Swiss J Palaeontol (2014) 133:77–97
DOI 10.1007/s13358-014-0065-7

Pleistocene scleractinian corals from Marsa Alam area, Red Sea Coast, Egypt: systematics and biogeography

Mahmoud A. Kora · Salah N. Ayyad · Heba M. El-Desouky

Received: 20 January 2013 / Accepted: 22 February 2014 / Published online: 10 May 2014

Abstract Coral reef terraces are investigated in five localities around Marsa Alam on the Egyptian Red Sea Coast. The reefal limestones and the alternating terrigenous clastics are assigned to the Pleistocene Samadai Formation. Sixty-one scleractinian coral species belonging to 25 genera and 10 families were identified. Thirteen scleractinian species, for the first time recorded from the Egyptian Red Sea coastal plain, are systematically studied. The stratigraphic distribution of these fossils is illustrated and discussed. Six species are extended to the Miocene and five other species are recorded from the Pliocene and still living in the present Red Sea and the Indo-Pacific. The geographic distributions of the identified coral species are illustrated on maps. These maps show that, all the identified coral species are distributed only throughout the Indo-Pacific realm, increasing from the central part westwards across the Indian Ocean to the Red Sea. There are four species that are restricted to the Red Sea, Arabian region and West Indian Ocean.

Keywords Scleractinian corals · Red Sea · Pleistocene · Palaeogeography · Egypt

Introduction

The study area lies along the Red Sea coastal plain between latitudes 24°30′ and 25°30′N in the Marsa Alam area, forming a strip that stretches 95 km along the coast and ranging in width from 1 to 6 km. The area is covered by Miocene and younger deposits with conspicuously raised coral reef terraces of Pleistocene age which run parallel to the shore line in a discontinuous pattern and at different elevations (Fig. 1). The Pleistocene succession is represented mostly by conglomerates that grade laterally or vertically into reefal limestones usually referred to as the Samadai Formation of Philobbos et al. (1989), which is conformably overlain by the Pleistocene raised beaches and coral reefs. The present study extends using the Samadai Formation to include the overlying raised beaches and coral reefs, as there is no remarkable lithological difference between them and it is rather difficult to separate them on maps. The studied succession overlies unconformably the Pliocene Shagra Formation or the Miocene Samh Formation (Fig. 2).

The aim of the present work is to shed more light on the systematics and palaeobiogeography of the scleractinian corals building the Pleistocene succession in the Marsa Alam area. To carry out this study, five stratigraphic successions have been investigated, measured and sampled. The selected localities include Wadi Abu Dabbab and Wadi Asalay (north of Marsa Alam) and Wadi Samadai, Sharm El-Fuquiri and Sharm El-Luli (south of Marsa Alam). The Pleistocene succession in the area varies in thickness from about 33 m at Sharm El-Luli, to about 23 m at Wadi Abu Dabbab (Fig. 2). An average thickness of about 27 m is recorded around Marsa Alam City. About 100 rock samples and 550 coral specimens were collected and studied in detail. All the collected sources are deposited at the Geology Department, Faculty of Science, Mansoura University, Mansoura, Egypt.

The Pleistocene macrofauna of the Red Sea Coast have been considered as a rich material for many paleontological studies, e.g., Hassan et al. (1975), Al-Rifaiy and Cherif (1989), Ziko et al. (1993a, b), El-Sorogy (1997), Gameil (1998), Kora and Abdel-Fattah (2000), El-Sorogy (2002),

M. A. Kora (✉) · S. N. Ayyad · H. M. El-Desouky
Department of Geology, Faculty of Science, Mansoura University, Mansoura, Egypt
e-mail: kora@mans.edu.eg; Mahmoud.kora@gmail.com

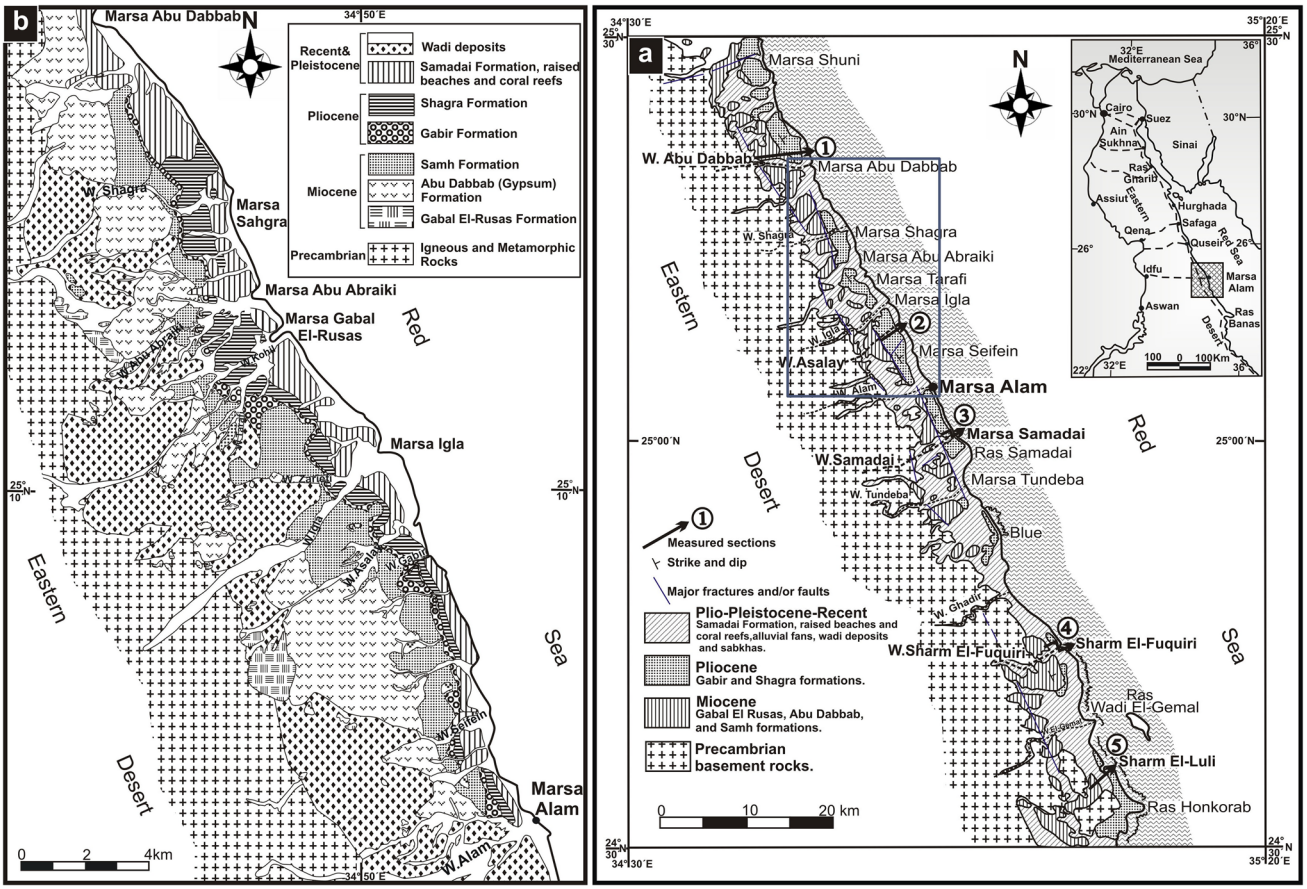


Fig. 1 **a** Simplified geological map of the study area (modified after Conoco-EGPC 1987); **b** distribution of the studied rock units between Wadi Abu Dabbab and Marsa Alam (Modified after El-Akkad and Dardir 1966)

Abd El-Wahab and El-Sorogy (2003) and El-Sorogy (2008). Geochronological, age dating and isotopic composition investigations for the Pleistocene-emerged coral reef terraces have been done by many workers, e.g., Gvirtzman et al. (1992), El Moursi et al. (1994), Strasser and Strohmenger (1997) and El-Asmar (1997). However, Plaziat et al. (2008) reviewed the dating of reefs on the coasts of the Red Sea including those of Egypt, Jordan, Sudan, Eritrea, Saudi Arabia and Djibouti and suggested a revision of dating of corals supposedly younger or older than the age assigned to the high-level isotopic substage MIS 5.5 (=5e).

Systematic palaeontology

The terminology, systematic classification and the criteria of identification of the encountered coral fossils are generally in accordance with Wells (1956), Scheer and Pillai (1983), Sheppard and Sheppard (1991) and Veron (2000a, b, c), but taking into consideration the modern prospectives on cnidarian diversity proposed by Daly et al. (2007), Glynn et al. (2007), Benzoni et al. (2007, 2011), etc. The description of the corallite wall and septal microstructure used is based on the work of Budd and Stolarski (2011). The Coral ID online version prepared by Veron and Stafford-Smith (2011) is also used to check out the identifications.

The present study led to the recognition of 61 scleractinian coral species, representing about 53 % from the previously recorded Pleistocene corals along the Egyptian Red Sea Coast reaching 116 species, belonging to 10 families (Table 1). Thirteen species namely *Acropora stoddarti*, *A. spicifera*, *A. squarrosa*, *Stylophora wellsi*, *Pseudosiderastrea tayamai*, *Psammocora haimeana*, *Favites chinensis*, *F. vasta*, *Plesiastrea devantieri*, *Leptastrea purpurea*, *L. pruinosa*, *Echinopora hirsutissima* and *Porites lobata* are described here for the first time from the Pleistocene Samadai Formation including the raised reefs along the Egyptian Red Sea Coast. Moreover, *Acropora stoddarti* and *Plesiastrea devantieri* are described here for the first time from the Red Sea in the fossil and living coral records. A systematic description for the newly recorded corals is summarized below.

Phylum Cnidaria Hatschek 1888
Class Anthozoa Ehrenberg 1834

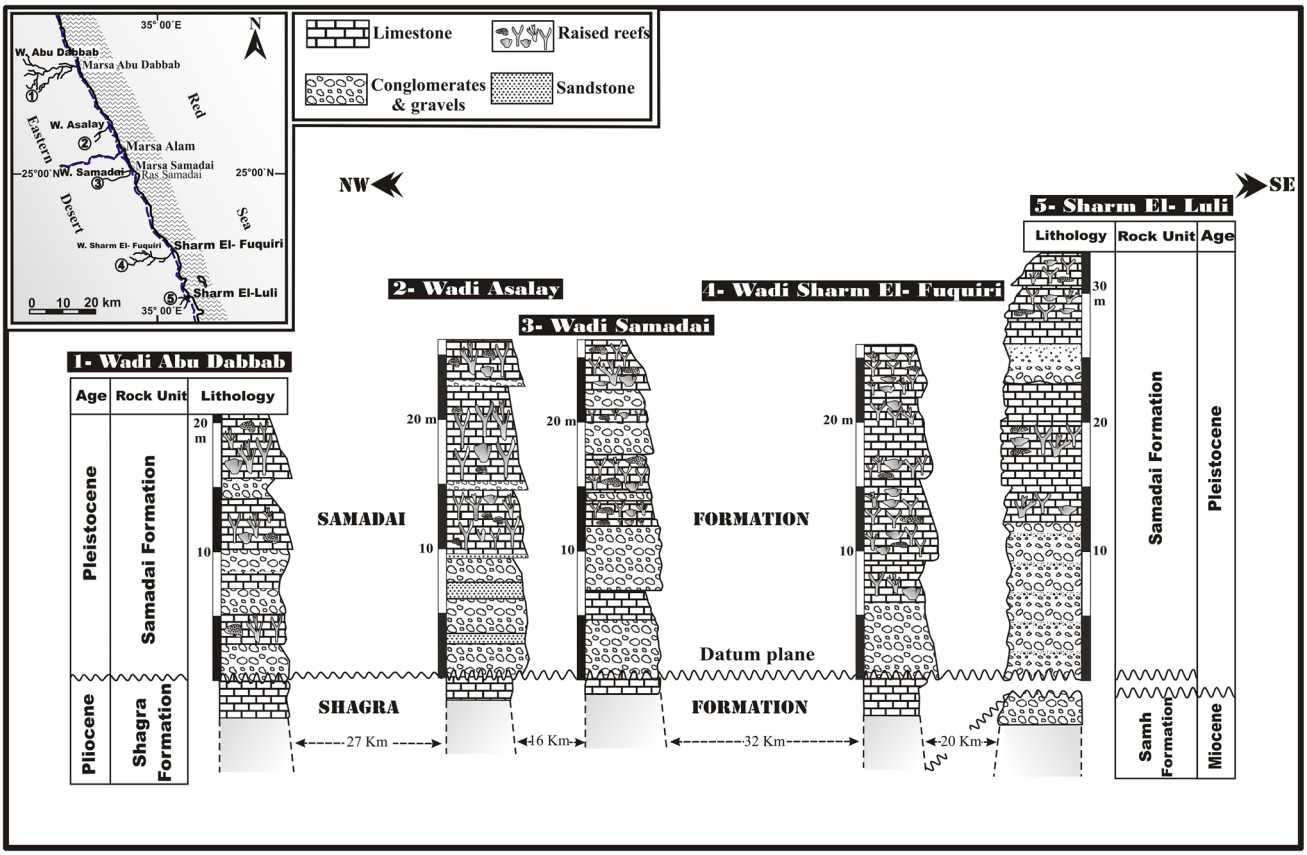


Fig. 2 Correlation chart of the studied successions along the Red Sea Coast

Subclass Hexacorallia Haeckel 1866
Order Scleractinia Bourne 1900
Family Acroporidae Verrill 1902
Genus *Acropora* Oken 1815

Acropora stoddarti Pillai & Scheer 1976
(Fig. 3a1–a3)

1976 *Acropora stoddarti* Pillai & Scheer.—27–28, pl. 5, figs. 1, 2; pl.6, figs. 1–3.
1986 *Acropora stoddarti* Pillai & Scheer.—Veron: 191.
2000a *Acropora stoddarti* Pillai & Scheer.—Veron 1: 232, figs. 1–5.
2004 *Acropora stoddarti* Pillai & Scheer.—Edward et al.: 17.

