

**AN ANNOTATED CHECKLIST OF THE GORGONIANS
(ANTHOZOA: OCTOCORALLIA) OF SINGAPORE,
WITH A DISCUSSION OF GORGONIAN DIVERSITY
IN THE INDO-WEST PACIFIC**

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ABSTRACT. - Previously published taxonomic descriptions or faunal lists of the gorgonian fauna of Singapore are combined with newly collected material. An annotated checklist of 31 gorgonian species from 12 genera (and 6 families) collected from reef sites around Singapore is presented together with colour plates (including in situ photographs) of each species to facilitate the use of this paper as a guide for field identification.

INTRODUCTION

In spite of their cosmopolitan (from the poles to the equator, from intertidal zones to the deep sea trenches) distribution (Alderslade, 1984), gorgonian corals (order Gorgonacea; subclass Octocorallia = Alcyonaria) have not been studied extensively in the Indo-Pacific region. This group of colonial anthozoans has, however, been well studied in the Mediterranean, and to a lesser extent, in the Caribbean (Bayer, 1981a). In his paper, Bayer (op cit) distinguished four categories of taxonomic knowledge of octocorals in major geographical regions of the world. Most parts of the southeast Asian region (including Singapore) would be classified under his fourth category which is defined as having "scattered taxonomic descriptions and isolated distributional records, many of them inadequately substantiated".

The taxonomic literature on gorgonians from the Indo-Malayan region include the monographs of the Siboga (Nutting 1910a-f; Stiasny, 1937) and Snellius (Stiasny, 1940) expeditions which describe the fauna of the Malay Archipelago (mainly present day Indonesia). Stiasny (1941) and Mai-Bao-Thu & Domantay (1970, 1971) discussed the Philippine aspect of this fauna. In the Indian Ocean, Hickson (1906a, b) and Faure (1977) discussed the gorgonian fauna of the Maldives and Mascarene Archipelago, respectively, while more recently, Van Ofwegen (1987) described species of the family Melithaeidae from the Indian Ocean and the Malay Archipelago. A comprehensive list of other less extensive taxonomic papers describing species found in the region can be found in Bayer

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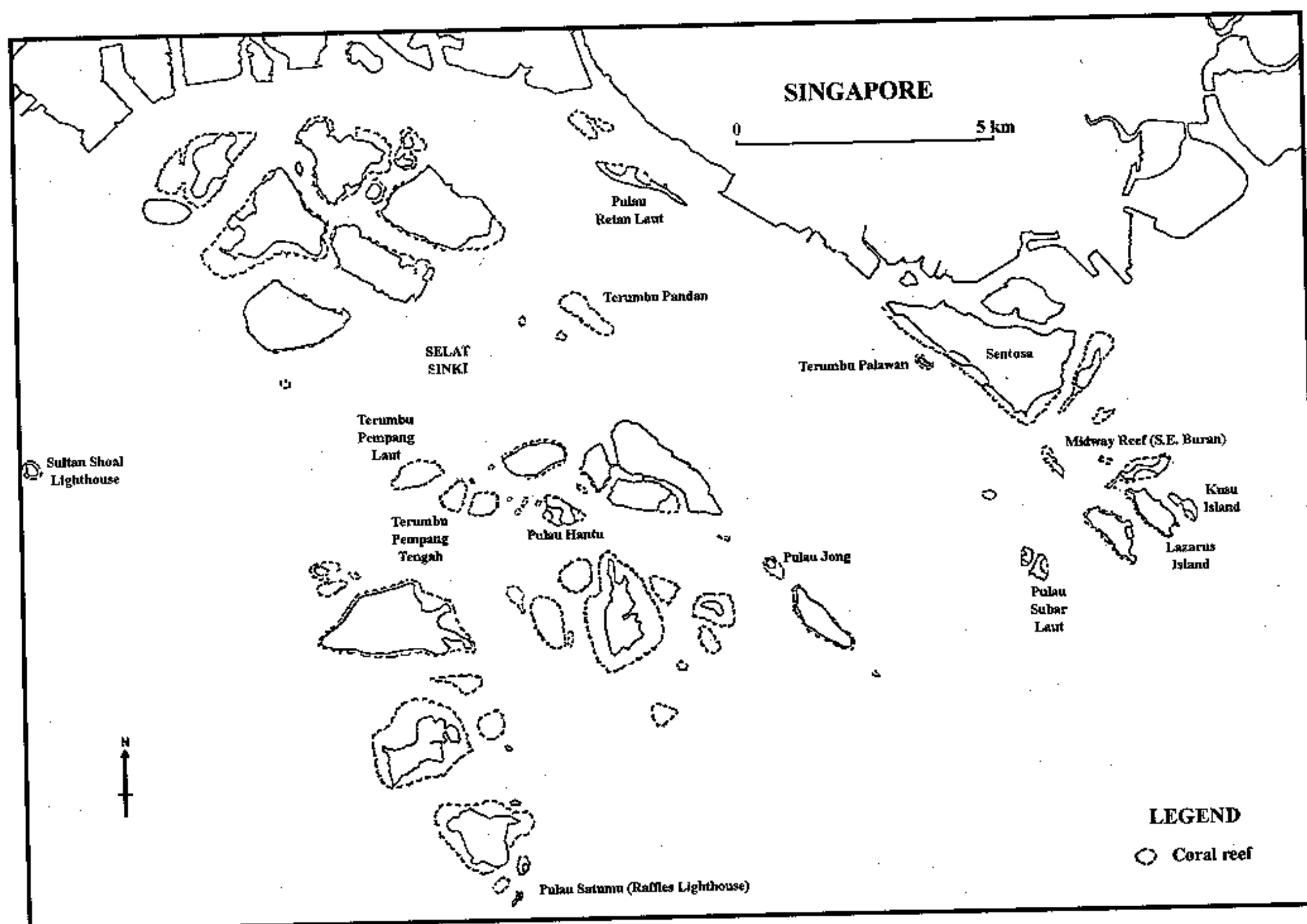
(1981b). The only previous published records of gorgonians from Singapore are a record of *Mopsella elongata* by Verrill (1864), a mention of *Juncella* (sic) *gemmacea* Val. from Singapore in the Berlin Museum by Studer (1880), descriptions of four species of these invertebrates by Shann (1912), and a more recent study of their distribution (Goh & Chou, 1994), in which 21 species were listed. Of these, only the work of Shann (1912) was primarily taxonomic. A detailed description of species of the family Melithaeidae is being prepared (Van Ofwegen et al., in prep.).

Singapore is an island located at the southern tip of the Malay peninsula, between the South China Sea to the east, the Strait of Malacca to the west, and the Java Sea to the south placing it approximately in the centre of the Sunda Shelf and at one of the few places where water from the Pacific Ocean connects (via the South China Sea) with that of the Indian Ocean and vice-versa. Massive land reclamation, especially since the late 1960s has resulted in high sedimentation rates (Low & Chou, 1994) in the coastal waters off Singapore. The presence of at least 31 species of gorgonians in Singapore that tolerate this high chronic sedimentation is remarkable, considering that, "As a rule, however, most (gorgonian) species live in clean water with a minimum of constant sedimentation" (Bayer, 1956). Light attenuation is very high, with less than 5% of incident light radiation reaching the depth of 10m (Chuang, 1977). Water transparency is low, with Secchi depths ranging from 1.3m to 4.7m, often in the lower scale of the range (Chou, 1986). This could have resulted in the observation that all species listed can be found in less than 20m of water; most at depths of between 12m to 18m. This is in contrast to the generally deeper (>25m, at least) occurrence of gorgonians found on many other reefs in the region (pers. obs.) and can be attributed to the lower water transparency in Singapore (Goh & Chou, 1994).

The taxonomic status of gorgonians in Singapore is at present in a state of disarray. Any study, whether physiological, ecological, biochemical, or pharmaceutical, of these animals would have to begin at the very basic level of taxonomy to at least establish consistency in the nomenclature used (so that species can be referred to standardised names) and to enable other workers to reproduce or elaborate on the research conducted in the present work. This paper updates the list of all known gorgonian species found in Singapore including previously unpublished records, bringing to 31 the total number of species recorded here. Major taxonomic revisions are necessary in many of the families found in Singapore (P.N. Alderslade, pers. comm.), but until then, this list will have to suffice as a base on which other non-taxonomic work can proceed.

MATERIALS AND METHODS

Specimens were collected from 15 sites (Sultan Shoal Lighthouse, Terumbu Pempang Laut, Terumbu Pempang Tengah, Pulau Hantu, Terumbu Pandan, Pulau Retan Laut, Pulau Satumu (Raffles Lighthouse), Pulau Jong, Pulau Subar Laut, Lazarus Island, Midway Reef (S.E. Buran), Kusu Island, Terumbu Palawan, Sentosa and Selat Sinki) on the reefs, islands and channels south of Singapore (Map 1). Shann's (1912) material was obtained by dredging. All new material and those recorded in Goh & Chou (1994) were collected by hand using SCUBA and air-dried. Specimens were identified using morphological characteristics of the colonies and sclerites. Sclerites were extracted using 5% sodium hypochlorite (after Bayer, 1961) and examined under the light microscope. The classification used is that of Bayer (1981c) and the terminology used is based on Bayer et al. (1983).



Map 1. Gorgonian collection sites on the reefs and around the islands south of Singapore.

All specimens examined are deposited in the Zoological Reference Collection (ZRC) of the Department of Zoology, National University of Singapore. Voucher specimens have also been deposited at the Nationaal Natuurhistorisch Museum (previously Rijksmuseum van Natuurlijke Historie (RMNH)), the National Museum of Natural History (USNM) of the Smithsonian Institution, Washington, D.C., USA, and at the Northern Territory Museum of Arts and Sciences, Darwin, Australia. Shann's (1912) specimens (which we were not able to examine) are lodged in the British Museum of Natural History.

Besides the collection sites for specimens lodged in the ZRC, the known distribution of each species in Singapore is included using the published records of Shann (1912) and Goh & Chou (1994). Approximate depth ranges and the habitat where they are found are also given for all species. All species are illustrated with photographs: black and white figures are provided to illustrate colony morphology and size; colour plates, some taken in situ, are provided where necessary to differentiate morphologically similar species, to show the variety of colour morphs, or to facilitate field identification. Descriptive notes on colony morphology and sclerite structures (sufficient to differentiate species found here) are provided for indeterminate species.

