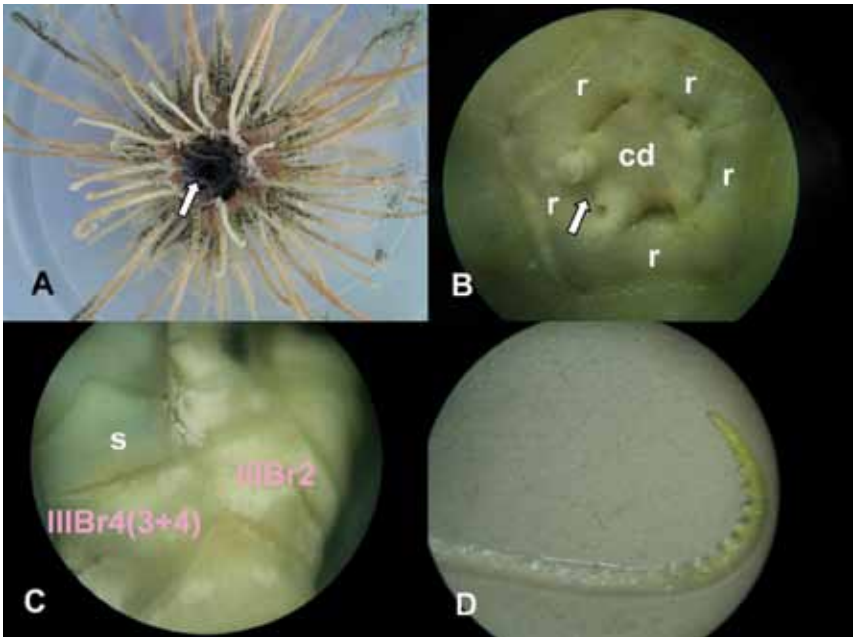

Figure 5. *Comaster nobilis.* A. Specimen white with black spotted central disc (arrow) and proximal arms; B. Oral side with mouth (arrow) located marginal to centrodorsal surrounded by radial ossicles; C. IIBr arm series; D. Oral pinnule with terminal combs, each tooth transversely oriented with each segment.

Legends: radial ossicles (r); suture/ligament (s); centrodorsal (cd); brachials (br).

Comatella nigra (Figure 6)

Materials examined: Annotations: Single specimen. DLSU Z.C. 010, South Reef Canyons, Subic Bay, July 21, 2007, and another; DLSU Z.C. 011, South Reef Canyons, Subic Bay, July 21, 2007; collected by C. Argüelles.

Diagnosis: Central disc and the proximal portion of arms very dark brown; proximal pinnules also dark brown but tips bright yellow; middle portion of the arms have even distributions of dark brown and yellow; distal portion of arms all yellow with some pinnules orange; cirri yellow and brown; mouth marginal to the central disc; all brachitaxes of the arms composed of two brachials only and joined by synarthry; axils asymmetrical, such that the arms are arranged in different planes; one tubercle in each cirral; non-confluent oral pinnules; thin, rounded keels found at the bases of each pinnule.

Genus *Phanogenia* Lovén, 1866

Diagnosis: Of the subfamily Phanogeniiae characterized as having arms arising from IIBr with the first syzygy at br_{1+2} or at br_{1+2} and br_{3+4} on adjacent arms; mouth located centrally or sub-centrally (Modified from Messing 2001).

Phanogenia gracilis (Figure 7)

Materials examined: Annotations: Single specimen. DLSU Z.C. 012, South Reef Canyons, Subic Bay, July 21, 2007; collector by C. Argüelles.

Diagnosis: Body brown to dark orange; mouth located central to the central disc; arms arising from IIBr and IIIBr with first syzygy at br_{1+2}; cirri absent; oral pinnules with confluent comb teeth (personal observation).

Family Himerometridae

Diagnosis: Feather stars under family Himerometridae have a single spine or keel in each segment of the cirri. Usually, the IIBr series are composed of 4(3+4) ossicles instead of two (Clark and Rowe, 1971).

Genus *Himerometra* A.H. Clark 1907

Diagnosis: Of the family Himerometridae characterized by the presence of three large proximal pinnules, P_1 being the largest and P_3 being the smallest (Modified from Clark and Rowe 1971).