Material. Two specimens collected from the southern side of Wadi Sharm El-Fuquiri (Sh.F 3-b2) and from Wadi Samadai (TI, S 18-2).

Description. Main branches of the corallum prostrate and coalescent to form a flattened solid plate with oval spaces. Corallites are immersed, occasionally sub-immersed to appressed tubular with rounded openings. On the upper surface, radials are more crowded, while those of the lower surface are widely spaced. They are 2–2.5 mm in outer diameter and 0.5–1 mm in inner calice diameter. Coenosteum is echinulate and porous.

Geographic distribution. Seychelles, Maldives, Houtman Abrolhos Islands on the west coast of Australia (Veron 1986, 2000a) and Gulf of Mannar southeast India (Edward et al. 2004).

Habitat. Reef slopes (Veron 2000a).

Acropora spicifera (Dana 1846)
(Fig. 3b1, b2)

1846 *Madrepora spicifera* Dana.—442, pl.33, figs. 4, 4a, 4b, 5.
1986 *Acropora spicifera* (Dana).—Veron: 176, figs. 1–3.
2000a *Acropora spicifera* (Dana).—Veron 1: 308, figs. 1–5.

Material. Two specimens collected from the Pleistocene Samadai Formation at Wadi Samadai and Wadi Sharm El-Luli (S 17-10 and Sh.L 5-12).

Description. Colonies are small with 5–9 mm thick anastomosing, tapering branches with blunt or rounded tips. Axial corallites are distinct but not exsert. Radial corallites

Table 1 Genera and species recorded in the present study from Marsa Alam area

Families	Genera	Species
1. Acroporidae	*Acropora*	*A. hemprichii*, *A. stoddarti**, *A. pharaonis*, *A. spicifera**, *A. squarrosa**, *A. valida* and *A. intermedia*
2. Pocilloporidae	*Pocillopora*	*P. damicornis* and *P. verrucosa*
	Seriatopora	*S. hystrix*
	Stylophora	*S. pistillata* and *S. wellsi**
3. Oculinidae	*Galaxea*	*G. fascicularis* and *G. astreata*
4. Siderastreidae	*Pseudosiderastrea*	*P. tayamai**
	Siderastrea	*S. savignyana*
	Psammocora	*P. haimeana**
	Coscinaraea	*C. monile* and *C. columna*
5. Agariciidae	*Pavona*	*Pavona* sp.
6. Fungiidae	*Cycloseris*	*C. patelliformis*
	Fungia	*F. fungites*, *F. klunzingeri*, *F. concinna* and *F. scutaria*
	Ctenactis	*C. echinata*
7. Merulinidae	*Hydnophora*	*H. microconos*
8. Mussidae	*Lobophyllia*	*L. corymbosa* and *L. hemprichii*
9. Faviidae	*Favia*	*F. telligera*, *F. speciosa*, *F. pallida* and *F. lizardensis*
	Favites	*F. pentagona*, *F. chinensis**, *F. abdita*, *F. flexuosa* and *F. vasta**
	Goniastrea	*G. edwardsi*, *G. retiformis* and *G. pectinata*
	Platygyra	*P. sinensis*, *P. daedalea* and *P. lamellina*
	Leptoria	*L. phrygia*
	Plesiastrea	*P. devantieri**
	Leptastrea	*L. bottae*, *L. purpurea**, *L. pruinosa**, *L. transversa* and *Leptastrea* sp.
	Cyphastrea	*C. serailia* and *C. microphthalma*
	Echinopora	*E. lamellosa*, *E. gemmacea* and *E. hirsutissima**
10. Poritidae	*Porites*	*P. solida*, *P. lobata**, *P. lutea*, *P. nodifera* and *P. columnaris*

* Species described here for the first time from the Pleistocene raised reefs along the Egyptian Red Sea Coast

are nariform with rounded openings; occasionally sub-immersed to immersed. Inner calice diameters of radials are 0.7–1 mm, while those of axial corallites are about 1 mm. Coenosteum is reticulate with spinules. Walls are synapticulothecate.

Geographic distribution. Red Sea, Malaysia, Singapore, South China Sea, Japan, Papua New Guinea, Marshall Islands and Fiji (Wallace 1999), Houtman Abrolhos Islands, south-west Australia (Veron 2000a).

Fig. 3 (*Scale bar* = 10 mm, unless otherwise stated): **a** *Acropora stoddarti* Pillai & Scheer 1976. S 18-2, Pleistocene raised reefs (T I), Wadi Samadai; **a1** upper surface of the corallum with many small proliferations; **a2** enlarged part of the upper surface showing the very crowded and immersed radials; **a3** enlarged part of the lower surface showing immersed and widely spaced radial corallites **b** *Acropora spicifera* (Dana 1846), Sh.L 5-12, Samadai Formation, Wadi Sharm El-Luli; **b1** a small corallum with short branches; **b2** close-up view showing anastomosing branches with radial corallites. **c** *Acropora squarrosa* (Ehrenberg 1834), S 20-15, Pleistocene raised reefs (T III), the northern side of Marsa Samadai; **c1** a small ramose corallum; **c2** close-up view on the branch tip showing the axial and radial corallites; **c3** close-up view on radial corallites with thick lip and very small rounded openings

Habitat Acropora spicifera (Dana) is found on reef slopes (Veron 2000a).

Acropora squarrosa (Ehrenberg 1834)
(Fig. 3c1–c3)

1834 *Heteropora squarrosa* Ehrenberg.—336.
1879 *Madrepora squarrosa* Ehrenberg.—Klunzinger 2: 13, pl. 2, fig. 9; pl. 4, fig. 12; pl. 9, fig. 9.
1976 *Acropora squarrosa* (Ehrenberg).—Pillai & Scheer: 31–32.
1983 *Acropora squarrosa* (Ehrenberg).—Scheer & Pillai: 44, pl. 8, figs. 3, 4.
1991 *Acropora squarrosa* (Ehrenberg).—Sheppard & Sheppard: 60, pl. 33.
2000a *Acropora squarrosa* (Ehrenberg)—Veron 1: 390, Figs. 1–5.

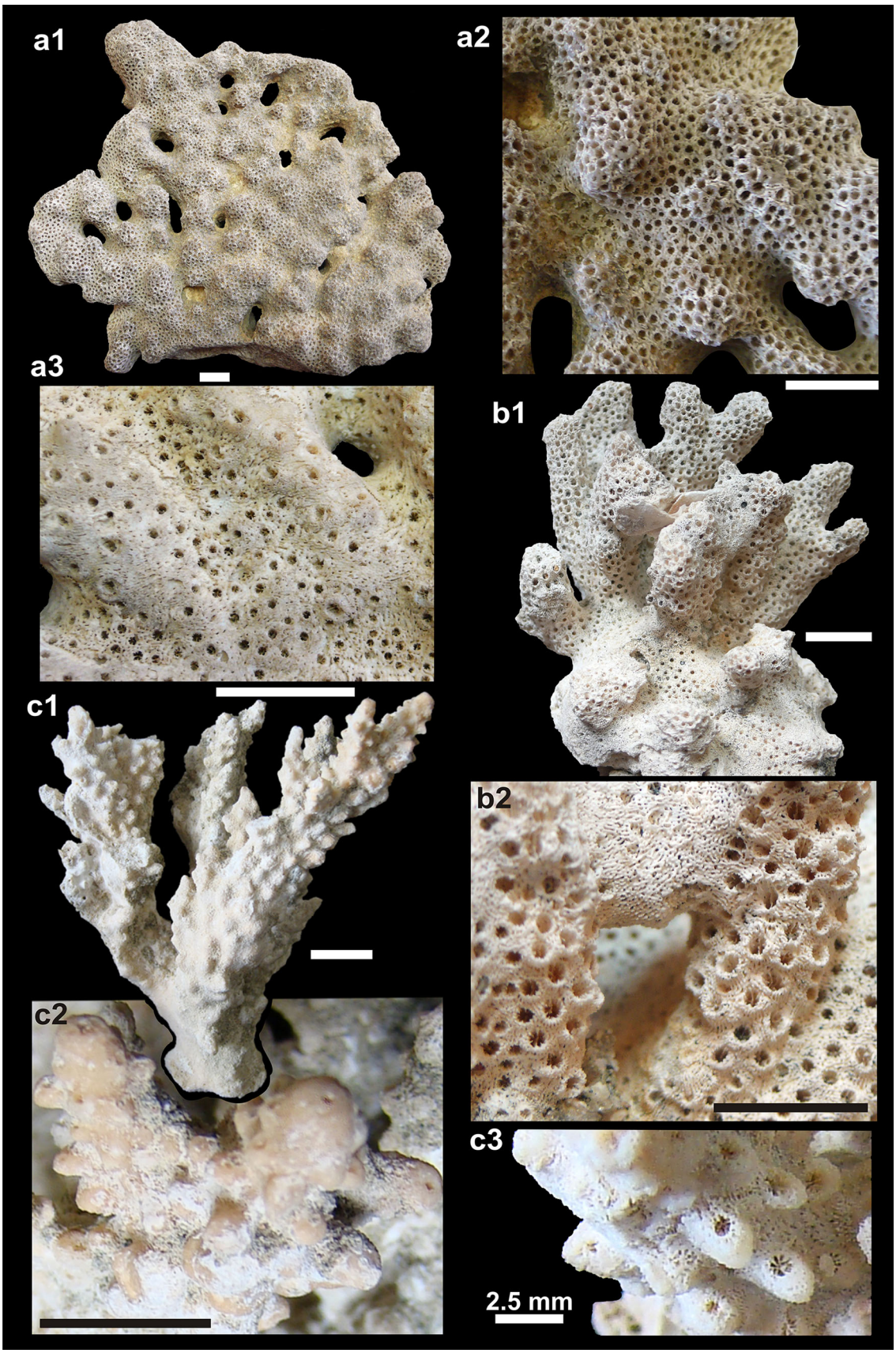
Material. Only one ramose corallum, collected from the Pleistocene raised reefs at the northern side of Marsa Samadai (T III, S 20-15).