RESULTS AND DISCUSSION

Annotated Species List

The present collection, comprising 31 species from 12 genera and six families is summarized in Table 1. Of these, 14 species represent new or potential new records for Singapore.

Table 1. Summary of gorgonian species found in Singapore.

Family	Genera	Sub-Genera	Species
Anthothelidae	<i>Solenocaulon</i>		sp. A
			sp. B
Subergorgiidae	<i>Subergorgia</i>		<i>suberosa</i>
			<i>mollis</i>
Melithaeidae	<i>Melithaea</i>		<i>ochracea</i>
	<i>Mopsella</i>		<i>rubeola</i>
			<i>retifera</i>
	<i>Acabaria</i>		<i>robusta</i>
Acanthogorgiidae	<i>Acanthogorgia</i>		<i>gracillima</i>
			sp. A
			sp. B
			sp. C
Plexauridae	<i>Echinomuricea</i>		<i>pulchra</i>
	<i>Astrogorgia</i>		sp. cf. <i>sinensis</i>
			sp. cf. <i>rubra</i>
			sp. A
			sp. B
			sp. A
			sp. B
			sp. C
			sp. D
			sp. E
			sp. F
	<i>Euplexaura</i>		sp. cf. <i>pinnata</i>
			sp. A
Ellisellidae	<i>Junceella</i>	<i>Junceella</i>	sp. A
		<i>Dichotella</i>	sp. cf. <i>gemmaea</i>
	<i>Ctenocella</i>	<i>Ctenocella</i>	<i>pectinata</i>
		<i>Ellisella</i>	<i>laevis</i>
		<i>Umbracella</i>	sp. cf. <i>umbraculum</i>
			sp. A

ANTHOTHELIDAE BROCH, 1916

Genus *Solenocaulon* Gray, 1857

Remarks.- This genus is a new record for Singapore. Anomuran crabs of the family Porcellanidae (predominantly *Aliaporcellana telestophila*) are frequently found living in association with the following two species, within the hollow spaces formed by the infolding of the branches. A discussion of this association can be found in Ng & Goh (1996).

Solenocaulon sp. A

(Fig. 1a; Pl. 3b)

Material Examined.- ZRC.1994.3822; ZRC.1996.1044 (Terumbu Pempang Tengah); ZRC.1994.3821 ('southern islands').

Description.- Colony red with white polyps; reddish-brown when dried; bifacial, with polyps almost exclusively on one side creating a distinct front and back of the colony; can grow to ca. 30 cm or more in height; terminal branches clavate; sclerites slightly red, dominated by long spindles (resembling narrow wart clubs); short girdled spindles and scattered needles also present.

Depth Range and Habitat.- 12-18m; lower reef slope and bottom; rock or sand substrata.

***Solenocaulon* sp. B**

(Fig. 1b; Pl. 3c)

Material Examined.- ZRC.1990.11937 (Terumbu Pempang Tengah).

Description.- Colony white with white polyps; greyish-brown when dried; distinctly bifacial; grows to a maximum of ca. 20cm in height; sclerites colourless, mainly broad tuberculate spindles.

Depth Range and Habitat.- 12-18m; lower reef slope and bottom; rock or sand substrata.

SUBERGORGIIDAE GRAY, 1859

Genus *Subergorgia* Gray, 1857

***Subergorgia suberosa* (Pallas, 1766)**

(Fig. 1c)

Material Examined.- ZRC.1990.11909 (Pulau Subar Laut); ZRC.1990.11910; ZRC.1990.11941 (Pulau Satumu (Raffles Lighthouse)); ZRC.1996.1045 (Terumbu Pempang Tengah).

Description.- Refer to Nutting (1910f: pp. 28-29; Pl. V, figs. 1, 1a; Pl. XI, fig. 7).

Depth Range and Habitat.- 10-15m; lower reef slope and bottom; rock or sand substrata.

Remarks.- Usually found on sites with a flat sandy substrate; first collected by Shann (1912) off Pasir Panjang; this site has since been reclaimed, and we were also not able to examine his specimen to verify its identification; this species has also been previously reported by Goh & Chou (1994) from Pulau Subar Laut, Pulau Satumu (Raffles Lighthouse), Sultan Shoal Lighthouse, Terumbu Pandan, Terumbu Pempang Laut, Terumbu Pempang Tengah, Pulau Hantu (East), Lazarus Island, Kusu Island, and Midway Reef (S.E. Buran).

***Subergorgia mollis* (Nutting, 1910)**

(new record)

(Fig. 1d)

Material Examined.- ZRC.1990.11940; ZRC.1994.3819 (Pulau Subar Laut); ZRC.1994.3820 (Terumbu Pempang Laut); ZRC.1996.1046 (Kusu Island).

Description.- Refer to Nutting (1910b: pp. 13-14; Pl. III, figs. 4,4a; Pl. IV, fig. 8).

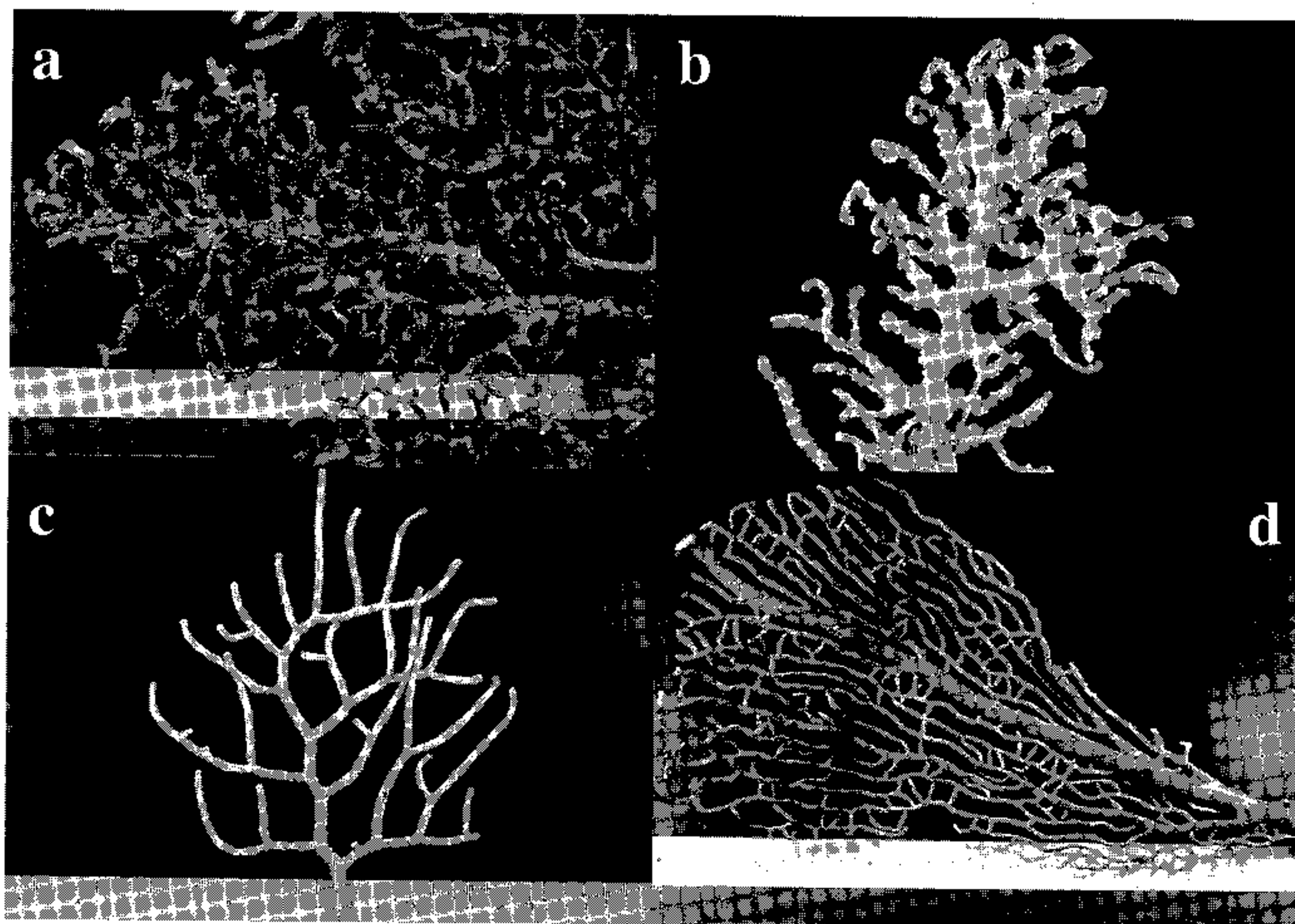


Fig. 1. Dried colonies of: a. *Solenocaulon* sp. A (ZRC.1996.1044); b. *So.* sp. B; c. *Subergorgia suberosa* (ZRC.1996.1045); d. *Su. mollis* (ZRC.1996.1046).

Depth Range and Habitat. - 12-18m; lower reef slope and bottom; rock or sand substrata; usually on reefs exposed to strong tidal currents.

Remarks. - Seldom found in less than 12m of water; where it is found, it can grow to very large sizes (2m across) and dominate the deeper water fauna.

MELITHAEIDAE GRAY, 1870

Remarks. - The species of this family are notoriously difficult to differentiate in the field, as the morphology and colouration of different species can be similar; or the same species can have variations in morphology and colour. Identification has to be based on sclerite characters, which can also be difficult, since many species intergrade with each other, even in sclerite forms (Bayer, 1981c; Van Ofwegen, 1987). This wide macro- and microscopic morphological variation will be described and discussed in a detailed description of this family (Van Ofwegen et al., in prep.), and is not discussed here.

Genus *Melithaea* Milne Edwards & Haime, 1857

Melithaea ochracea (Linnaeus, 1758)

(Pl. 1a, b)

Material Examined. - ZRC.1990.11932 (Terumbu Pempang Laut); ZRC.1995.5; ZRC.1995.8; ZRC.1995.76; ZRC.1995.77; ZRC.1995.78; ZRC.1995.79; ZRC.1995.80; ZRC.1995.81 (Pulau Subar

Laut); ZRC.1995.9-10; ZRC.1995.11 (Pulau Satumu (Raffles Lighthouse)); ZRC.1995.7; ZRC.1995.82 (Terumbu Pempang Tengah).

Description.- Refer to Van Ofwegen (1987: pp. 7-9; Figs. 1,2).

Depth Range and Habitat.- 3-8m; reef crest and upper slope; rock substrata.