Himerometra robustipinna (Figure 8)

Materials examined: Annotations: Single specimen. DLSU Z.C. 013, San Quentin, Subic Bay, July 21, 2007,

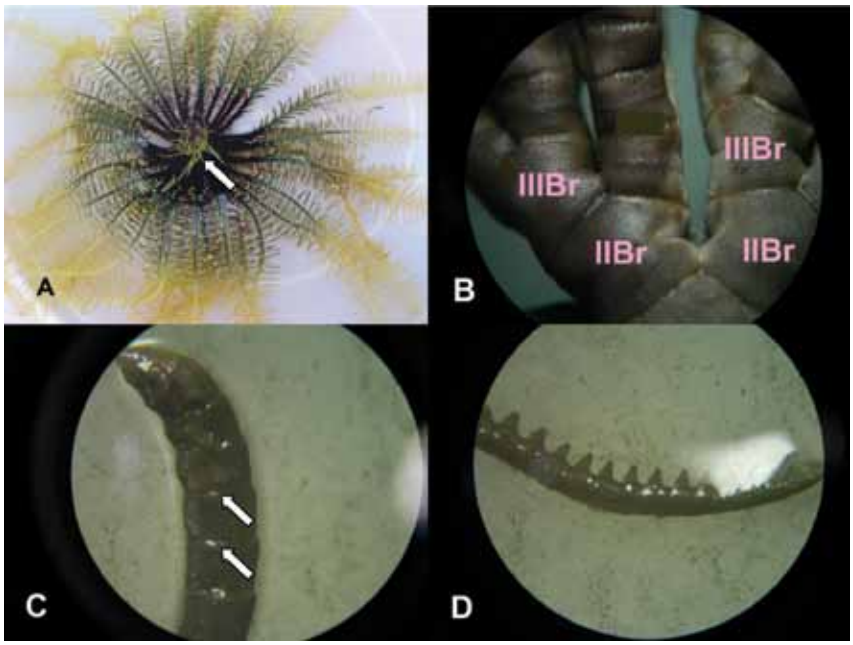

Figure 6. *Comatella nigra* A. Whole specimen showing aboral side with yellow brown- banded cirri (arrow), and arms dark brown at proximal end, dark brown pinnules at proximal segment to bright yellow at tips; B. Brachitaxes with two brachials (br) joined by synarthry; C. Cirrus showing one tubercle (arrows) per every ossicle (=cirral); D. Non-confluent oral pinnules.

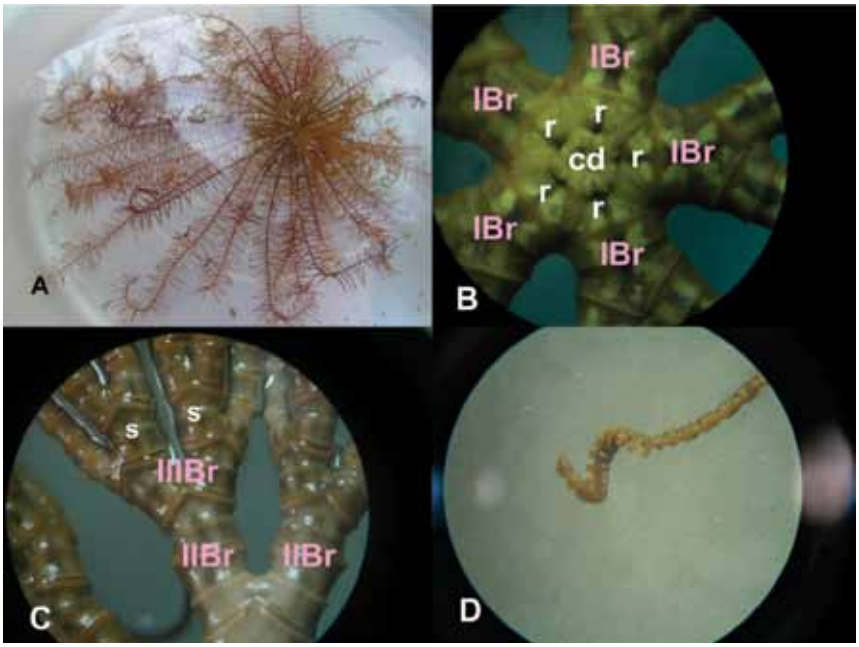

Figure 7. *Phanogenia gracilis* A. Body brown to dark orange with hair-like arms and pinnules and absence of cirri; B & C. centrodorsal surrounded by radial ossicles and arms brachitaxes (IBr to IIBr to IIIBr); D. Oral pinnules with confluent comb teeth.