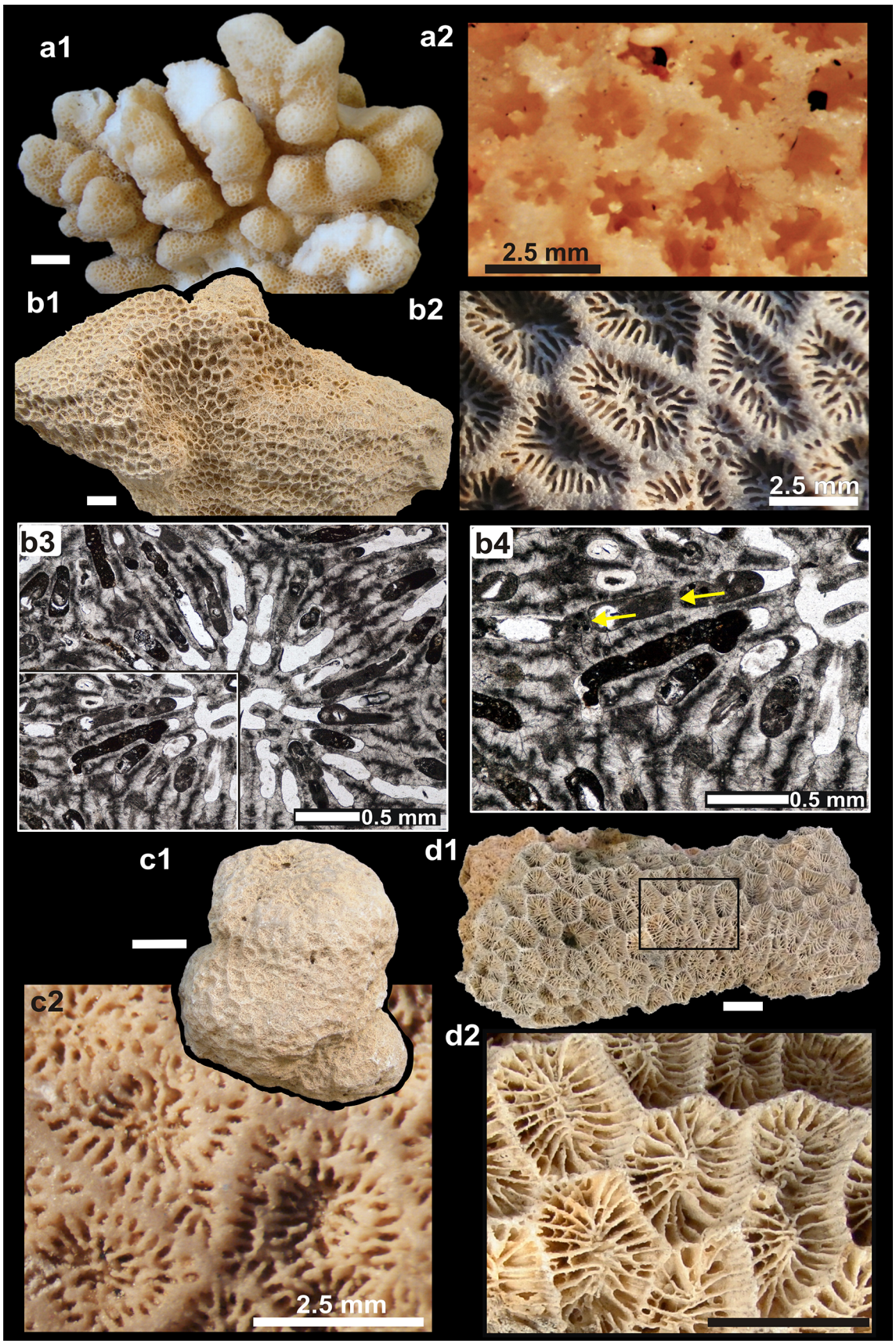
Description. The main branch is 1.5 cm thick and up to 7 cm long. Branchlets are up to 0.5 cm thick and 1.5 cm long. Axial corallites are dome-shaped with thick rounded walls, 2–3 mm in average diameter, very small calice openings (0.5 mm), 1.5–2 mm exsert. Radials are 1.5 mm in outer diameter, 2–4 mm long. They are narifom with rostrate development or thick lip and rounded small openings.

Geographic distribution. Red Sea, Seychelles, Maldives, Philippines, Great Barrier Reef, Murray Islands, Marshall Islands, Tahiti (Scheer and Pillai 1983).

Habitat. The species is common in sheltered water between 5 and 25 m (Sheppard and Sheppard 1991).

Family Pocilloporidae Gray 1842
Genus *Stylophora* Schweigger 1819
Stylophora wellsi Scheer 1964
(Fig. 4a1, a2)


a1
a2
a3
b1
b2
c1
c2
c3
2.5 mm


a1
a2
2.5 mm
b1
b2
2.5 mm
b3
0.5 mm
b4
0.5 mm
c1
c2
2.5 mm
d1
d2

◀**Fig. 4** (*Scale bar* = 10 mm, unless otherwise stated): **a** *Stylophora wellsi* Scheer 1964, Ad 25-a 7, Samadai Formation, Wadi Abu Dabbab; **a1** entire corallum with short, knobby branches; **a2** close up view showing the calices with their internal elements; two orders of septa and the styliform columellae. **b** *Pseudosiderastrea tayamai* Yabe & Sugiyama 1935, Sh.L 7-b 5, Pleistocene raised reefs (T I), Sharm El-Luli; **b1** a large massive corallum with cerioid corallites; **b2** close-up view on the cerioid corallites showing the septal arrangement and fusion; **b3** transverse thin section, showing a single corallite with septothecal wall and occasional thin synapticulothecal elements. The *box* is the area shown in Fig. **b4**; **b4** enlarged part of the area enclosed in the *box* shown in Fig. **b3**, showing septothecal wall with occasional synapticulothecal elements (*arrows*) **c** *Psammocora haimeana* Milne-Edwards & Haime 1851, Sh.F 3-b 19, Samadai formation, Wadi Sharm El-Fuquiri; **c1** massive rounded corallum; **c2** close-up view showing the corallites are separated by well-defined synapticulothecal walls **d** *Favites chinensis* (Verrill 1866), Ad 26-6, Pleistocene raised reefs, (T I), Wadi Abu Dabbab; **d1** massive corallum with angular cerioid corallites; **d2** close-up view of the area enclosed in the *black box* in Fig. **d1**, showing the cerioid corallites with intratentacular budding and endothecal dissepiments fill the calices in the form of concentric rows between the septa

1964 *Stylophora wellsi* Scheer.—613, figs. 1–5.
1983 *Stylophora wellsi* Scheer.—Scheer & Pillai: 25–26, pl. 3, figs. 5–7.
1991 *Stylophora wellsi* Scheer.—Sheppard & Sheppard: 42–44, pl. 13, fig. 16.
2000b *Stylophora wellsi* Scheer.—Veron 2: 64, figs. 1–3.

Material. One well-preserved corallum collected from the Pleistocene Samadai Formation at Wadi Abu Dabbab (Ad 25-a 7).

Description. Branches are short, knobby and thick (up to 3 cm thick). Calices are closely spaced, 0.6–0.1 mm in diameter. They contain 12 septa, arranged in two cycles; six primary septa are short or fused with the columellae, the other six are rudimentary. Columellae are styliform. Coenosteum is spiny. Calices are leveled with the coenosteum and there are no hoods.

Remark. *S. wellsi* Scheer is clearly distinguished from other *Stylophora* spp. by its short, knobby, thick and blunt ended branches.

Geographic distribution. *S. wellsi* is common in the northern and central parts and less so in the southern parts (Sheppard and Sheppard 1991), it is also recorded from Madagascar (Veron 2000b).

Habitat. *S. wellsi* Scheer grows only in very shallow water exposed to strong swell and wave action. It is very rare below 3 m deep (Sheppard and Sheppard 1991; Veron 2000b).

Family Siderastreidae Vaughan & Wells 1943
Genus *Pseudosiderastrea* Yabe & Sugiyama 1935

Pseudosiderastrea tayamai Yabe & Sugiyama 1935
(Fig. 4b1–b4)

1956 *Anomastraea* (*Pseudosiderastrea*) *tayamai* Yabe & Sugiyama.—Wells: F385, fig. 276/2.
1980 *Pseudosiderastrea tayamai* Yabe & Sugiyama.—Veron & Pichon: 85–89, figs. 144–147.
1988 *Pseudosiderastrea tayamai* Yabe & Sugiyama.—Pillai & Patel: 63, pl. 9, fig. B.
1991 *Pseudosiderastrea tayamai* Yabe & Sugiyama.—Sheppard & Sheppard: 76,78, figs. 65 a-b.
2000b *Pseudosiderastrea tayamai* Yabe & Sugiyama.—Veron 2: 134, figs. 1–4.
2007 *Pseudosiderastrea tayamai* Yabe & Sugiyama.—Benzoni et al.: 43, figs. 4/D1-4.
2012 *Pseudosiderastrea tayamai* Yabe & Sugiyama.—Pichon et al.: 97, fig. 8.

Material. Four moderately well-preserved coralla collected from the Pleistocene Samadai Formation at Sharm El-Fuquiri (Sh.F 3b-1) and Sharm El-Luli (Sh.L 5-4) and from the raised reefs (TI) at Wadi Abu Dabbab (Ad 26-7) and Wadi Sharm El-Luli (Sh.L 7-b 5).

Description. Coralla are encrusting to sub-massive. Corallites are cerioid, polygonal, usually elongated, monocentric and 2.5–5 mm in diameter. Septa are up to 32 per calice. Columellae consist of several pinnules. Interseptal dissepiments are narrow, thin, have various shapes from convex sub-horizontal to slightly concave, vesicular dissepiments also exist.

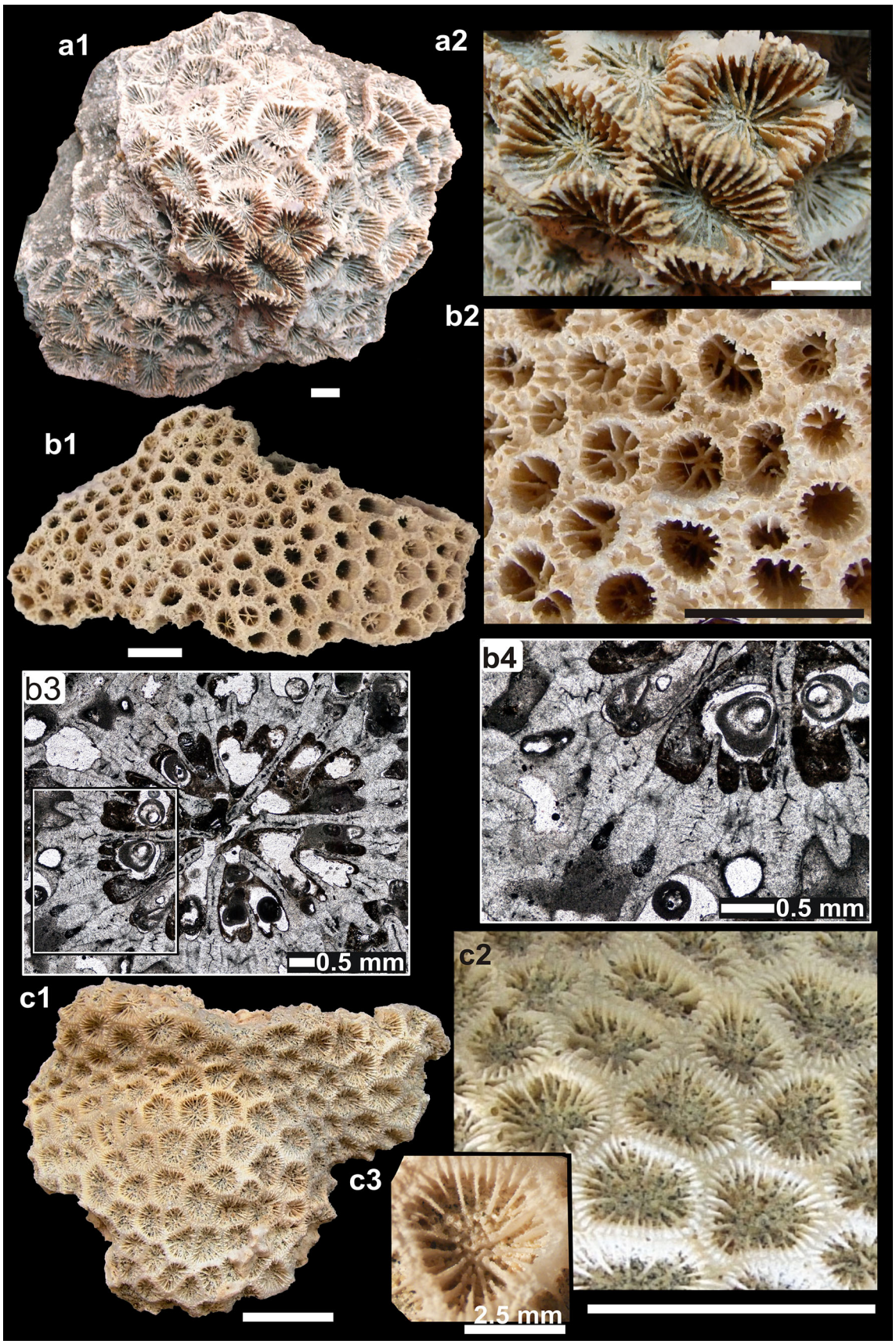
Geographic distribution. Arabian Gulf, Arabian Sea (Sheppard and Sheppard 1991), Bali in Indonesia, Great Barrier Reef of Australia, Papua New Guinea and Maldive Islands (Veron 2000b), Western Indian Ocean, Gulf of Kutch, Gulf of Mannar, west coast of Kerala, Andamans, Celebes, Aru Island (Pillai and Patel 1988), Madagascar, Singapore, Philippines (Veron and Pichon 1980).

Habitat. According to Sheppard and Sheppard (1991); this species is fairly common in shallow sheltered water of reef slopes.