Remarks.- Wide variation in colouration in Singapore; two specimens found in the ZRC misidentified as *Corallum inutile* (Cat. no. 128, Gp. 3, Locality: Malaya) and *Gorgonia verrucosa* (Cat. no. 115, Gp. 3, Locality: Penang); previously collected at Pulau Blakang Mati (Sentosa Island) by Shann (1912) and recorded as *Melitodes albitincta* with no published records since.

Genus *Mopsella* Gray, 1857

Mopsella rubeola (Wright & Studer, 1889)

(new record)

(Pl. 1c, d, e, f, 2a)

Material Examined.- ZRC.1990.11942; ZRC.1995.6 (Pulau Satumu (Raffles Lighthouse)); ZRC.1995.13, ZRC.1995.14-15 (Terumbu Pempang Laut); ZRC.1995.16 (Midway Reef (S.E. Buran)); ZRC.1995.17-18; ZRC.1995.83 ('southern islands'); ZRC.1995.84; ZRC.1995.85 (Pulau Semakau); ZRC.1995.86 (Terumbu Palawan).

Description.- Refer to Stiasny (1940: pp.231-234; Pl. X, figs. 18, 19; Fig. I); various colour morphs occur: white, pink, orange, bright yellow.

Depth Range and Habitat.- 3-8m; reef crest and upper slope; rock substrata.

Remarks.- Different colour morphs make this species difficult to distinguish in the field.

Mopsella retifera (Lamarck, 1816)

(Pl. 2b)

Material Examined.- ZRC.1995.12; ZRC.1995.87; ZRC.1995.88 (Pulau Subar Laut).

Description.- Refer to Stiasny (1940: pp. 230-231; Pl. XIV, figs. 36, 37; Fig. H).

Depth Range and Habitat.- 3-8m; reef crest and upper slope; rock substrata.

Remarks.- Verrill (1864) recorded this species as *Mopsella elongata* from an unspecified site in Singapore; not recorded since; has also not been recorded at any site other than Pulau Subar Laut in Singapore.

Genus *Acabaria* Gray, 1859

***Acabaria robusta* (Shann, 1912)**

(Pl. 2c, d)

Material Examined.- ZRC.1995.19 (Pulau Subar Laut); ZRC.1995.89; ZRC.1995.90 (Terumbu Pempang Tengah); ZRC.1995.91 (Terumbu Palawan); ZRC.1995.92 ('southern islands'); ZRC.1996.1047 (Terumbu Pempang Tengah).

Description.- Refer to Shann (1912: pp. 525-526; Pl. LXII, fig. 9; Pl. LXIII, fig. 15); colony pink with white calyces or red with white calyces; branches planar and reticulate.

Depth Range and Habitat.- 3-20m; reef crest through slope to bottom; rock or sand substrata.

Remarks.- Previously recorded by Shann (1912) in Singapore as *Wrightella robusta*; not recorded since then; will be formally placed in the genus *Acabaria* by Van Ofwegen et al. (in prep.), but reported here as *A. robusta* to facilitate its use and to prevent future confusion; type specimen of *W. robusta* in British Museum of Natural History examined by L.P. Van Ofwegen and compared with specimens collected in Singapore to confirm identification; only melithaeid found on lower reef slope and bottom, and on sand substrata.

***Acabaria gracillima* (Ridley, 1884)**

Material Examined.- None.

Remarks.- Not collected or recorded since Shann's (1912) collection at Salat Sinki (Selat Sinki); the exact location of Shann's site at Salat Sinki was not given, but probably corresponds to Terumbu Pempang Laut, a large patch reef adjacent to Selat Sinki.

ACANTHOGORGIIDAE GRAY, 1859

Genus *Acanthogorgia* Gray, 1857

***Acanthogorgia* sp. A**

(Fig. 2a; Pl. 3d)

Material Examined.- ZRC.1990.11914, 11915; ZRC.1996.1048 (Pulau Subar Laut).

Description.- Polyps contractile, not retractile, white when alive and also when dried; colony planar, reticulate; sclerites dominated by bent spindles, with a few branched spindles; no needles.

Depth Range and Habitat.- 12-18m; lower reef slope and bottom; rock substrata on well flushed, less disturbed reefs.

Remarks.- Previously identified as *A. boninensis* (Goh & Chou, 1994), but unlikely that this species occurs this far south (P.N. Alderslade, pers. comm.); previously reported by Goh & Chou (1994) from Pulau Subar Laut and Pulau Satumu (Raffles Lighthouse).

***Acanthogorgia* sp. B**

(Fig. 2b; Pl. 3e)

Material Examined.- ZRC.1990.11916, 11917 (Pulau Satumu (Raffles Lighthouse)).

Description.- polyps contractile, not retractile; yellow when alive and brown when dried; sclerites mainly bent spindles, occasional hockey-stick spindles (with more pronounced tuberculation on shorter end) and needles.

Depth Range and Habitat.- 12-18m; lower reef slope and bottom; rock substrata on well flushed, less disturbed reefs.

Remarks.- Not observed since its collection in 1990; previously identified as *A. dofleini* (Goh & Chou, 1994), but unlikely that this species occurs this far south (P.N. Alderslade, pers. comm.).

***Acanthogorgia* sp. C**

(Fig. 2c; Pl. 3f)

Material Examined.- ZRC.1990.11943, ZRC.1996.1049 (Pulau Satumu (Raffles Lighthouse)); ZRC.1994.3816 (Terumbu Pempang Laut).

Description.- Colony morphology similar to sp. A, except that polyps are purple when alive and creamy white when dried; sclerites mainly bent spindles and wart clubs, bent spindles broader than in sp. A; no needles.

Depth Range and Habitat.- 12-18m; lower reef slope and bottom; rock substrata on well flushed, less disturbed reefs.

Remarks.- Potential new record when identified.

PLEXAURIDAE GRAY, 1859

Genus *Echinomuricea* Verrill, 1869

***Echinomuricea pulchra* Nutting, 1910**

(Fig. 2d)

Material Examined.- ZRC.1990.11918 (Lazarus Island); ZRC.1990.11919 (Pulau Retan Laut); ZRC.1996.1050 (Terumbu Pempang Tengah).

Description.- Refer to Nutting (1910a: pp. 59-60; Pl. X, figs. 3, 3a; Pl. XXI, fig. 7).

Depth Range and Habitat.- 10-16m; mainly bottom; sand substrata.

Remarks.- Unidentified white coloured sponge species frequently found growing between raised, exert calyces of gorgonian; previously also reported in Goh & Chou (1994) from Lazarus Island and Pulau Retan Laut, as well as Terumbu Pandan, Terumbu Pempang Laut, and Midway Reef (S.E. Buran).

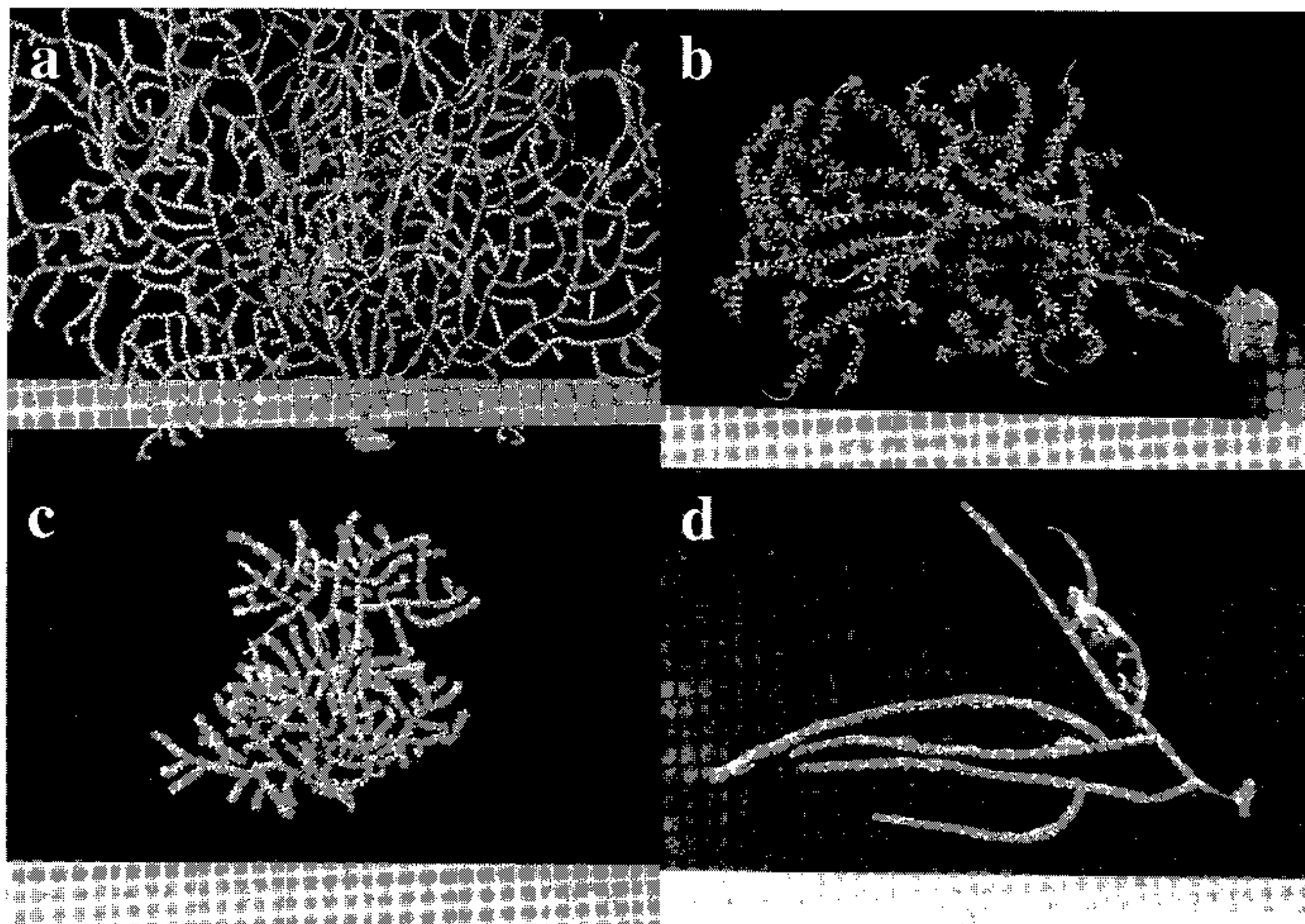


Fig. 2. Dried colonies of: a. *Acanthogorgia* sp. A (ZRC.1996.1048); b. *A.* sp. B (ZRC.1990.11917); c. *A.* sp. C (ZRC.1996.1049); d. *Echinomuricea pulchra* (ZRC.1996.1050).