Legends: centrodorsal (dc); radial ossicles (r).

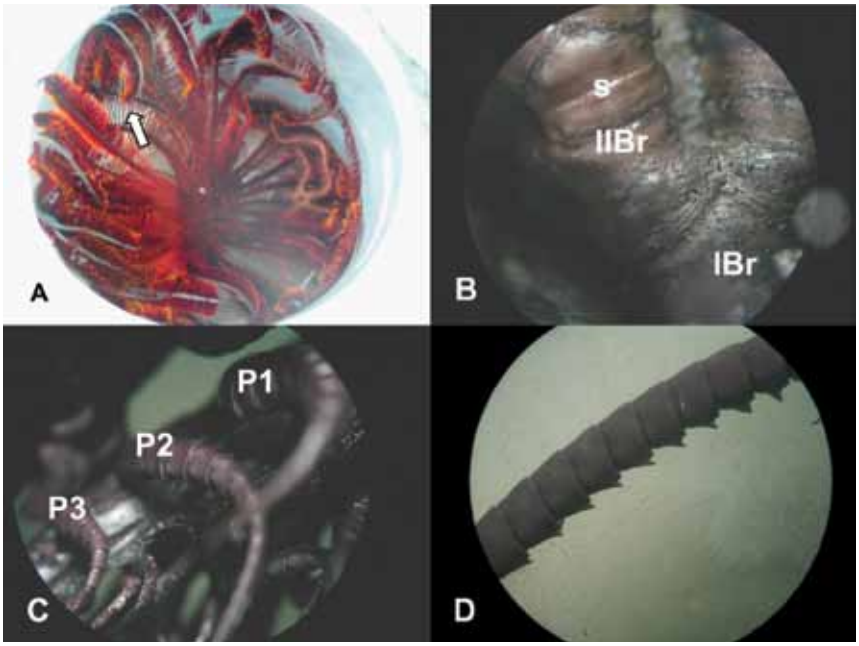

Figure 8. *Himerometra robustipinna*. A. Whole specimen with whitish brachials in distal arms (arrow), and dark red oral pinnules and bright orange or yellow at tips. Note dark red cirri; B. IIBr series showing only two brachials; C. First three pinnules considered largest and stiffest among the pinnules; D. Cirrals each with a single spine.

Legends: suture (s); pinnules (P1-3); brachials (br)

Figure 9. *Stephanometra tenuipinna*. A. Dark orange to light brown body showing mouth (arrow). B. Arm division with two brachials joined by synarthry. C. Each cirral provided with a single spine. D. Enlarged and stiff oral pinnule.

and another; DLSU Z.C. 014, LST, Subic Bay, October 12, 2007; collector by C. Argüelles.

Diagnosis: Brachials whitish in distal areas of arms; oral pinnules dark red and pinnules beyond P_1 bright orange or yellow at tips; cirri dark red; mouth found central to the central disc; most of IIBr series of the arms composed of 4(3+4) brachials but few with only two brachials; single spine on each cirral; first three pinnules largest and stiffest among all other pinnules (personal observation).

Family Mariametridae

Diagnosis: Possess a single spine or tubercle in each segment of the cirri; species always have two ossicles composing the IIBr series of the arms (Modified from Clark & Rowe 1971).

Genus *Stephanometra* A. H. Clark, 1909

Diagnosis: Characterized with one or more enlarged and stiff proximal pinnules; series of divisions of arms with rounded ventrolateral extensions separating them (Modified from AM Clark & Rowe 1971).

Stephanometra tenuipinna (Figure 9)

Materials examined: Annotations: Single specimen. DLSU Z.C. 015, LST, Subic Bay, October 12, 2007; collected by C. Argüelles.

Diagnosis: Whole body dark orange to light brown; mouth found central in the central disc; all the division series of the arms composed of two brachials joined by synarthry; each cirral with a single well-developed spine; oral pinnules very much enlarged and stiff compared to more distal pinnules (personal observation).

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