Genus *Siderastrea* de Blainville 1830
Genus *Psammocora* Dana1846

Psammocora haimeana Milne-Edwards & Haime 1851
(Fig. 4c1, c2)

1860 *Psammocora haimeana* Milne-Edwards & Haime.—221.
1879 *Psammocora haimeana* Milne-Edwards & Haime.—Klunzinger 3: 81, pl. 9, fig. 5.
1983 *Psammocora haimeana* Milne-Edwards & Haime.—Scheer & Pillai: 19, pl.1, figs. 7, 4.
1983 *Psammocora nierstraszi* Horst.—Scheer & Pillai: 18–19, pl. 1, figs. 3, 4.


a1
a2
b1
b2
b3
b4
0.5 mm
0.5 mm
c1
c2
c3
2.5 mm

◀**Fig. 5** (*Scale bar* = 10 mm, unless otherwise stated): **a** *Favites vasta* (Klunzinger 1879), Sh.L 7-b 10, Pleistocene raised reefs, (T I), Sharm El-Luli; **a1** massive corallum with cerioid corallites; **a2** close-up view on three corallites showing its details. **b** *Plesiastrea devantieri* Veron 2000a, b, c, Sh.L 7-b 9, Pleistocene raised reefs, (T I), Sharm El-Luli; **b1** general view of the massive corallum; **b2** close-up view on the corallites of the upper surface of the corallum. **b3** transverse thin section, showing a single corallite with septothecal wall, the *box* is the area shown in Fig. **b4**; **b4** enlarged part of the wall that enclosed in the *box* shown in Fig. **b3**, showing the septothecal wall **c** *Leptastrea purpurea* (Dana 1846), S 19-5, Pleistocene raised reefs (T II), Wadi Samadai; **c1** general view of small incrusting corallum; **c2** close-up view on the cerioid corallites of the corallum in Fig. **c1**; **c3** close-up view on one corallite showing the septal pattern and the vertical pinnules compose the columella

1983 *Psammocora profundicella* Gardiner.—Scheer & Pillai: 19, pl. 1, figs. 5, 6.
2000b *Psammocora haimeana* Milne-Edwards & Haime.—Veron 2: 152, figs. 1–4.
2000b *Psammocora profundicella* Gardiner.—Veron 2: 149, figs. 4, 5.
2000b *Psammocora superficialis* Gardiner.—Veron 2: 150, figs. 1–5.
2007 *Psammocora profundicella* Gardiner.—Benzoni et al.- 40, fig. 2.

Material. One moderately well-preserved small corallum (up to 6 cm long and 5 cm spread), collected from the Pleistocene Samadai Formation at Wadi Sharm El-Fuquiri (Sh.F 3-b 19).

Description. Corallum is sub-massive with uneven surface. Corallites are polygonal, 2–3 mm in diameter; they are either single or arranged in short series (up to 4 calices per series). Petaloid septo-costae are inconspicuous. Up to 12 septa reach the columella and they ramify at the collines. Corallite walls have on its both sides two rows of synapticulae connecting the septo-costae.

Remarks. According to Sheppard and Sheppard (1991) in their extensive study on a large collection of specimens that collected from the Red Sea and Arabian Gulf; *P. nierstraszi*, *P. profundicella* and *P. superficialis* are junior synonyms of *P. haimeana*. The present specimen differs from *P. haimeana* and *P. superficialis* of Veron (2000b) in that the petaloid septo-costae are inconspicuous rather than that of Veron (2000b) where the primary septo-costae are distinctly petaloid. The present specimen has corallites shallower than those of *P. haimeana*; it matches with *P. profundicella* of Veron (2000b).

Geographic distribution. Red Sea, Arabian Gulf and Arabian Sea (Sheppard and Sheppard 1991), Seychelles, South Africa, Lakshadweep, Cocos-Keeling Islands, Java, Great Barrier Reef, Solomon Islands, Marshall Islands, Funafuti, Cook Islands and Tahiti (Scheer and Pillai 1983), Maldive Islands, Ashmore Reef of Western Australia, Guam, Scott Reef in Western Australia, Ryukyu Islands in Japan, Papua New Guinea and Negros in Philippines (Veron 2000b).

Habitat. It is very common and abundant species at depths from 8 to 30 m on reefs with clear or even moderately turbid water, such as the central barrier reefs and exposed fringing reefs (Sheppard and Sheppard 1991).

Favites chinensis (Verrill 1866)
(Fig. 4d1, d2)

1977 *Favites chinensis* (Verrill).—Veron et al.: 53–54, figs. 83–85.
1991 *Favites chinensis* (Verrill).—Sheppard & Sheppard: 127, fig. 139.
2000c *Favites chinensis* (Verrill).—Veron 3: 143, figs. 5–8.

Material. Two specimens collected from the Pleistocene Samadai Formation at Wadi Samadai (S 17-2) and from the Pleistocene raised reefs at Wadi Abu Dabbab (T I), Ad 26-6.

Description. Coralla are massive. Corallites are cerioid, polygonal, angular, 5–13 mm in diameter. Walls are thin (0.5 mm thick). Endothecal dissepiments exist. Septa are 30–62 in number per calice according to its diameter. They are arranged in two orders. Paliform lobes are formed in some calices but inconspicuous. Columellae are trabecular. Walls are parathecal.

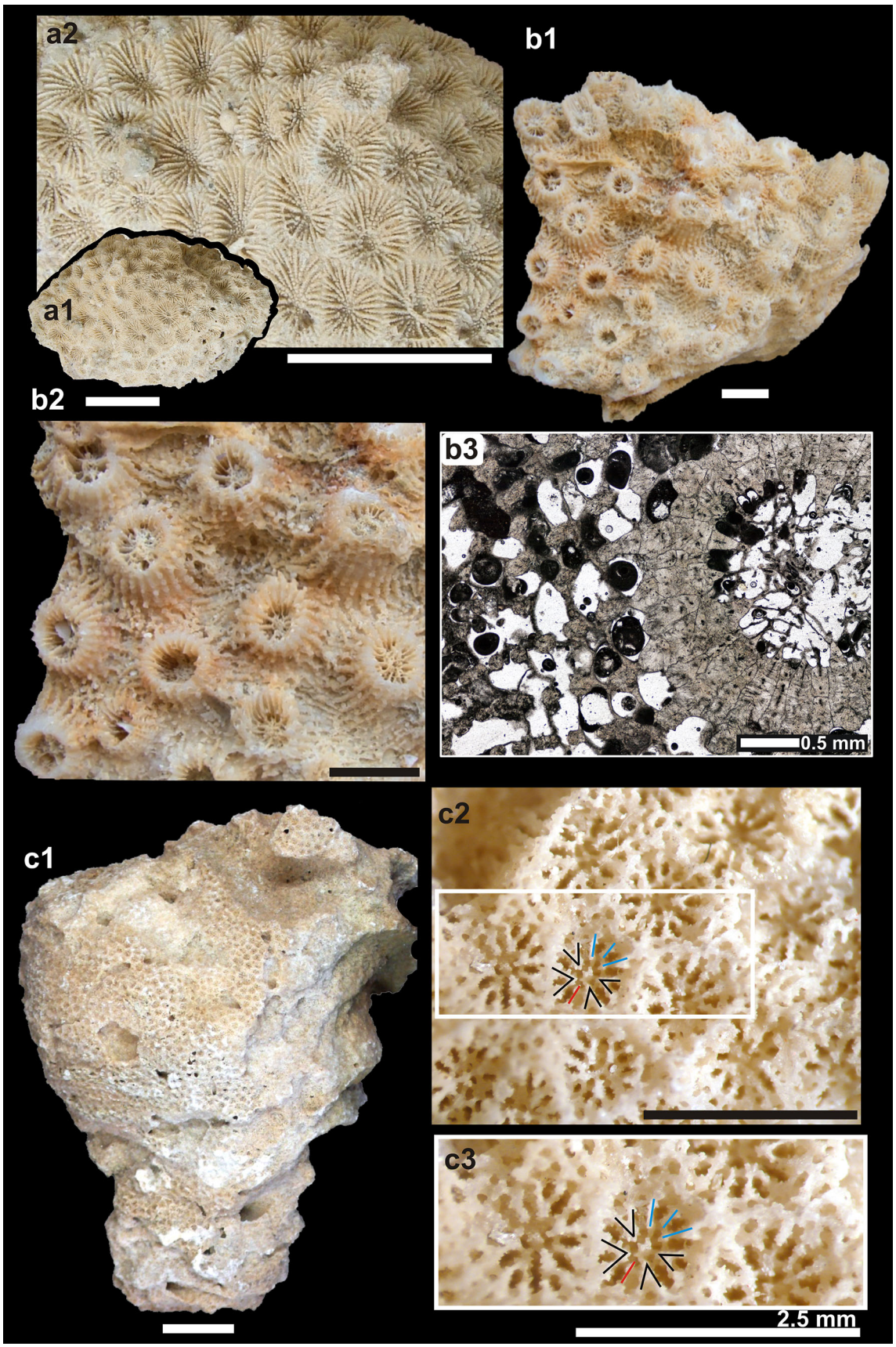
Remark. *Favites chinensis* (Verrill) is close to *F. abdita* (Ellis & Solander) but is distinguished by having smaller corallites which are usually angular, with fewer septa and (less reliably) fewer but more elongated septal dentations (Veron et al. 1977).

Geographic distribution. Red Sea, Arabian Gulf and Arabian Sea (Sheppard and Sheppard 1991), recorded from Ceylon, Indonesia, Japan, New Caledonia and the Great Barrier Reef (Veron et al. 1977), Calamian Islands (Veron 2000c).

Habitat. This species is a hardy one which is common on reef flats. It is especially common in pockets and depressions on the reef flat, but appears to require good water movement as it is much less common nearer back reef slopes of offshore reefs than on fore-reef crests (Sheppard and Sheppard 1991).

Favites vasta (Klunzinger 1879)
(Fig. 5a1, a2)

1879 *Prionastraea vasta* Klunzinger.—Klunzinger 3:38, pl. 4, fig. 12, pl. 10, fig. 4a, b.
1971 *Favites vasta* (Klunzinger).—Chevalier, 229: pl. 22, fig. 3, pl. 25, fig. 4.


a2
a1
b1
b2
b3
0.5 mm
c1
c2
c3
2.5 mm

◀**Fig. 6** (*Scale bar* = 10 mm, unless otherwise stated): **a** *Leptastrea pruinosa* Crossland 1952, Sh.L 5-1, Samadai Formation, Wadi Sharm El-Fuquiri; **a1** small incrusting corallum; **a2** close-up view on the cerioid corallites; **b** *Echinopora hirsutissima* Milne-Edwards & Haime 1849; Sh.L 9-1, Pleistocene raised reefs, (T III), Sharm El-Luli; **b1** part of sub-massive to laminar corallum; **b2** close-up view showing the exsert plocoid corallites with more beaded and spiny well-developed hirsute exothecal costae; **b3** transverse thin section, showing the septothecal wall and the exothecal vesicular dissepiments **c** *Porites lobata* Dana 1846, Sh.L 8-30, Pleistocene raised reefs (T II), Sharm El-Luli; **c1** part of massive colony; **c2** close-up view showing the corallites' details; **c3** enlarged view of the area enclosed in the *black box* in Fig. **c2**

1977 *Favites flexuosa* (Dana).—Veron et al.: 61–64, figs. 102–109, 435.
1983 *Favites flexuosa* (Dana).—Scheer & Pillai: 116, pl. 28, fig. 8.
1991 *Favites flexuosa* (Dana).—Sheppard & Sheppard: 129–130, pl. 95, fig. 142.
2000c *Favites vasta* (Klunzinger).—Veron 3: 152, figs. 1–5.

Material. Three large colonial parts, collected from the Pleistocene raised reefs at Sharm El-Luli, T I, Sh.L 7-b (10, 11, 12).

Description. Coralla are massive with well-developed epitheca at the lower surface. Corallites are cerioid, polygonal and angular in shape, 10–25 mm in long calice diameter, deep (up to 8.5 mm). Walls are thick (up to 3.5 mm thick). Up to 65 septa per calice according to its size are arranged in two orders. Endothecal dissepiments are prominent. Walls are septothecal.

Remarks. According to Veron (2000c); this species was incorrectly synonymized with *Favites flexuosa* by Veron et al. (1977), Scheer and Pillai (1983) and Sheppard and Sheppard (1991).

Geographic distribution. Red Sea (Klunzinger 1879), Papua New Guinea, Pemba Island and Zanzibar in Tanzania, Great Barrier Reef (Veron 2000c).

Habitat. Most reef environments (Veron 2000c).

Genus *Plesiastrea* Milne-Edwards & Haime 1848

Plesiastrea devantieri Veron 2000a, b, c
(Fig. 5b1–b4)

2000c *Plesiastrea devantieri* Veron.—Veron 3: 288, figs. 1–2.
2002 *Plesiastrea devantieri* Veron.—Veron: 167, figs. 303–305.
2011 *Plesiastrea devantieri* Veron.—Benzoni et al.: 235, figs. 1C, 2C.

Material. Two specimens collected from the Pleistocene raised reefs at Sharm El-Luli, TI, (Sh.L 7-b 6, 9).

Description. Coralla are massive. Corallites are rounded, plocoid, 2.5–5 mm in diameter. Both intra- and extratentacular budding exist. Up to 30 septa per calice are arranged in three orders; only septa of the first order (6–8 septa) reach the axis forming pali. Coenosteum is vesicular. Columellae are poorly developed. Walls are septothecal. Dissepiments are vesicular.

Geographic distribution. Recorded only from Socotra in the Gulf of Aden and Madagascar (Veron 2002).

Habitat. Shallow reef environments, especially lagoons (Veron 2002).