Genus *Astrogorgia* Verrill, 1868

Remarks.- All species are potential new records for Singapore. Only two species have been described for this genus (Kükenthal, 1924; L.P. Van Ofwegen, pers. comm.), so at least two are also new species.

Astrogorgia sp. cf. *sinensis* (Verrill, 1865)

(Fig. 3a)

Material Examined.- ZRC.1994.3826-3827 (Terumbu Pempang Laut); ZRC.1996.1051 (Pulau Subar Laut).

Description.- See Remarks.

Depth Range and Habitat.- 10-16m; lower reef slope and bottom; rock or sand substrata.

Remarks.- Colony morphology and sclerite descriptions agree with those of Verrill (1865: p. 187; Pl. 5, figs. 5,5a; 1868: p.414); since the descriptions were brief, and the authors were unable to examine the type specimens, we feel that it is more prudent to call it *Astrogorgia* sp. cf. *sinensis*.

Astrogorgia sp. cf. *rubra* Thomson & Henderson, 1906

(Fig. 3b)

Material Examined.- ZRC.1990.11938, 11946 (Pulau Satumu (Raffles Lighthouse)); ZRC.1994.3825 (Terumbu Pempang Laut); ZRC.1996.1052 (Pulau Subar Laut).

Description.- See Remarks.

Depth Range and Habitat.- 10-16m; lower reef slope and bottom; rock or sand substrata.

Remarks.- Colony morphology agrees with that of Thomson & Henderson (1906; p. 69; Pl. V, fig. 10), but 'small warty clubs' and 'irregular double clubs' not present in these specimens.

Astrogorgia sp. A

(Fig. 3c; Pl. 4f)

Material Examined.- ZRC.1990.11945 (Terumbu Pandan); ZRC.1994.3817-3818 (Terumbu Pempang Laut); ZRC.1996.1053 ('southern islands').

Description.- Colony cream with yellow polyps when alive, cream when dried; colony non-planar, sympodially branched with an obvious main stem; sclerites colourless, mainly bent spindles of different sizes, all with small curvature, some almost rod-like; thick straight spindles also present.

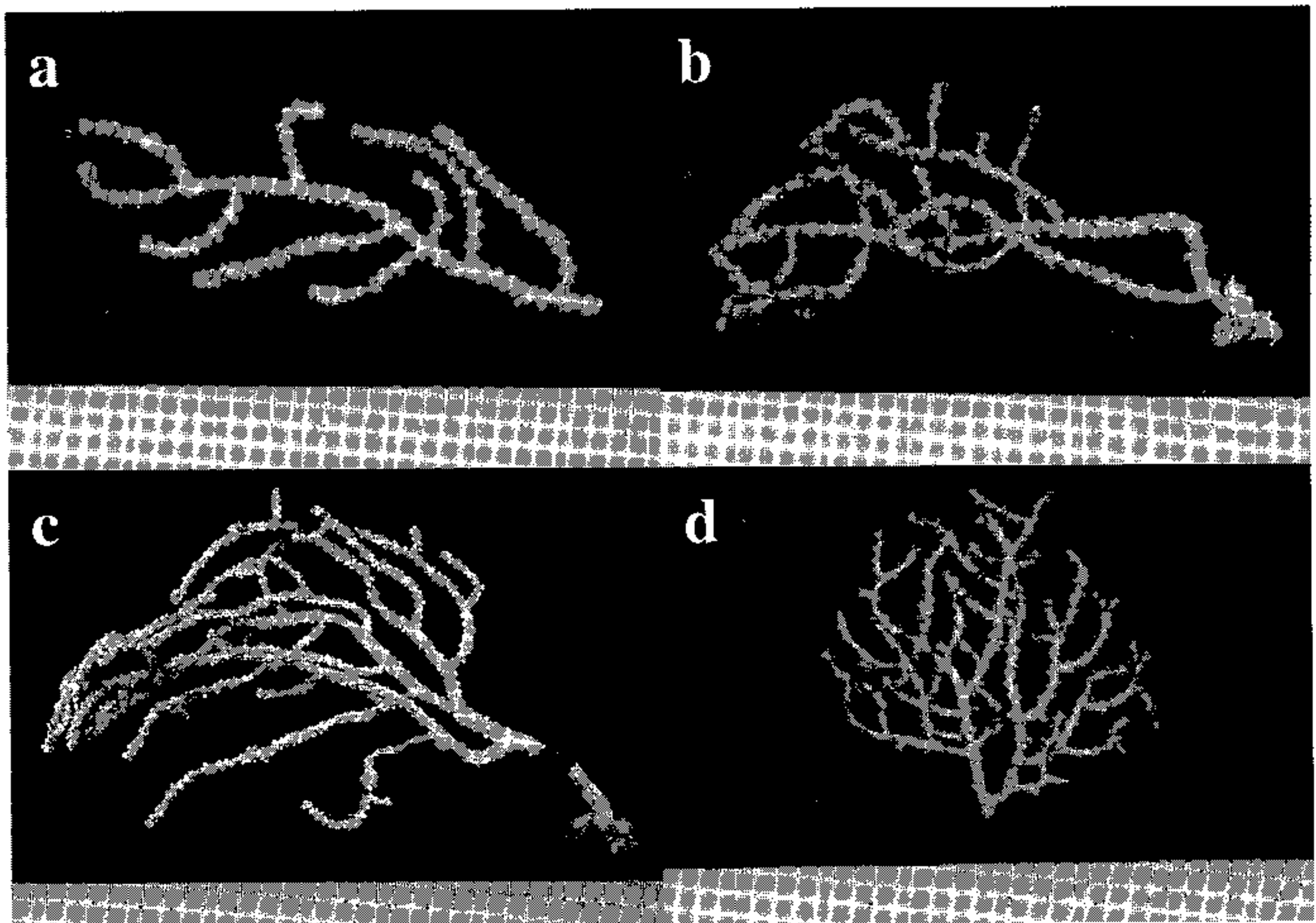


Fig. 3. Dried colonies of: a. *Astrogorgia* sp. cf. *sinensis* (ZRC.1996.1051); b. *A.* sp. cf. *rubra* (ZRC.1996.1052); c. *A.* sp. A (ZRC.1996.1053); d. *A.* sp. B (ZRC.1996.1054).

Depth Range and Habitat.- 10-16m; lower reef slope and bottom; rock or sand substrata.

***Astrogorgia* sp. B**

(Fig. 3d)

Material Examined.- ZRC.1990.11936, ZRC.1994.3824, ZRC.1996.1054 (Pulau Satumu (Raffles Lighthouse)); ZRC.1990.11947 (Pulau Subar Laut).

Description.- Colony dark pink (as in *A. sp. cf. rubra*); calyces smaller than in other three species; branching planar and bifacial; sclerites mainly bent spindles, some small, some very large (ca. three times broader than in other three species) with no intermediate-sized bent spindles.

Depth Range and Habitat.- 10-16m; lower reef slope and bottom; rock or sand substrata.

Genus *Echinogorgia* K  lliker, 1865

Remarks.- The six species can be differentiated into three groups, based on the morphology of the colonies. *Echinogorgia* spp. A, B, and C are planar, with a reticulate network of anastomosing branches. *Echinogorgia* sp. D is also planar, but branching is lyrate. *Echinogorgia* spp. E and F are non-planar, and colonies consist of relatively few, but very long branches. *Echinogorgia* spp. A, B, and C were misidentified as ?*Heterogorgia* spp. A, B, and C, respectively, in Goh & Chou (1994).

***Echinogorgia* sp. A**

(Fig. 4a; Pl. 4a)

Material Examined.- ZRC.1990.11934 (Kusu Island); ZRC.1994.3788-3795; ZRC.1996.1055 (Terumbu Pempang Tengah); ZRC.1994.3796,3797 (Pulau Satumu (Raffles Lighthouse)); ZRC.1994.3798 (Terumbu Pandan); ZRC.1994.3799 (Sultan Shoal Lighthouse); ZRC.1994.3800 (Terumbu Pempang Laut).

Description.- Colony purple, with purple polyps when alive; greyish-brown when dried; sclerites consist of rooted leaves, thornstars, thornscales, six-radiates and spindles, including leaf spindles.

Depth Range and Habitat.- 10-16m; lower reef slope and bottom; rock or sand substrata.

Remarks.- Frequently associated with the barnacle *Conopea navicula*.

***Echinogorgia* sp. B**

(Fig. 4b; Pl. 4b)

Material Examined.- ZRC.1994.3801-3802 (Pulau Satumu (Raffles Lighthouse)); ZRC.1994.3803 (Terumbu Pempang Laut); ZRC.1994.3804-3805; ZRC.1996.1056 (Terumbu Pempang Tengah).

Description.- Colony bright yellow, with yellow polyps when alive; dull yellow when dried; sclerites consist of rooted leaves, thornstars, thornscales, bent spindles and clubs.

Depth Range and Habitat.- 10-16m; lower reef slope and bottom; rock or sand substrata.

Remarks.- Also associated with *Conopea navicula*.

***Echinogorgia* sp. C**

(Fig. 4c; Pl. 4c)

Material Examined.- ZRC.1990.11935, ZRC.1994.3806-3807 (Pulau Satumu (Raffles Lighthouse)); ZRC.1994.3808 (Pulau Retan Laut); ZRC.1994.3809-3814 (Terumbu Pempang Tengah); ZRC.1994.3815 (Pulau Subar Laut); ZRC.1996.1057 ('southern islands').

Description.- Colony yellow, with purple polyps when alive; dull yellow when dried; can resemble *Echinogorgia* sp. B if polyps retracted, but closer examination will reveal purple calyces; sclerites consist of thornstars, thornscales, bent spindles, needles and six-radiates; no leaf spindles present.

Depth Range and Habitat.- 10-16m; lower reef slope and bottom; rock or sand substrata.

Remarks.- Also associated with *Conopea navicula*.

***Echinogorgia* sp. D**

(Fig. 4d)

Material Examined.- ZRC.1994.3828, ZRC.1996.1058 (Terumbu Pempang Tengah).