Leptastrea purpurea (Dana 1846)
(Fig. 5c1–c3)

1846 *Astrea purpurea* Dana: 239, pl. 12, figs. 10 a-c.
1879 *Leptastrea ehrenbergana* Milne-Edwards & Haime.—Klunzinger 3: 46, pl. 6, fig. 3.
1925 *Leptastrea purpurea* (Dana).—Hoffmeister: 20.
1977 *Leptastrea purpurea* (Dana).—Veron et al.: 158–161, figs. 303–310, 467.
1980 *Leptastrea purpurea* (Dana).—Wijsman-Best: 248–249, pl. 3, figs. 1, 2.
1983 *Leptastrea purpurea* (Dana).—Scheer & Pillai: 132, pl. 31, figs. 11, 12.
1988 *Leptastrea purpurea* (Dana).—Pillai & Patel: 69.
1989 *Leptastrea purpurea* (Dana).—Pillai & Jasmine: 190.
1991 *Leptastrea purpurea* (Dana).—Sheppard & Sheppard: 138–139, fig. 159.
1996 *Leptastrea purpurea* (Dana).—Riegl: 34, fig. 16a.
2000c *Leptastrea purpurea* (Dana).—Veron 3: 236, figs. 1–5.
2004 *Leptastrea purpurea* (Dana).—Edward et al.: 56.
2007 *Leptastrea purpurea* (Dana).—Glynn et al.: fig. 8G.

Material. Two well-preserved coralla (S 19-5, 6), collected from the Pleistocene raised reefs (T II) at Wadi Samadai.

Description. Coralla are small and incrusting. Corallites are angular, cerioid to sub-cerioid, discrete, 2–6.5 mm inner calice diameter. Wall thickened (1–2 mm) with intercorallite groove in the middle. There are 30–60 septa per calice depending on its width. Primary septa are the thickest and the longest, they drop vertically to reach the columella and form Paliform lobes.

Remark. This study follows Wijsman-Best (1980) and Scheer and Pillai (1983) in listing *Leptastrea ehrenbergana* Milne-Edwards & Haime that was recorded by Klunzinger (1879b) from the Red Sea as a synonym of *Leptastrea purpurea* (Dana).

Geographic distribution. Widespread from Red Sea to Hawaii (Scheer and Pillai 1983), Arabian Sea and Arabian Gulf (Sheppard and Sheppard 1991), Great Barrier Reef and Ashmore Reef in Australia (Veron 2000c), Samoa and Fiji islands (Hoffmeister 1925).

Habitat. This species is found on reefs subject to strong wave action, to fairly deep sheltered water (Sheppard and Sheppard 1991). Frick and Schuhmacher (1983) recoded it from the northern Red Sea, Sinai coast at depths ranging from 2 to 82 m.

Leptastrea pruinosa Crossland 1952
(Fig. 6a1, a2)

1952 *Leptastrea pruinosa* Crossland.—116, pl. 3, fig. 1.
1977 *Leptastrea pruinosa* Crossland.—Veron et al.: 163, figs. 319–326, 469–472.
1980 *Leptastrea pruinosa* Crossland.—Wijsman-Best: 250, pl. 2, fig. 1.
2000c *Leptastrea pruinosa* Crossland.—Veron 3: 237, figs. 9–11.

Material. Two small parts of moderately well-preserved encrusting coralla (Sh.L 5-1, 2), are collected from the Pleistocene Samadai Formation at Wadi Sharm El-Fuquiri.

Description. Coralla are small and incrusting, with angular, cerioid and discrete corallites. Corallites are 2–6 mm in diameter. Calices are relatively shallow with 35–50 septa arranged mostly in four cycles. The first two cycles are hard to separate, reach the columellae centers and form paliform lobes. Septa of the third and the forth cycles are shorter. Columella composed of several pinnules.

Geographic distribution. This species does not have a wide distribution; it is only recorded in the Indonesian Archipelago, Great Barrier Reef of Australia and New Caledonia (Wijsman-best 1980) and Calamian Islands in Philippines, Ryukyu Islands in Japan, Guam, Vanuatu and Sinai Peninsula in Egypt (Veron 2000c).

Habitat. This species is found in shallow clear water (Veron 2000c).

Echinopora hirsutissima Milne-Edwards & Haime 1849
(Fig. 6b1–b3)

1849 *Echinopora hirsutissima* Milne-Edwards & Haime.—Pl. 4 figs. 3, 4.
1976 *Echinopora hirsutissima* Milne-Edwards & Haime.—Pillai & Scheer: 62–63, pl. 26, fig. 2.
1977 *Echinopora hirsutissima* Milne-Edwards & Haime.—Veron et al.: 192, figs. 383–387.
1980 *Echinopora hirsutissima* Milne-Edwards & Haime.—Wijsman-Best: 255–256, pl. 4, figs. 3, 4.
1996 *Echinopora hirsutissima* Milne-Edwards & Haime.—Riegl: 40–41, fig. 18b.
2000c *Echinopora hirsutissima* Milne-Edwards & Haime.—Veron 3: 260–261, figs. 1–7.

Material. Two incomplete well-preserved specimens, Sh.L 9-1 and Sh.L 9-2, collected from the Pleistocene raised reefs at Sharm El-Luli, T III.

Description. Coralla are sub-massive to laminar with a well-developed epitheca on the lower surface. Corallites are 5–7.5 mm in diameter, plocoid, rounded, conical or cylindrical with thick walls (1.5–2 mm). They are highly exsert over the theca (up to 7.5 mm). Spiny exothecal costae are well developed. There are 23–30 septa in each calice. Walls are septothecal. Exothecal vesicular dissepiments are abundant.

Remark. *Echinopora hirsutissima* Milne-Edwards & Haime is almost similar to *E. gemmacea* (Lamarck), but the latter has smaller corallites and less coarse structures. Exothecal costae in *E. hirsutissima* are more beaded and spiny than any other *Echinopora*.

Geographic distribution. Widely distributed from the Red Sea to New Caledonia (Wijsman-Best 1980), Chagos, Reunion Island and Maldives (Pillai and Scheer 1976), South-west Indian Ocean (Riegl 1996), Pemba Island and Zanzibar in Tanzania, Seychelles, Madagascar and Sinai Peninsula in Egypt (Veron 2000c).

Habitat. Exposed, shallow reef environments (Riegl 1996 and Veron 2000c).

Porites lobata Dana 1846
(Fig. 6c1–c3)

1846 *Porites lobata* Dana.—562, pl. 55, fig. 1.
1925 *Porites lobata* Dana.—Hoffmeister: 73.
1982 *Porites lobata* Dana.—Veron & Pichon:16–18, figs. 9–13.
1991 *Porites lobata* Dana.—Sheppard & Sheppard: 68, pl. 39.
2000c *Porites lobata* Dana.—Veron 3: 284, figs. 1–5.
2007 *Porites lobata* Dana.—Glynn et al.: 82, figs. 7A-G.
2007 *Porites lobata* Dana.—Nothdurft & Webb: 16, 18, figs. 12/A-G.

Material. Five specimens, collected from the Pleistocene raised reefs (T II), at Wadi Sharm El-Luli (Sh.L 8).

Description. Coralla are massive, hemispherical. Corallites are polygonal, 0.8–1.2 mm in average calice diameter. All skeletal elements inside the corallites including columellae, septa, paliform lobes and the denticles are ornamented with spines. Columella is styliform and compressed in the direction of the directive septa.

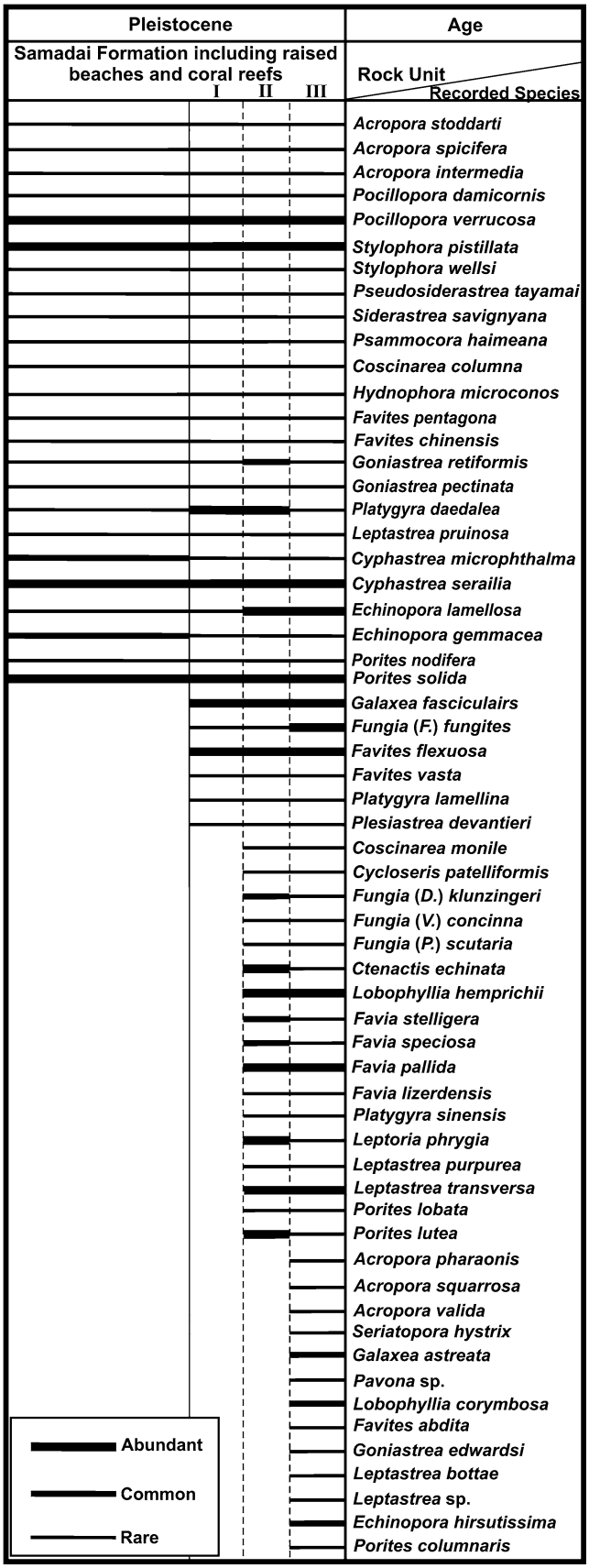


Fig. 7 Stratigraphic distribution of the scleractinian corals recognized in the Marsa Alam area

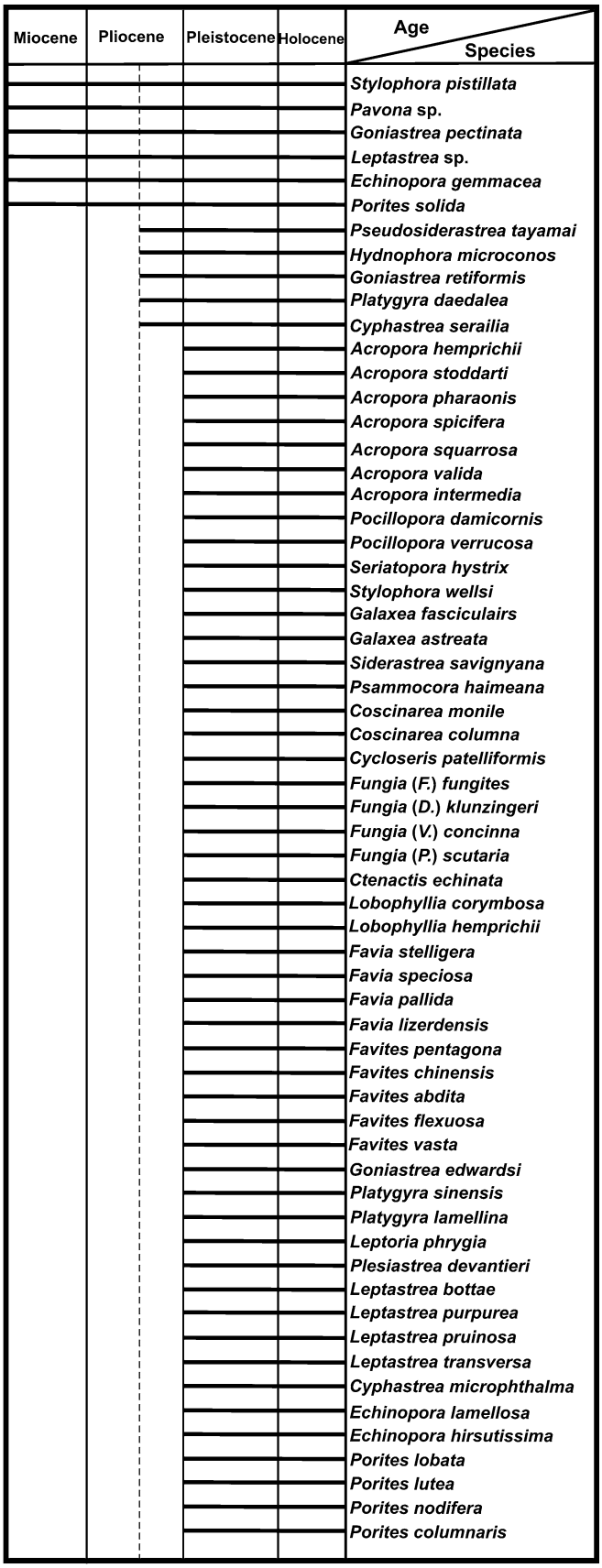


Fig. 8 Known age ranges of the identified corals based on their previous records in/and outside Egypt

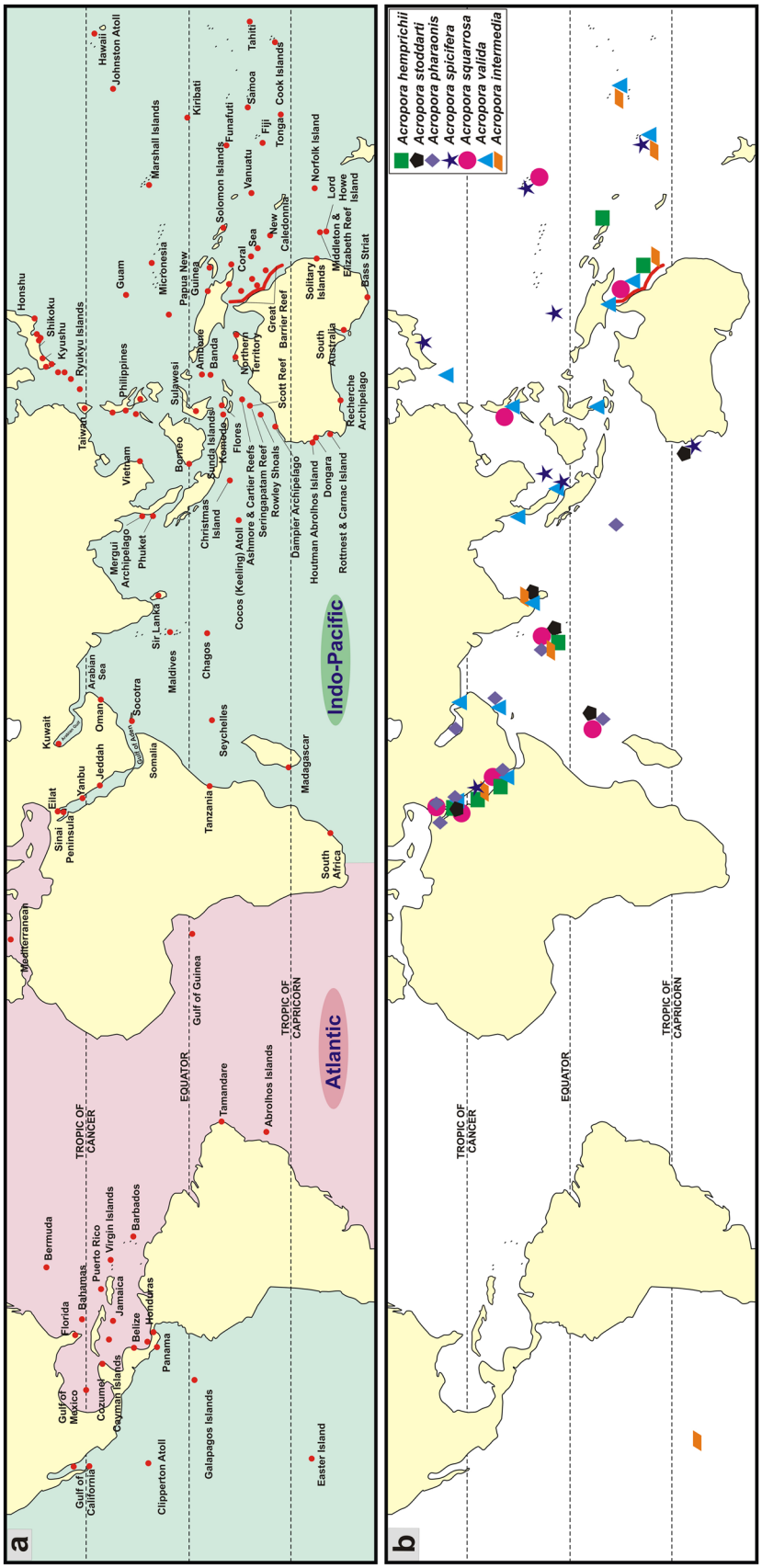
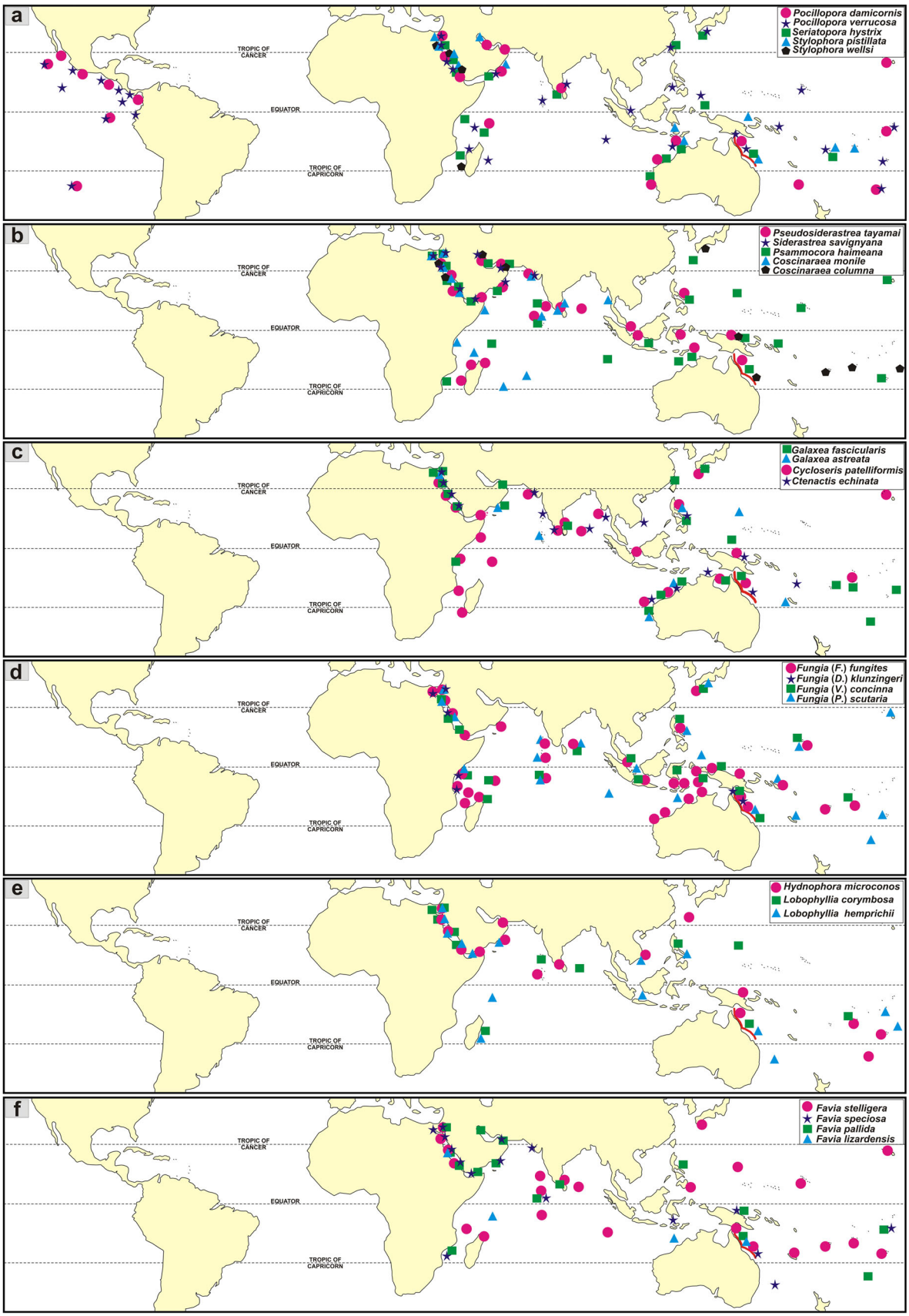


Fig. 9 **a** Index map of the world showing the locations of the main reef sites mentioned in the present study (modified after Veron 2000a). **b** Distribution map for *Acropora hemprichii*, *A. stoddarti*, *A. pharaonis*, *A. spicifera*, *A. squarrosa*, *A. valida and A. intermedia*


a
Pocillopora damicornis
Pocillopora verrucosa
Seriatopora hystrix
Stylophora pistillata
Stylophora wellsi
b
Pseudosiderastrea tayamai
Siderastrea savignyana
Psammocora haimeana
Coscinaraea monile
Coscinaraea columna
c
Galaxea fascicularis
Galaxea astreata
Cycloseris patelliformis
Ctenactis echinata
d
Fungia (F.) fungites
Fungia (D.) klunzingeri
Fungia (V.) concinna
Fungia (P.) scutaria
e
Hydnophora microconos
Lobophyllia corymbosa
Lobophyllia hemprichii
f
Favia stelligera
Favia speciosa
Favia pallida
Favia lizardensis
TROPIC OF CANCER
EQUATOR
TROPIC OF CAPRICORN

◀**Fig. 10** Distribution maps for: **a** *Pocillopora damicornis*, *P. verrucosa*, *Seriatopora hystrix*, *Stylophora pistillata* and *S. wellsi*; **b** *Pseudosiderastrea tayamai*, *Siderastrea savignyana*, *Psammocora haimeana*, *Coscinaraea monile and C. columna;* **c** *Galaxea fascicularis*, *G. astreata*, *Cycloseris patelliformis* and *Ctenactis echinata*; **d** *Fungia* (*F.*) *fungites*, *F.* (*D.*) *klunzingeri*, *F.*(*V.*) *concinna* and *F.* (*P.*) *scutaria*; **e** *Hydnophora microconos*, *Lobophyllia corymbosa* and *L. hemprichii*; **f** *Favia stelligera*, *F. speciosa*, *F. pallida* and *F. lizardensis*

Remarks. *P. lobata* Dana can be differentiated from *P. lutea* Milne-Edwards & Haime, as the former has free triplet septa, while these are fused in *P. lutea* Milne-Edwards & Haime. It is characterized by having distinct paliform lobes, which differentiate it from *P. solida* (Forskål).

Geographic distribution. Red Sea and Gulf of Aden (Sheppard and Sheppard 1991), Easter (Rapa Nui) and Sala-y-Gómez Islands (Glynn et al. 2007), Great Barrier Reef of Australia, Clipperton Atoll, eastern Pacific (Veron 2000c).

Habitat. *P. lobata* Dana dominates in back reef margins, lagoons and some fringing reefs (Veron 2000c).

Stratigraphic distribution and correlation

The total number of species recorded in the present work represents about 7.7 % from the living coral species recorded by Veron (2000a, b, c) from the world, reaching 793 species. On the generic level, the studied corals in the Marsa Alam area represent 25 genera compared to 34 genera previously recorded from the Egyptian Red Sea coastal plain (about 74 %). All scleractinian coral families recorded by previous workers from the Pleistocene succession along the Egyptian Red Sea Coast (12 families) are recorded here from the Marsa Alam area except for the Pectiniidae and Dendrophylliidae (Table 1). These are representing two-thirds (12/18) of the known scleractinian coral families.