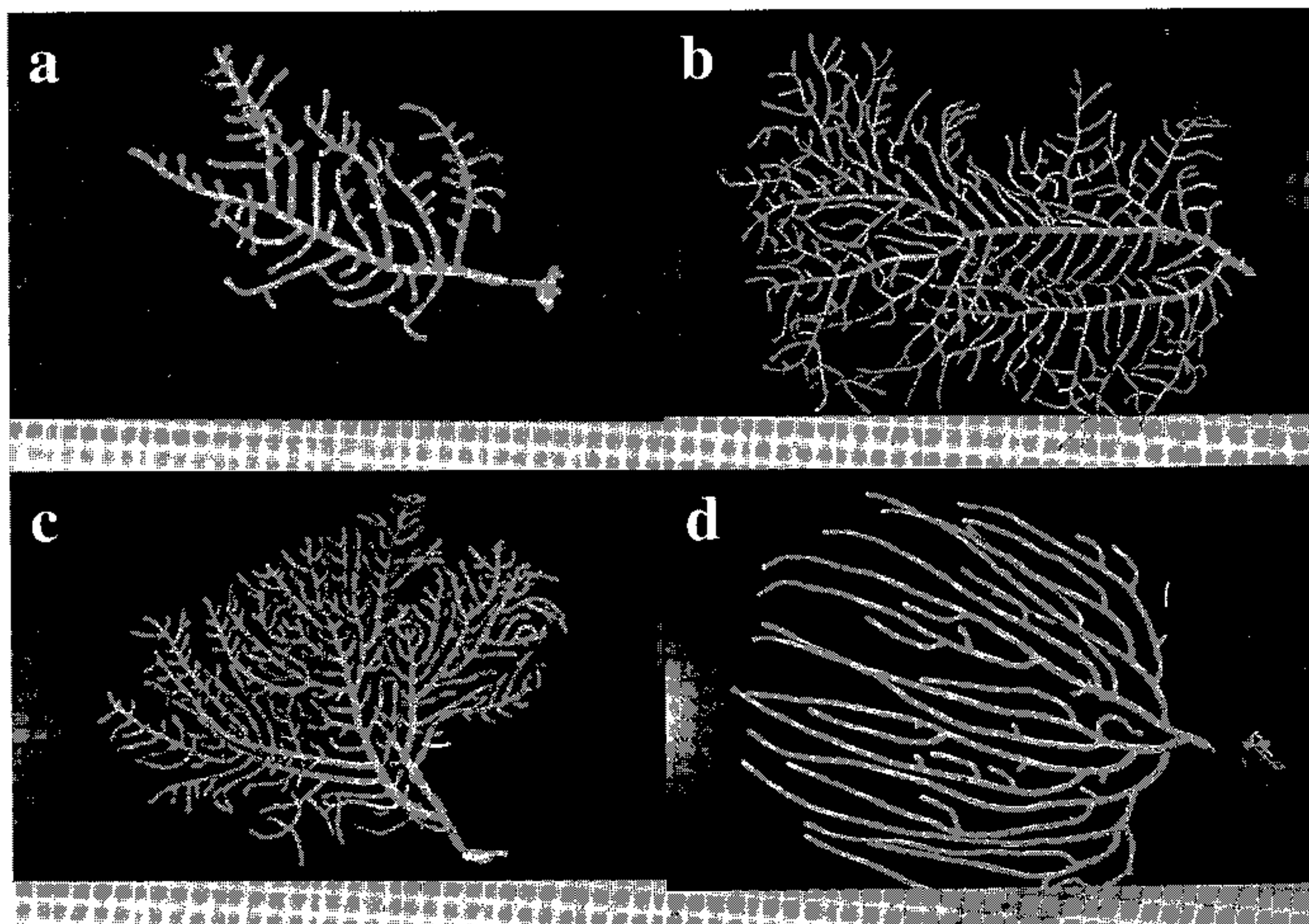


Fig. 4. Dried colonies of: a. *Echinogorgia* sp. A (ZRC.1996.1055); b. *E.* sp. B (ZRC.1996.1056); c. *E.* sp. C (ZRC.1996.1057); d. *E.* sp. D (ZRC.1996.1058).

Description.- Major distinguishing feature is the lyrate colony form; colony yellowish-orange when alive and dried; sclerites mainly rooted leaves, with bent and branched spindles.

Depth Range and Habitat.- 10-16m; lower reef slope and bottom; rock or sand substrata.

Remarks.- Potential new record when identified.

***Echinogorgia* sp. E**

(Fig. 5a; Pl. 4d)

Material Examined.- ZRC.1994.3829-3830 (Terumbu Pempang Tengah); ZRC.1996.1059 ('southern islands').

Description.- Colony orangy-brown when alive and dried; non-planar branching morphology, with most branching nearer the colony base; sclerites mainly rooted leaves, with numerous antlers.

Depth Range and Habitat.- 10-16m; lower reef slope and bottom; rock or sand substrata.

Remarks.- Potential new record when identified.

***Echinogorgia* sp. F**

(Fig. 5b; Pl. 4e)

Material Examined.- ZRC.1994.3831 (Terumbu Pempang Tengah); ZRC.1994.3832 (Terumbu Pempang Laut); ZRC.1996.1060 (Sultan Shoal Lighthouse).

Description.- Colony dark brown when alive and dried; non-planar branching morphology, with most branching nearer the colony base; sclerites mainly rooted leaves, antlers present but uncommon.

Depth Range and Habitat.- 10-16m; lower reef slope and bottom; rock or sand substrata.

Remarks.- Potential new record when identified.

Genus *Euplexaura* Verrill, 1865

Remarks.- Both species are potential new records for Singapore.

***Euplexaura* sp. cf. *pinnata* (Nutting, 1910)**

(Fig. 5c)

Material Examined.- ZRC.1990.11933 (Sultan Shoal Lighthouse); ZRC.1990.11949 (Pulau Satumu (Raffles Lighthouse)); ZRC.1996.1069 ('southern islands').

Description.- Refer to Nutting (1910b: pp. 7-8; Pl. IV, fig. 5); colony cream with yellow polyps when alive, dirty white when dried; bushy growth form; terminal branches clavate.

Depth Range and Habitat.- 12-18m; lower reef slope and bottom; rock substrata.

Remarks.- Colony morphology and sclerite descriptions agree well with Nutting's (1910b), but the descriptions were brief, and the authors were unable to examine the type specimens to confirm identification.

***Euplexaura* sp. A**

Fig. 5d.

Material Examined.- ZRC.1994.3823 (Midway Reef (S.E. Buran)); ZRC.1996.1061 (Pulau Satumu (Raffles Lighthouse)).

Description.- Colony white with yellow polyps when alive, white when dried; bushy growth form; terminal branches clavate; sclerites consist of spindles of various shapes and sizes, wart-clubs, and tuberculate spheroids.

Depth Range and Habitat.- 12-18m; lower reef slope and bottom; rock substrata.

ELLISELLIDAE GRAY, 1859

Remarks.- A recent revision of this family (Bayer & Grasshoff, 1994) recognises only four extant genera (*Junceella*, *Ctenocella*, *Nicella*, and *Riisea*), with many previously valid genera relegated to sub-generic status.

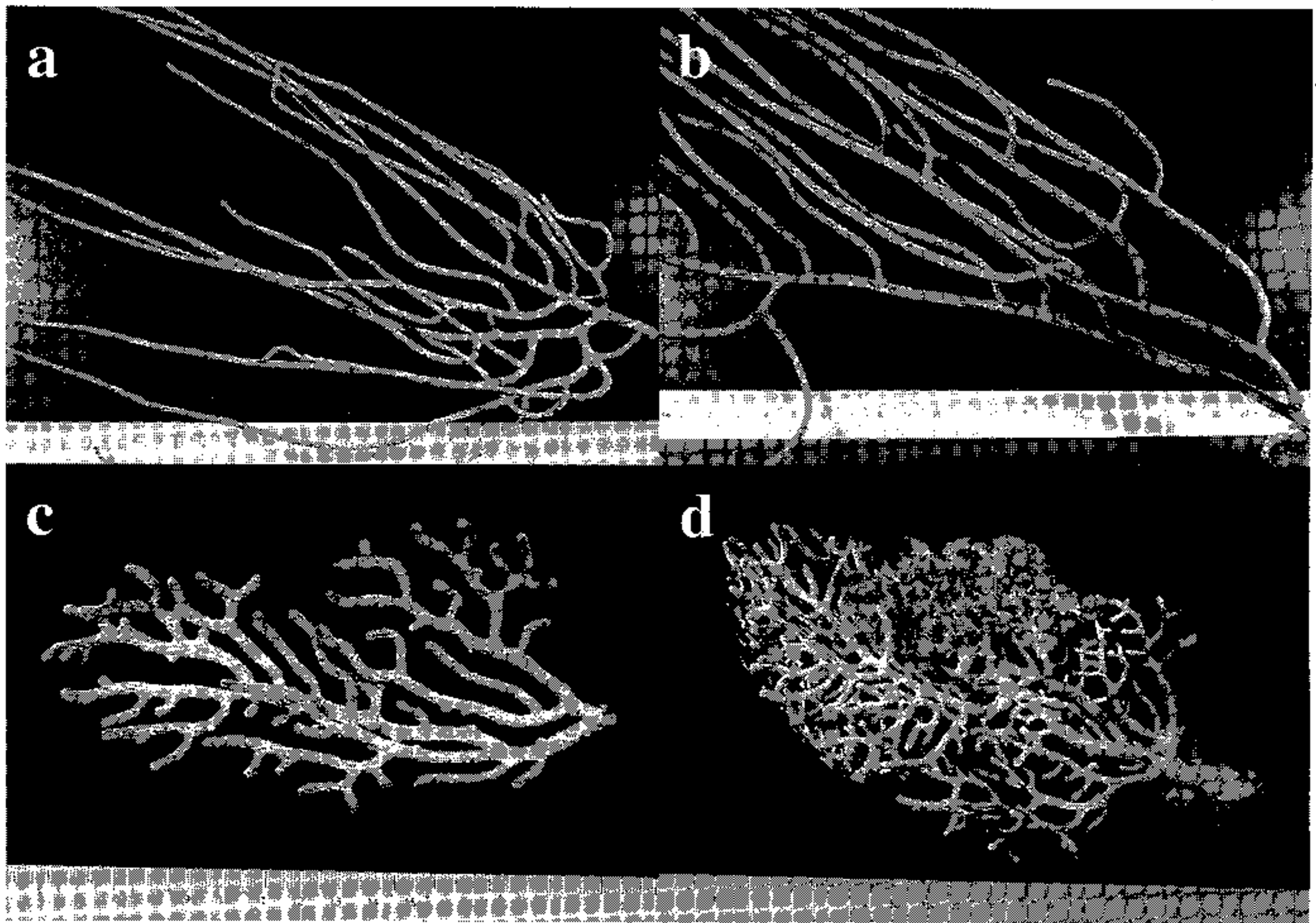


Fig. 5. Dried colonies of: a. *Echinogorgia* sp. E (ZRC.1996.1059); b. *Ec.* sp. F (ZRC.1996.1060); c. *Euplexaura* sp. cf. *pinnata* (ZRC.1996.1069); d. *Eu.* sp. A (ZRC.1996.1061).