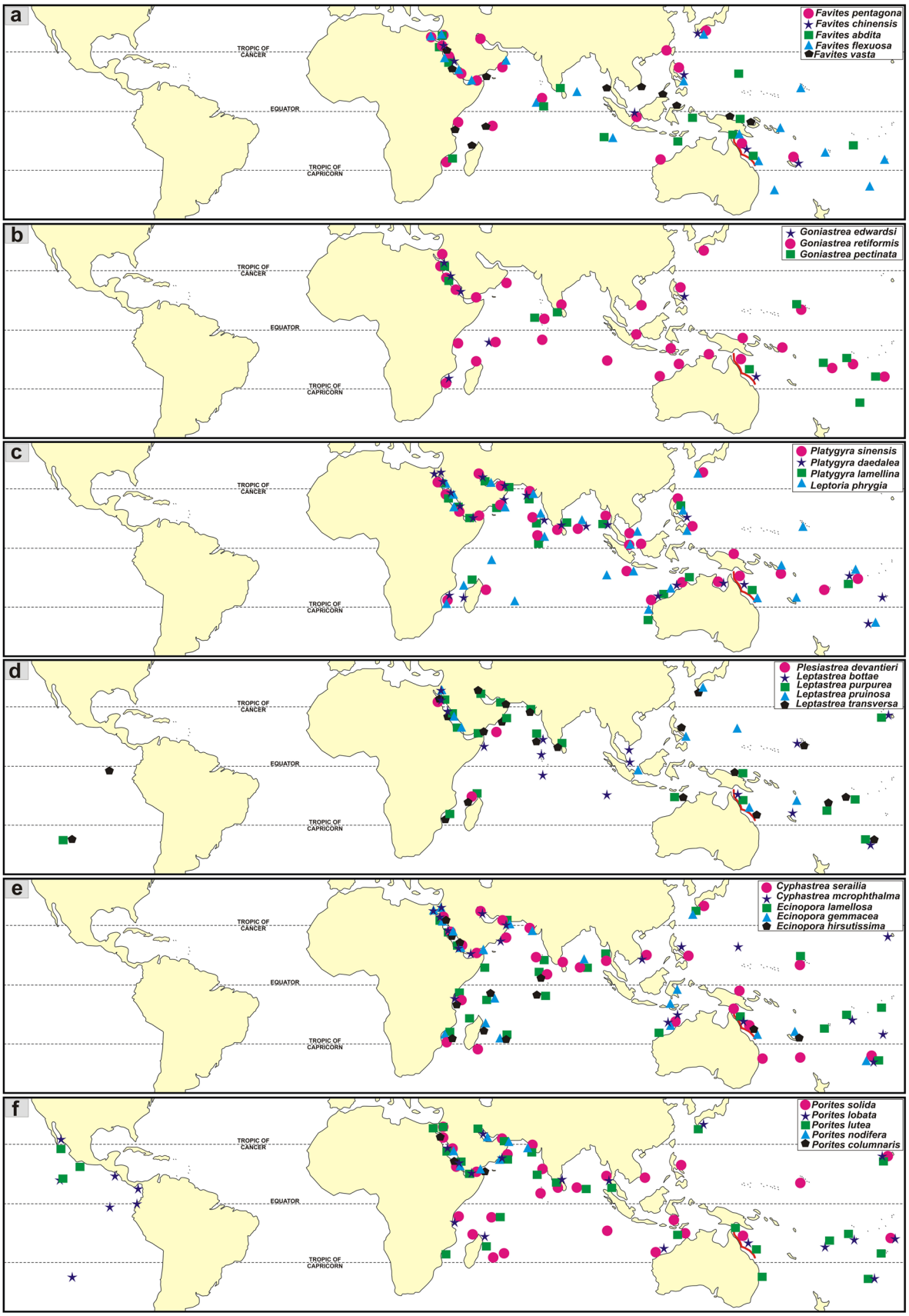
The vertical distribution of these fossils is illustrated in Fig. 7, and the age ranges of the specifically identified corals, based on their previous records in/and outside Egypt, known from the available literature, are given in Fig. 8. Among the recorded coral fossils, the faviid family (27 species) is the highest in diversity (about 44 % from the total number of the recorded species) and also is the most abundant in the collected material, followed by the acroporid, fungiid and poritid families (Table 1). Stratigraphically, 24 species are recorded from the lower part of the Samadai Formation, usually referred to as the older reef, and are also present in the raised beaches and coral reefs (Fig. 7). The rest of the coral fauna is recorded from the overlying coral reef terraces, of which 13 are, restricted to the youngest Pleistocene terrace (III) and still surviving in the fringing reefs.

The stratigraphic range of the majority (50 species) of the identified species which have been previously recorded from the corals still living in the present Red Sea and the Indo-Pacific is extended down to the Pleistocene (Fig. 8). The following six species are extended to the Miocene; *Stylophora pistillata* (Esper), *Goniastrea pectinata* (Ehrenberg), *Echinopora gemmacea* (Lamarck) *Porites solida* (Forskål), *Pavona* sp. and *Leptastrea* sp. There are other five species recorded from the Pliocene and still living in the present Red Sea and the Indo-Pacific; *Pseudosiderastrea tayamai* Yabe & Sugiyama, *Hydnophora microconos* (Lamarck), *Cyphastrea serailia* (Forskål), *Platygyra daedalea* (Ellis & Solander) and *Goniastrea retiformis* (Lamarck).

It is rather difficult to compare the scleractinian coral fauna of different regions due to the differences in sampling intensity and in the taxonomic interpretations of different authors. However, as far as the published data permits, a low diversity (8 species) is found in the Gabal Tanka area (Gameil 1998) and in the Gulf of Suez region (11 species; El-Sorogy 2002). The Gulf of Aqaba and Southern Sinai area yielded more diverse coral fauna, where 29 species were recorded by El-Sorogy (1997). This is followed by the Hurghada–Quseir area where 54 species were described by Ziko et al. (1993a, b), Zalat et al. (2000), and Abd El-Wahab and El-Sorogy (2003). The Marsa Alam area is higher in diversity where about 80 species were recorded (Kora and Abdel-Fattah 2000 and the present work).

Palaeobiogeography

During the Miocene Epoch, the closure of the Tethys Sea and the isolation of the Mediterranean Sea led to the formation of two coral faunas; the Atlantic and far eastern Pacific and that of the Indian Ocean and western Pacific. The subsequent closure of the Isthmus of Panama and the extinction of corals on both sides of the Isthmus during the Plio-Pleistocene glaciation resulted in two coral communities; the Atlantic and Indo-Pacific corals (Fig. 9a) that are almost completely different at species level (Veron 1985). According to Veron (2000a); the history of corals subsequent to the Miocene becomes decreasingly visible in the fossil record and increasingly visible in the taxonomy and distribution in living corals. Throughout the geologic history of the Red Sea, the Early Pliocene was the time of closing the connection with the Mediterranean Sea (Braithwaite 1987). The Plio-Pleistocene fauna and flora of the Red Sea are totally Indo-Pacific in affinity and origin (Kora and Abdel-Fattah 2000). Although the Red Sea was once connected with the Palaeo-Mediterranean, the great evaporation of the


a
Favites pentagona
Favites chinensis
Favites abdita
Favites flexuosa
Favites vasta
b
Goniastrea edwardsi
Goniastrea retiformis
Goniastrea pectinata
c
Platygyra sinensis
Platygyra daedalea
Platygyra lamellina
Leptoria phrygia
d
Plesiastrea devantieri
Leptastrea bottae
Leptastrea purpurea
Leptastrea pruinosa
Leptastrea transversa
e
Cyphastrea serailia
Cyphastrea mcrophthalma
Ecinopora lamellosa
Ecinopora gemmacea
Ecinopora hirsutissima
f
Porites solida
Porites lobata
Porites lutea
Porites nodifera
Porites columnaris
TROPIC OF CANCER
EQUATOR
TROPIC OF CAPRICORN

◀**Fig. 11** Distribution map for: **a** *Favites pentagona*, *F. chinensis*, *F. abdita*, *F. flexuosa* and *F. vasta*; **b** *Goniastrea edwardsi*, *G. retiformis* and *G. pectinata*; **c** *Platygyra sinensis*, *P. daedalea*, *P. lamellina* and *Leptoria Phrygia*; **d** *Plesiastrea devantieri*, *Leptastrea bottae*, *L. purpurea*, *L. pruinosa* and *L. transversa*; **e** *Cyphastrea serailia*, *C. microphthalma*, *Echinopora lamellosa*, *E.gemmacea* and *E. hirsutissima*; **f** *Porites solida*, *P. lobata*, *P. Lutea*, *P. nodifera* and *P.columnaris*

Miocene would have completely eliminated the Mediterranean fauna.

The geographic distributions of the identified coral species are illustrated in Figs. 9, 10, 11. This is based on the distribution maps and data published by different authors, e.g., Scheer and Pillai (1983), Veron (2000a, b, c), Sheppard and Sheppard (1991), Veron (1993), Glynn et al. (2007), etc. These maps show that all the identified coral species are distributed only throughout the Indo-Pacific realm. There are four species that are restricted to the Red Sea, Arabian region and West Indian Ocean. *Stylophora wellsi* Scheer is distributed in the Red Sea and Madagascar (Fig. 10a). *Plesiastrea devantieri* Veron has a very minor distribution; in the Gulf of Aden and Madagascar and is recorded for the first time from the Red Sea (Fig. 11d). *Porites nodifera* Klunzinger is only distributed within the Arabian region (Red Sea, Gulf of Aden, Arabian Sea, Gulf of Oman and Arabian Gulf). *Porites columnaris* Klunzinger is only distributed throughout the Red Sea and the Gulf of Aden (Fig. 11f). For all other species distributions, there is a general progressive decrease in the coral diversity eastwards across the Pacific, while it increases from the central Indo-Pacific westwards across the Indian Ocean to the Res Sea.

During the Pleistocene, extensive sea level fluctuations mostly at −30 to −80 m below present sea level resulted in two reef growth phases, and uplift of older fringing reefs at margins, forming terraces (Sheppard et al. 1992). Raised beaches and coral reef terraces were developed over either the reefal limestone or the conglomerates of the Samadai Formation. These reefs are characterized by fringing reef types in comparison with their living counterparts. They are missing in front of the wadi mouths where they are replaced by terrigenous sediments and gravels of alluvial fans. Throughout the present study, a staircase of three marine raised reef terraces with different altitudes from 12–17 m (TI), 5–12 m (TII) and 2–4 m (TIII) above the present sea level are recognized. The present day altitudes of these terraces are the product of eustatic sea level fluctuations combined with differential tectonic uplift (Dullo 1990, El Moursi et al. 1994).

According to Tucker (2003), the reefal facies were interbedded with terrigenous clastics that were deposited in shoreface–foreshore and fluvial environments, either contemporaneous with reefal sedimentation or during the subsequent lowstands. The reefal carbonates are mainly coral framestones composed mostly of large scleractinian coral colonies up to several meters in diameters, occasionally interbedded with fossiliferous conglomerates, sandstones and beach rocks. The conglomerates are interpreted as a series of prograding clastic beaches developed at a time of sea level stillstand. These microfacies and the faunal associations suggest deposition mainly in the organic reef buildups dissected by short-time pluvial episodes (Kora et al. 2013). Among the scleractinian corals recorded from the Pleistocene raised reefs; the faviid corals are the most dominant family with the highest diversity. They range in depth from 20 m to about 40 m (Sheppard and Sheppard 1991).

Conclusions

The Pleistocene raised beaches and coral reefs of the Marsa Alam area form a discontinuous strip in three morphological terraces with different altitudes ranging between 17 and 2 m above the present sea level. These terraces are included here in the underlying reefal limestones and conglomerates known as the Samadai Formation as there is no remarkable lithological difference between them. Also, it is rather difficult to separate them on maps. The Pleistocene coral-bearing succession was developed over the Miocene/Pliocene deposits after a period of uplift and truncation.

The systematic palaeontology of the encountered scleractinian corals led to the recognition of 61 scleractinian coral species belonging to 25 genera. Thirteen species including *Acropora stoddarti*, *A. spicifera*, *A. squarrosa*, *Stylophora wellsi*, *Pseudosiderastrea tayamai*, *Psammocora haimeana*, *Acanthastrea hemprichii*, *Favites chinensis*, *Plesiastrea devantieri*, *Leptastrea purpurea*, *L. pruinosa*, *Echinopora hirsutissima* and *Porites lobata* are systematically described here for the first time from the Pleistocene succession along the Egyptian Red Sea Coast. All scleractinian coral families recorded by previous workers from the Pliocene–Pleistocene succession along the Egyptian Red Sea Coast (12 families) are recorded here from the Marsa Alam area except for the Pectiniidae and Dendrophylliidae. These are representing two-thirds (12/18) of the known scleractinian coral families. Among the recorded coral fossils, the faviid family (27 species) is the highest in diversity (up to 44 % from the total number of species recorded) and also is the most abundant in the collected material. This is followed by the acroporid, fungiid and poritid families.

The stratigraphic distribution of these fossils is illustrated in a faunal range chart and their age ranges are also discussed and correlated with the published data. The

stratigraphic range of the majority (50 species) of the identified corals which have been previously recorded from the corals still living in the present Red Sea and the Indo-Pacific is extended down to the Pleistocene. Only six species are extended to the Miocene and five species recorded from the Pliocene and still living in the present Red Sea and the Indo-Pacific.

The geographic distribution of the identified corals is illustrated on maps. All the identified coral species are distributed only throughout the Indo-Pacific realm. Four species are restricted to the Red Sea, Arabian region and West Indian Ocean: *Stylophora wellsi* is distributed in the Red Sea and Madagascar; *Plesiastrea devantieri* has a very minor distribution in the Gulf of Aden and Madagascar and is recorded here for the first time from the Red Sea; *Porites nodifera* is only distributed within the Arabian region (Red Sea, Gulf of Aden, Arabian Sea, Gulf of Oman and Arabian Gulf) whereas *Porites columnaris* is distributed throughout the Red Sea and the Gulf of Aden. For all other species distributions, there is a general progressive decrease in the coral diversity eastwards into the Pacific, while it increases from the central Indo-Pacific westwards across the Indian Ocean to the Red Sea.

Acknowledgments Thanks to the editor and to the two anonymous reviewers, whose advices and comments aided in improving the manuscript. We also thank our colleague Haytham El Atfy for his help during the field work.