Genus *Junceella* Valenciennes, 1855

Remarks.- Incorporates the former genera *Junceella*, *Heliana*, and *Dichotella* as subgenera (Bayer & Grasshoff, 1994).

Sub-genus *Junceella* s.s.

***Junceella (Junceella) sp. A*
(Fig. 6a (top))**

Material Examined.- ZRC.1990.11924(white), 11926(creamy yellow) (Pulau Hantu); ZRC.1990.11925 (Terumbu Pandan); ZRC.1996.1062 (creamy yellow) (Terumbu Pempang Laut).

Description.- Whip-like; occurs in three colour morphs: white, creamy yellow and reddish-brown; white morph most frequently encountered.

Depth Range and Habitat.- 10-18m; lower reef slope and bottom; rock or sand substrata.

Remarks.- Previously reported in Goh & Chou (1994) at 11 other sites: Sultan Shoal Lighthouse, Terumbu Pandan, Terumbu Pempang Laut, Terumbu Pempang Tengah, Pulau Semakau, Pulau Satumu (Raffles Lighthouse), Pulau Jong, Pulau Subar Laut, Lazarus Island, Kusu Island, Midway Reef (S.E. Buran).

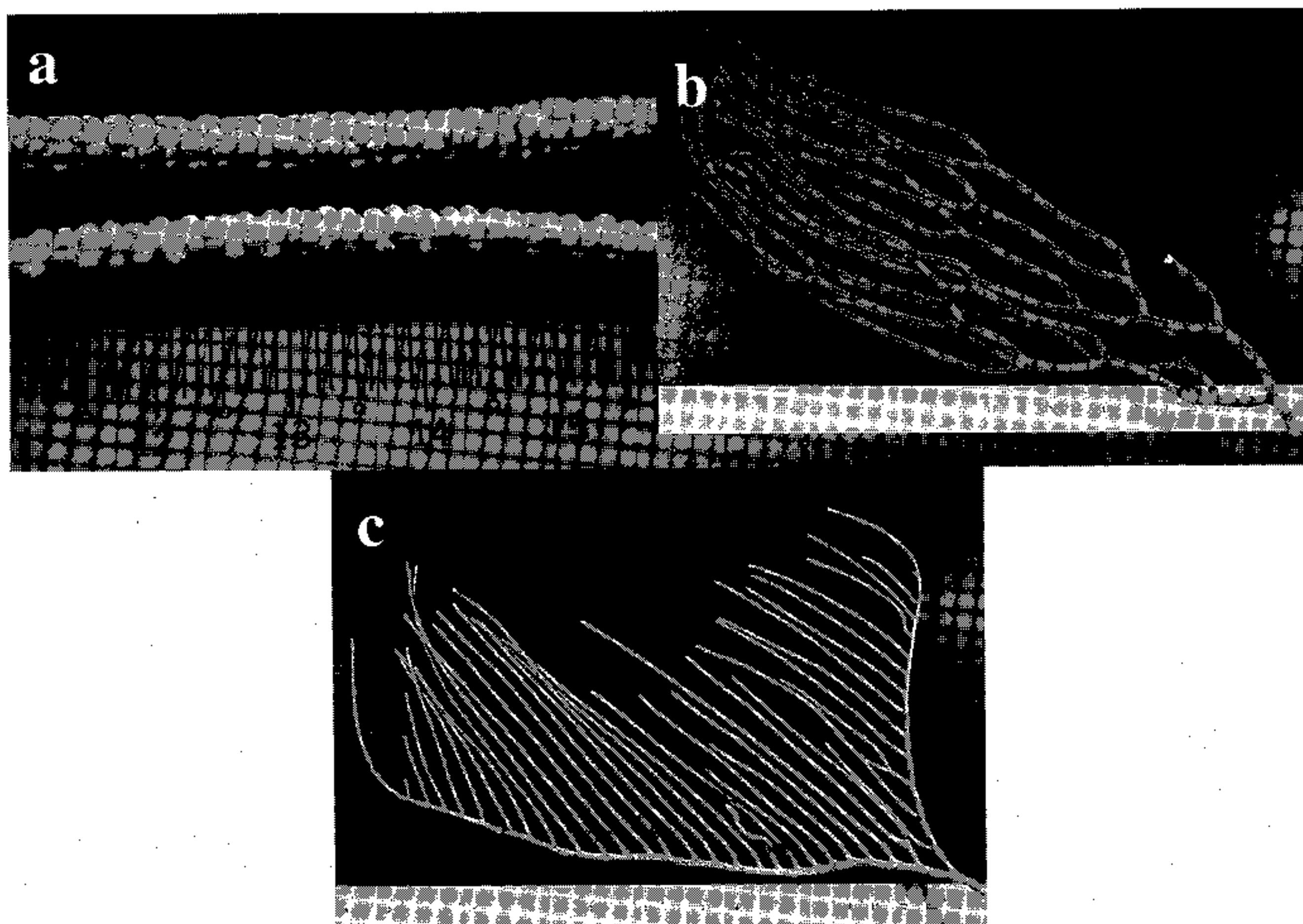


Fig. 6. Dried colonies of: a. Top: *Junceella (Junceella) sp. A* (ZRC.1996.1062); Bottom: *Ctenocella (Ellisella) laevis* (ZRC.1996.1066); b. *J. (Dichotella) sp. cf. gemmacea* (ZRC.1996.1063); c. *Ctenocella (Ctenocella) pectinata* (ZRC.1996.1065).

Sub-genus *Dichotella* Gray, 1870

Junceella (Dichotella) sp. cf. gemmacea (Valenciennes, 1855)
(Fig. 6b; Pl. 3a)

Material Examined.- ZRC.1990.11927(white), 11928(reddish brown) (Midway Reef (S.E. Buran)); ZRC.1996.1063 (reddish brown) (Terumbu Pempang Laut); ZRC.1996.1064 (white) ('southern islands').

Description.- Branching dichotomous; species also occurs in the same colour morphs as *Junceella (Junceella) sp. A*; white morph commonest; matches description by Nutting (1910d: pp. 20-21; Pl. IV, figs. 1, 1a), but different in colony colour.

Depth Range and Habitat.- 10-18m; lower reef slope and bottom; rock or sand substrata.

Remarks.- Studer (1880) made reference to a specimen of *Juncella* (sic) *gemmacea* Val. from Singapore, believed to be in the Berlin Museum; previously reported in Goh & Chou (1994) at Sultan Shoal Lighthouse, Terumbu Pandan, Terumbu Pempang Laut, Terumbu Pempang Tengah, Pulau Satumu (Raffles Lighthouse), Pulau Jong, Pulau Subar Laut, Lazarus Island, Kusu Island.

Genus *Ctenocella* Valenciennes, 1855

Remarks.- Incorporates the former genera *Ctenocella*, *Ellisella*, *Viminella*, *Verrucella*, *Umbracella*, and *Phenilia* as sub-genera.

Sub-genus *Ctenocella s.s.*

Ctenocella (Ctenocella) pectinata (Pallas, 1766)
(Fig. 6c).

Material Examined.- ZRC.1990.11929 (white), ZRC.1996.1065 (Terumbu Pandan); ZRC.1990.11930 (reddish brown) (Kusu Island); ZRC.1990.11931 (reddish brown) (Terumbu Pempang Tengah).

Description.- Refer to Nutting (1910d: pp. 15-16), Kükenthal (1924: pp. 374-375; Fig. 185).

Depth Range and Habitat.- 10-18m; lower reef slope and bottom; rock or sand substrata.

Remarks.- Two colour morphs occur here: white and reddish-brown; previously reported in Goh & Chou (1994) from the above two sites, as well as Terumbu Pempang Laut, Pulau Subar Laut, and Midway Reef (S.E. Buran).

Sub-genus *Ellisella* Gray, 1858

***Ctenocella (Ellisella) laevis* (Verrill, 1865)**

(Fig. 6a (bottom))

Material Examined.- ZRC.1990.11923 (Pulau Jong); ZRC.1996.1066 (Sultan Shoal Lighthouse).

Description.- Refer to Nutting (1910d: pp. 27-28; Pl. V, figs. 2, 2a; Pl. X, fig. 6), Kükenthal (1924: p. 366).

Depth Range and Habitat.- 10-16m; lower reef slope and bottom; rock or sand substrata.

Remarks.- Nutting (1910d) referred to the species as *Scirpearella hemispherica*; placed in *Ellisella laevis* by Kükenthal (1924); previously reported in Goh & Chou (1994) from Pulau Jong, and Sultan Shoal Lighthouse, Terumbu Pandan, Pulau Hantu (East), and Pulau Subar Laut.

Sub-genus *Umbracella* Gray, 1858

Remarks.- These two species were previously misidentified as two varieties of *Subergorgia reticulata* (Goh & Chou, 1994).

***Ctenocella (Umbracella) sp. cf. umbraculum* (Ellis & Solander, 1786)**

(Pl. 2e)

Material Examined.- ZRC.1990.11905 (Terumbu Pempang Laut); ZRC.1990.11906 (Pulau Satumu (Raffles Lighthouse)); ZRC.1990.11907 (Pulau Jong); ZRC.1996.1067 (Terumbu Pandan).

Description.- Planar, reticulate, with frequently anastomosing branches; colony dull orange ("brick-red") in colour; sclerites orange, with eight-radiates and tuberculate spindles in about equal numbers; agrees well with the colonial morphology of the neotype (Bayer & Grasshoff, 1994; pp. 35-37; Figs.8,9).

Depth Range and Habitat.- 10-18m; lower reef slope and bottom; rock or sand substrata.

Remarks.- Sclerites require more detailed analyses and comparisons before a definitive identification is arrived at; reported in Goh & Chou (1994) from the following sites besides the four above: Sultan Shoal Lighthouse, Terumbu Pempang Tengah, Pulau Hantu (East), Pulau Subar Laut, Lazarus Island, Kusu Island, Midway Reef (S.E. Buran).

Ctenocella (Umbracella) sp. A

(Pl. 2f)

Material Examined.- ZRC.1990.11908 (Pulau Subar Laut); ZRC.1996.1068 ('southern islands').

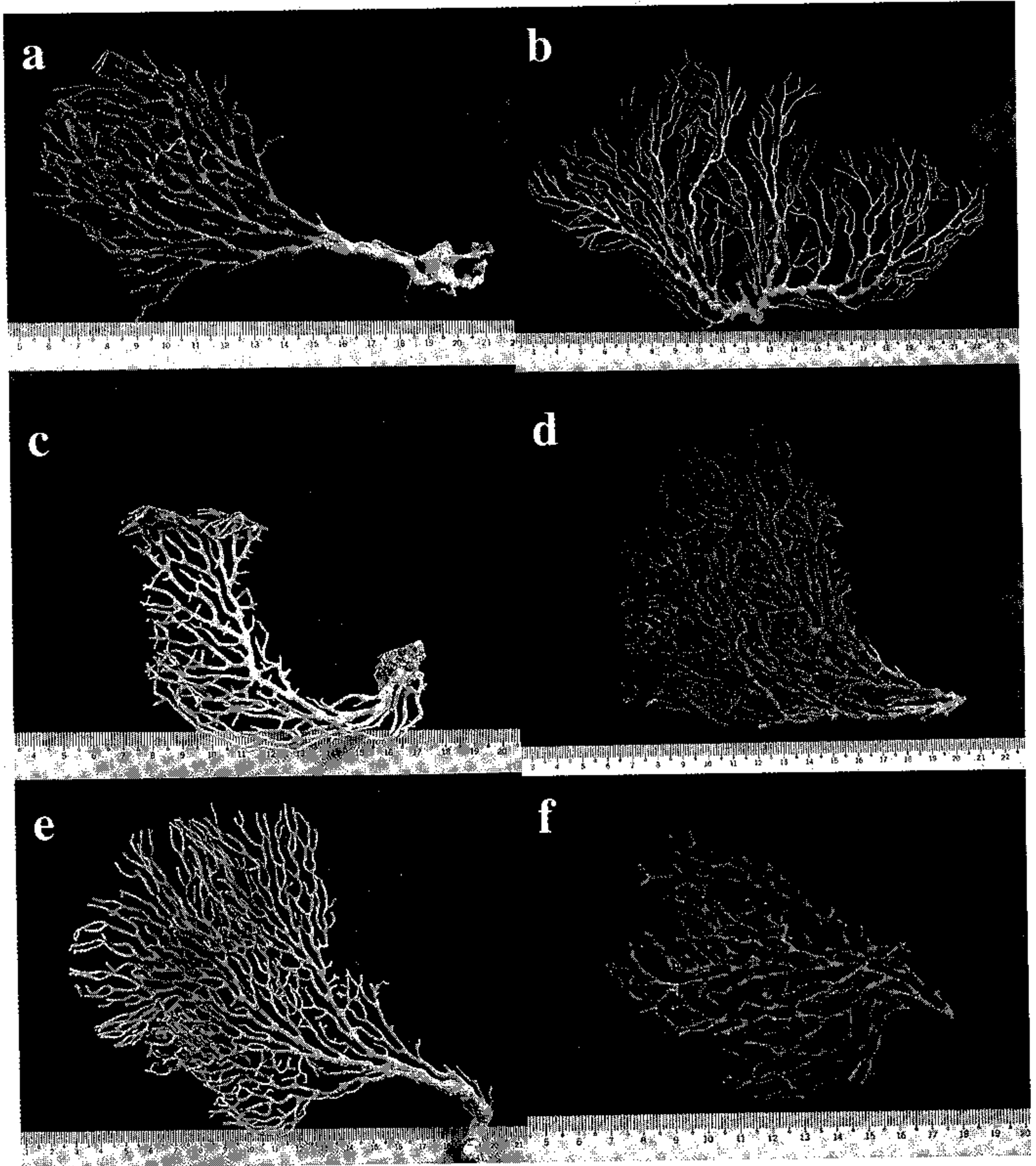
Description.- Planar, reticulate colony with frequently anastomosing branches; colony white with very small (<2mm, fully extended) white polyps; sclerites colourless, eight-radiates dominate, with some tuberculate spindles.

Depth Range and Habitat.- 10-18m; lower reef slope and bottom; rock or sand substrata.

Remarks.- Reported in Goh & Chou (1994) from Pulau Subar Laut and Sultan Shoal Lighthouse, Terumbu Pandan, Terumbu Pempang Laut, Terumbu Pempang Tengah, Pulau Hantu (East), Pulau Satumu (Raffles Lighthouse), Pulau Jong, Lazarus Island, Kusu Island, Midway Reef (S.E. Buran).

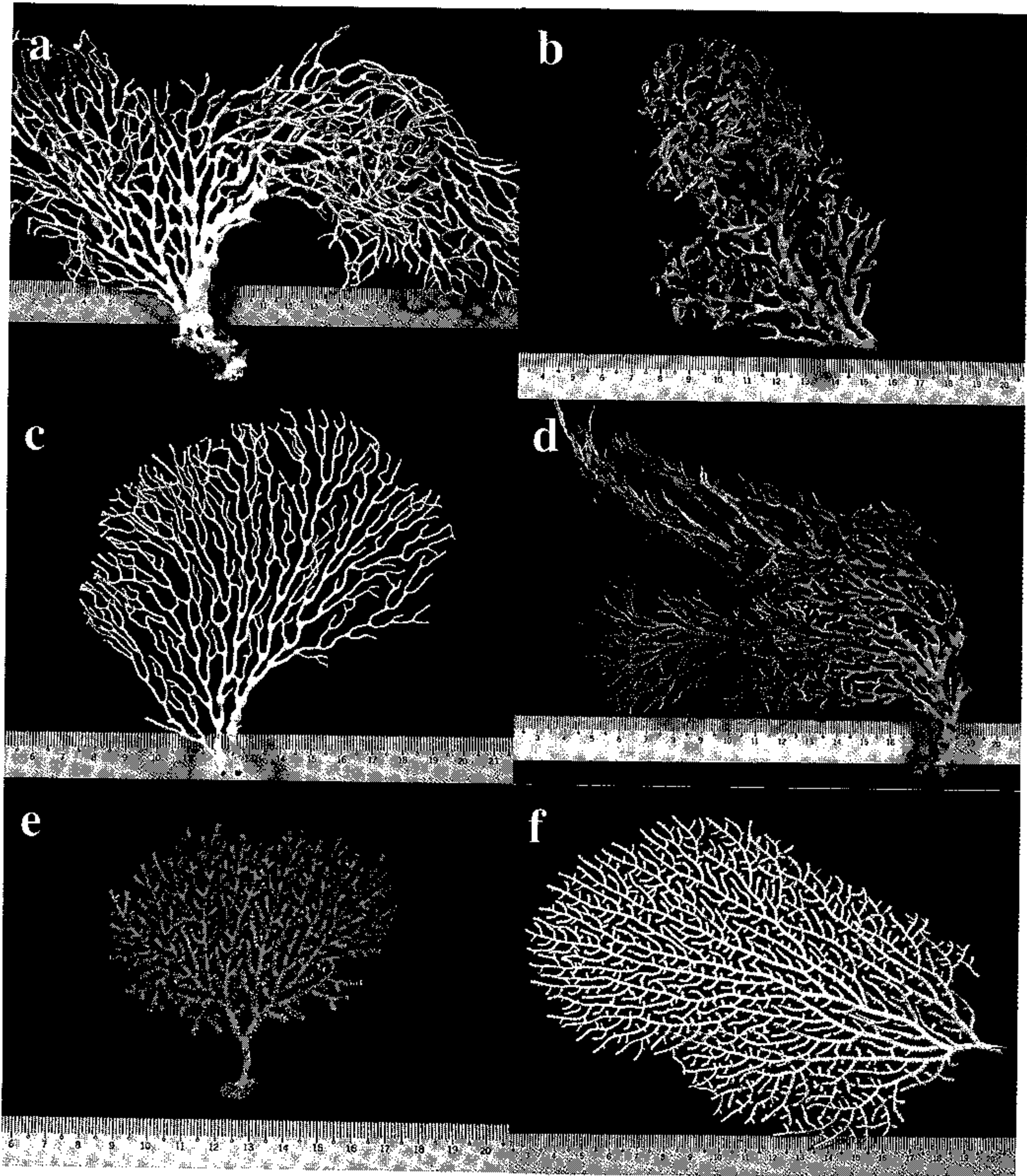
Comparison of Diversity with Other Indo-Pacific Localities

A total of 31 species from 12 genera and 6 families are listed in this paper, of which 14