References

Abd El-Wahab, M., & El-Sorogy, A. S. (2003). Scleractinian corals as pollution indicators, Red Sea coast, Egypt. *Neues Jahrbuch für Geologie und Paläontologie, Monatshefte, 11*, 641–655.

Al-Rifaiy, I. A., & Cherif, O. H. (1989). Paleogeographic significance of Pliocene and Pleistocene mega-invertebrates of the Red Sea and the Gulf of Aqaba. *Journal University Kuwait (Science), 16*(2), 367–399.

Benzoni, F., Roberto, A., Stefani, F., & Pichon, M. (2011). Phylogeny of the coral genus *Plesiastrea* (Cnidaria, Scleractinia). *Contributions to Zoology, 80*(4), 231–249.

Benzoni, F., Stefani, F., Stolarski, J., Pichon, M., Mitta, G., & Galli, P. (2007). Debating phylogenetic relationships of the scleractinian *Psammocora*: molecular and morphological evidences. *Contributions to Zoology, 76*(1), 35–54.

Braithwaite, C. J. R. (1987). Geology and palaeogeograpy of the Red Sea region. In A. J. Edwards & S. M. Head (Eds.), *Key environments, Red Sea* (pp. 22–44). Oxford: Pergamon Press.

Budd, A. F., & Stolarski, J. (2011). Corallite wall and septal microstructure in scleractinian reef corals: comparison of molecular clades within the family Faviidae. *Journal of Morphology, 272*, 66–88.

Chevalier, J. P. (1971). Les scleractiniaires de la Melanesie Francaise (Nouvelle Caledonie, ties Chesterfild, lies Loyaute, Nouvelles Hebrides). *Exped. Franc. Recifs Corall. Nouvdle-Caledonie, 5*, 301.

Conoco-EGPC. (1987). Geological map of Egypt-NG 36 SE Gabal Hamata. Scale 1: 500 000. In E. Klitzsch, F. List & G. Pöhlmann. Cairo: Coral and the Egyptian General Petroleum Corporation.

Daly, M., Brugler, M. R., Cartwright, P., Collins, G. A., Dawson, M. N., Fautin, D. G., et al. (2007). The phylum Cnidaria: A review of phylogenetic patterns and diversity 300 years after Linnaeus. *Zootaxa, 1668*, 127–182.

Dullo, W.-C. (1990). Facies, fossil record and age of Pleistocene reefs from the Red Sea (Saudi Arabia). *Facies, 22*, 1–46.

Edward, J.K.P., Patterson, J., Venkatesh, M., Mathews, G., Chellaram, C. & Wilhelmsson, D. (2004). A field guide to stony corals (Scleractinia) of Tuticorin in Gulf of Mannar, Southeast coast of India. In *Suganthib Devadason Marine Research Institute* (*SDMRI*) (p. 85). Special research publication no. 4.

El Moursi, M., Hoang, C. T., El-Fayoumy, I. F., Hegab, O., & Faure, H. (1994). Pleistocene evolution of the Red Sea coastal plain, Egypt: Evidence from uranium-series dating of emerged reef terraces. *Quaternary Science Reviews, 13*, 345–359.

El-Akkad, S., & Dardir, A. (1966). Geology of the Red Sea coast between Ras Shagra and Marsa Alam with short notes on the exploratory work at Gebel El- Rusas lead-zinc deposits. *Geologic Survey Egypt, 35*, 1–67.

El-Asmar, H. M. (1997). Quaternary isotope stratigraphy and paleoclimate of coral reef terraces, Gulf of Aqaba, South Sinai, Egypt. *Quaternary Science Reviews, 16*, 911–924.

El-Sorogy, A. S. (1997). Pleistocene coral reefs of southern Sinai, Egypt: Fossil record, facies and diagenetic alterations. *Middle East Research Center Ain Shams University, Earth Science Series, 11*, 17–36.

El-Sorogy, A. S. (2002). Palaeontology and depositional environments of the Pleistocene coral reefs of the Gulf of Suez, Egypt. *Neues Jahrbuch für Geologie und Paläontologie, Abhandlungen, 225*(3), 337–371.

El-Sorogy, A. S. (2008). Contributions to the Pleistocene coral reefs of the Red Sea coast, Egypt. *Arab Gulf Journal Scientific Research, 26*(1/2), 63–85.

Fricke, H. W., & Schuhmacher, H. (1983). The depth limits of the Red Sea stony corals: an ecophysiological problem (a deep diving survey by submersible). *Marine Ecology, 4*(2), 163–194.

Gameil, M. (1998). Pleistocene corals from Wadi Tanka, Sinai, Egypt. *Middle East Research Center Ain Shams University, Earth Science Series, 12*, 173–187.

Glynn, P. W., Wellington, G. M., Riegl, B., Olson, D. B., Broneman, E., & Wieters, E. A. (2007). Diversity and biogeography of the scleractinian coral fauna of Easter Island (Rapa Nui). *Pacific Science, 61*(1), 67–90.

Gvirtzman, G., Kronfeld, J., & Buchbinder, B. (1992). Dated coral reefs of southern Sinai (Red Sea) and their implication to late Quaternary sea levels. *Marine Geology, 108*, 29–37.

Hassan, M.Y., Abed, M.M. & El-Bedewy, F.M. (1975). Some scleractinian corals from the Red Sea coast, Egypt. *Proceedings Egyptian Academy Science* (Vol. XXVIII, pp. 43–49).

Hoffmeister, J. E. (1925). Some corals from American Samoa and the Fiji Islands. *Papers from the department of marine biology of the Carnegie Institution of Washington, 22*, 1–90.

Klunzinger, C.B. (1879). Die Korallenthiere des Roten Meeres (**2**, pp.1–88, **3**, pp.1–100). Berlin: Gutmann.

Kora, M., & Abdel-Fattah, Z. (2000). Pliocene and Plio-Pleistocene macrofauna from the Red Sea coastal plain (Egypt): Biostratigraphy and biogeography. *Geologica et Palaeontologica, 34*, 219–235.

Kora, M., Ayyad, S., & El-Desouky, H. (2013). Microfacies and environmental interpretation of the Pliocene-Pleistocene carbonates in the Marsa Alam area, Red Sea coastal plain, Egypt. *Journal of environmental sciences, Mansoura University, 42*(1), 155–182.

Nothdurft, L. D., & Webb, G. E. (2007). Microstructure of common reef-building coral genera *Acropora*, *Pocillopora*, *Goniastrea* and *Porites*: constrains on spatial resolution in geochemical sampling. *Facies, 53*, 1–26.

Philobbos, E. R., El-Haddad, A. A., & Mahran, T. M. (1989). Sedimentology of syn—rift Upper Miocene (?)—Pliocene sediments of the Red Sea area: a model from the environs of Marsa Alam, Egypt. *Egyptian Journal Geology, 33*(1–2), 201–227.

Pichon, M., Chuang, Y. Y., & Chen, C. A. (2012). *Pseudosiderastrea formosa* sp. nov. (Cnidaria: Anthozoa: Scleractinia) a new coral species endemic to Taiwan. *Zoological Studies, 51*(1), 93–98.

Pillai, C. S. G., & Jasmine, S. (1989). The coral fauna of Lakshadweep. *CMFRI, Bulletin, 43*, 179–195.

Pillai, C. S. G., & Patel, M. I. (1988). Scleractinian corals from the Gulf of Kutch. *Journal of Marine Biological Association, India, 30*(1&2), 54–74.

Pillai, C. S. G., & Scheer, G. (1976). Report on the stony corals from the Maldive Archipelago. *Zoologica (Stuttgart), 43*, 83.

Plaziat, J.-C., Reyss, J.-L., Choukri, A. & Cazala, C. (2008). Diagenetic rejuvenation of raised coral reefs and precision of dating. The contribution of the Red Sea reefs to the question of reliability of the Uranium-series datings of Middle to Late Pleistocene key-reef terraces of the world.- Carnets de Geologie/ Notebooks on Geology, Brest, Article 2008/04 (CG2008_A04).

Riegl, B. (1996). Corals of the South-west Indian Ocean, IV. The hard coral family Faviidae GREGOY 1900 (Scleractinia: Faviina). *Investment Report Oceanographic Research Institute, 70*, 1–47.

Scheer, G., & Pillai, C. S. G. (1983). Report on the stony corals from the Red Sea. *Zoologica, 133*, 1–198.

Sheppard, C. R. C., Price, A., & Roberts, C. (1992). *Marine ecology of the Arabian Region: Patterns and processes in extreme tropical environments* (p. 359). London: Academic Press.

Sheppard, C. R. C., & Sheppard, A. L. S. (1991). Corals and coral communities of Arabia. *Fauna of Saudi Arabia, 12*, 170.

Strasser, A., & Strohmenger, Ch. (1997). Early diagenesis in Pleistocene coral reefs, southern Sinai, Egypt: response to tectonics, sea-level and climate. *Sedimentology, 44*, 537–558.

Tucker, M. E. (2003). Mixed clastic-carbonate cycles and sequences: quaternary of Egypt and Carboniferous of England. *Geologica Croatica, 56*(1), 19–37.

Veron, J.E.N. (1985). Aspects of the biogeography of hermatypic corals. *Tahiti: Proceedings of the fifth international coral reef congress* (Vol. 4, pp. 83–88).

Veron, J. E. N. (1986). *Corals of Australia and the Indo-Pacific* (p. 644). Australia: Angus and Robertson.

Veron, J.E.N. (1993). *A biogeographic database of hermatypic corals: species of the central Indo-Pacific, genera of the world* (Vol. 10, p. 433). Australian Institute of Marine Science Monograph Series.

Veron, J.E.N. (2000a). Corals of the world. In M. Stafford-Smith (Ed.) *Townsville* (Vol. 1, p. 463). Australia: Australian Institute of Marine Science.

Veron, J.E.N. (2000b). Corals of the world. In M. Stafford-Smith (Ed.). *Townsville* (Vol. 2, p. 429). Australia: Australian Institute of Marine Science.

Veron, J.E.N. (2000c). Corals of the world. In M. Stafford-Smith (Ed.) *Townsville* (Vol. 3, p. 490). Australia: Australian Institute of Marine Science.

Veron, J.E.N. (2002). *New species described in corals of the world*. Monograph Series 11 (p. 207). Australian Institute of Marine Science.

Veron, J.E.N. & Pichon, M. (1980). *Scleractinia of Eastern Australia, Part III: Families Agariciidae, Siderastreidae, Fungiidae, Oculinidae, Merulinidae, Mussidae, Pectiniidae*. Monograph Series 4 (p. 422). Australian Institute of Marine Science.

Veron, J.E.N. & Pichon, M. (1982). *Scleractinia of Eastern Australia, Part IV: Family Poritidae*. Monograph Series 5 (p. 159). Australian Institute of Marine Science.

Veron, J.E.N., Pichon, M. & Wijsman-Best, M. (1977). *Scleractinia of Eastern Australia, Part II. Families Faviidae, Trachyphylliidae*. Monograph Series 3 (p. 233). Australian Institute of Marine Science.

Veron, J.E.N. & Stafford-Smith, M.G. (2011). Coral ID. www.coralid.com version 1.1. Australian Institute Marine Science.

Wallace, C. C. (1999). *Staghorn Corals of the World: A Revision of the Genus Acropora (Scleractinia, Astrocoeniina, Acroporidae), worldwide, with emphasis on morphology, phylogeny and biogeography*. Melbourne: CSIRO. 422 pp.

Wells, J.W. (1956). Scleractinia. In Moore, R.C. (Ed.), *Treatise on Invertebrate Paleontology, Part F: Coelenterata* (pp. F328–444). Geological Society of America and University of Kansas press.

Wijsman-Best, M. (1980). Indo-Pacific coral species belonging to the subfamily Montastreinae VAUGHAN & WELLS, 1943 (Scleractinia-Coelenterata) part II. The Genera *Cyphastrea, Leptastrea, Echinopora* and *Diploastrea*. *Zoologische Mededelingen, Rijksmuseum van Natuurlijke Historie*, Leiden *55*(21), 235–263.

Zalat, A., Hamza, F., Ziko, A., & El-Sorogy, A. S. (2000). Scleractinian corals (Suborder Faviina) of the Pleistocene coral reefs in the area between Hurghada and Quseir, Red Sea coast. *Egypt. Egyptian Journal of Geology, 44*(1), 237–255.

Ziko, A., Hamza, F. & El-Sorogy, A.S. (1993). Non molluscan macrofauna of the Pliocene—Quaternary sequence in Quseir area, Red Sea coast, Egypt. *Bulletin of the Faculty of Science, Mansoura University*, *Symposium of the Quaternary & Development in Egypt* (pp. 237–274).

Ziko, A., Hamza, F., Zalat, A., & El-Sorogy, A. S. (1993b). Scleractinian corals (Suborder Fungiina) of the Pleistocene raised reefs in the area between Hurghada and Quseir, Red Sea coast, Egypt. *Bulletin of the Faculty of Science, Ain Shams University, 31*, 325–341.