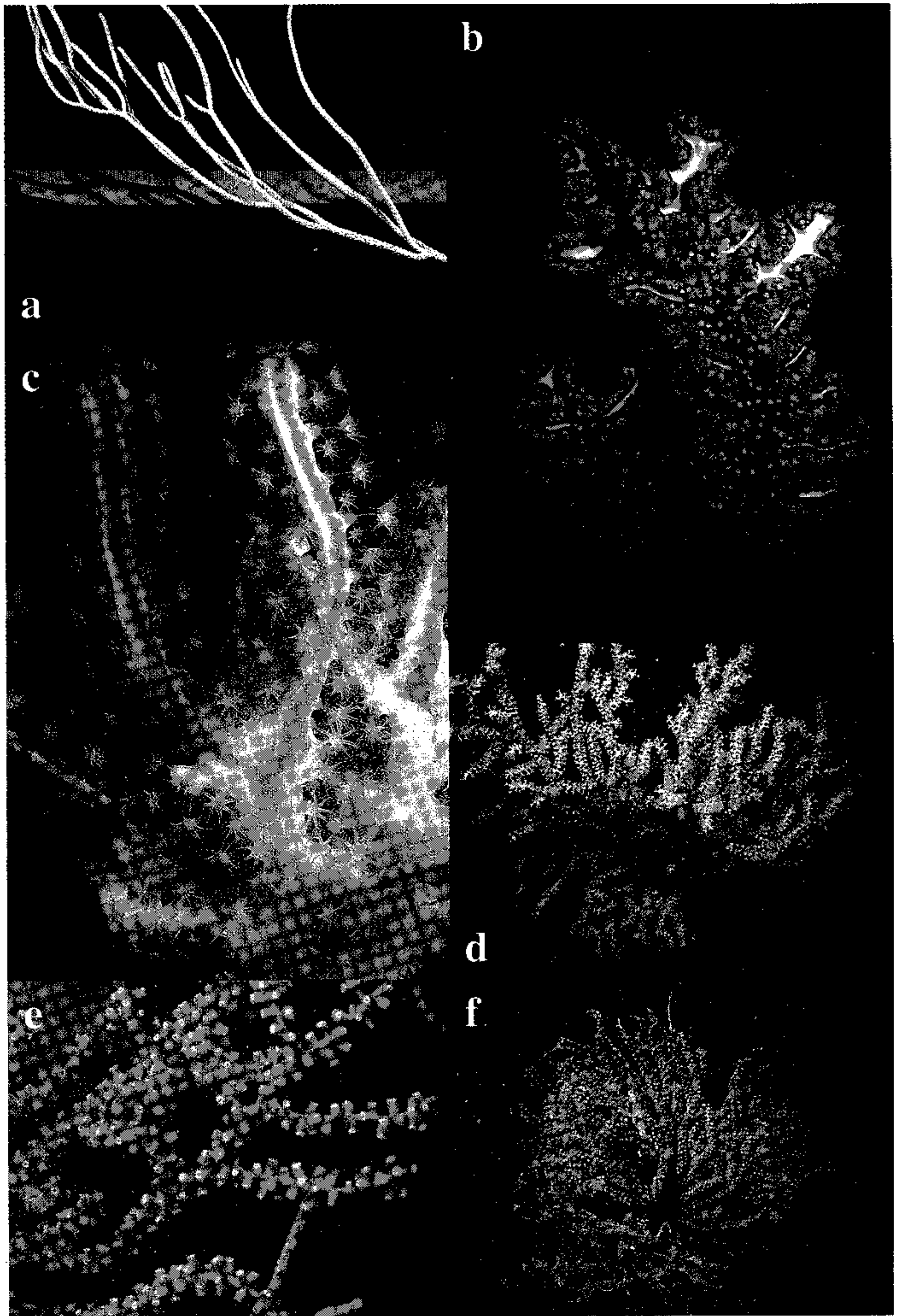


Pl. 1. Dried colonies of: a. *Melithaea ochracea* (ZRC.1995.5); b. *Me. ochracea* (ZRC.1995.11); c. *Mopsella rubeola* (ZRC.1990.11942); d. *Mo. rubeola* (ZRC.1995.6); e. *Mo. rubeola* (ZRC.1995.13); f. *Mo. rubeola* (ZRC.1995.14).

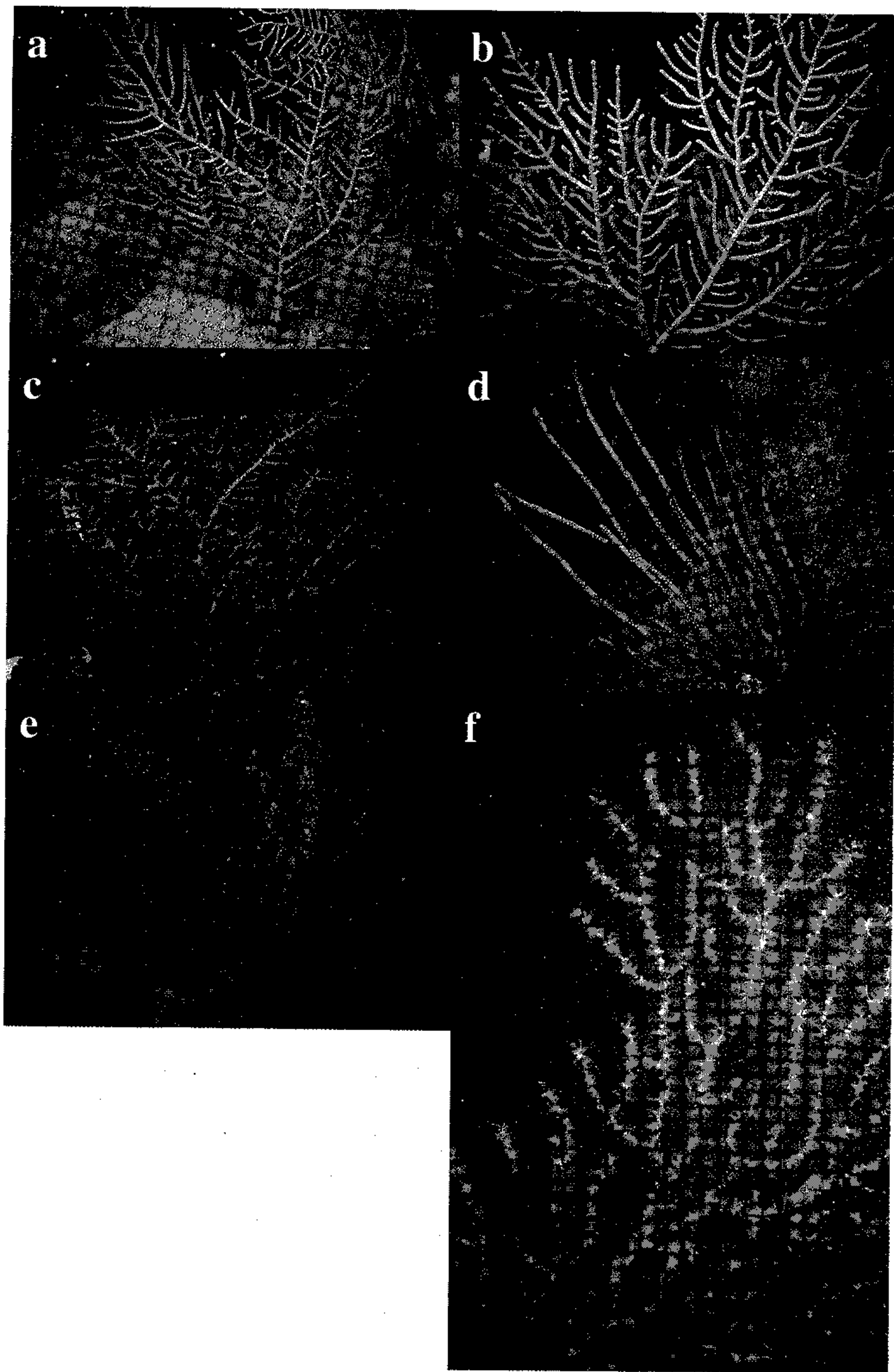
represent new or potential new records for Singapore (and possibly the Malay peninsula). From Indonesia, the collection of the Siboga Expedition was summarized by Bayer (1961), who counted 445 octocoral (excluding Pennatulacea) species, of which 225 were gorgonians and only 42% of these 225 species were found in shallow (<50m) waters (Grigg & Bayer, 1976). Stiasny (1940), describing the collections from the Snellius Expedition recorded 21 species, 17 genera and 9 families. Sixty-two species, 36 genera and 15 families (Mai-Bao-Thu & Domantay, 1970, 1971) were recorded from the Philippines. Farther north, 26 species, 12 genera and 5 families were recorded from Hong Kong (Zou & Scott, 1980). In the Indian Ocean, 15 species, 11 genera and 5 families from the Maldives (Hickson, 1906a, b) and 37 species, 20 genera and 9 families from the Mascarene Archipelago (Faure, 1977) have been collected. In all these analyses (except in Grigg & Bayer (1976), where the species were not



Pl. 2. Dried colonies of: a. *Mopsella rubeola* (ZRC.1995.18); b. *M. retifera* (ZRC.1995.12); c. *Acabaria robusta* (ZRC.1995.19); d. *A. robusta* (ZRC.1996.1047); e. *Ctenocella (Umbracella) sp. cf. umbraculum* (ZRC.1996.1067); f. *C. (Umbracella) sp. A* (ZRC.1996.1068).



Pl. 3. a. Dried colonies of *Junceella (Dichotella) sp. cf. gemmacea* (top: ZRC.1996.1064; bottom: ZRC.1996.1063); in situ: b. *Solenocaulon sp. A*; c. *S. sp. B*; d. *Acanthogorgia sp. A*; e. *A. sp. B*; f. *A. sp. C*.



Pl. 4. In situ: a. *Echinogorgia* sp. A; b. *E.* sp. B; c. *E.* sp. C; d. *E.* sp. E; e. *E.* sp. F; f. *Astrogorgia* sp. A.

listed), the number of families and genera were based on valid families and genera (Bayer, 1981c) as far as possible so that direct comparisons with the present work could be made. To prevent confusion, for the purpose of this comparison, we retain Bayer's (1981c) families and genera, resulting in not 12, but 14 genera from Singapore. The number of species and families are unchanged.

Significantly higher taxon diversity is evident in the Philippines (Mai-Bao-Thu & Domantay, 1970, 1971), and in the Indonesian archipelago (Siboga Expedition, in Bayer, 1961). Taking these statistics at face value and concluding that the gorgonian fauna in Singapore is inherently poor compared to other tropical seas of the region is an oversimplification of the true picture. It must be taken into account that the species list obtained by Mai-Bao-Thu & Domantay (1970, 1971) were compilations of a total of 15 separate collections over almost a hundred years. The Siboga Expedition was also an extensive survey comprising more than 300 stations throughout the Indonesian archipelago whose main purpose was to obtain taxonomic collections of bottom-dwelling invertebrates. In terms of number of samplings and geographical extent of surveys, direct comparison of numbers from these lists with the present study is thus inappropriate in the light of the immaturity of taxonomic work on gorgonians in Singapore.

The smaller number of species found here compared with these collections is better explained in terms of the smaller sampling size and area rather than an inherent poor fauna. The fact that a comparable (37, compared with the 31 reported here) number of species was reported from the Mascarene Archipelago (Faure, 1977), a checklist comprising a compilation of 20 separate works over a period of more than two centuries, suggests that the species diversity in Singapore is relatively rich. In fact, when compared with the fauna collected during the two year (1929-30) Snellius Expedition (Stiasny, 1940), the expedition to the Maldives at the turn of the century (1899-1900) (Hickson, 1906a, b), and the report from Hong Kong (Zou & Scott, 1980), the species diversity from Singapore is found to be richer.

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