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SOFT CORALS (OCTOCORALLIA, ALCYONACEA) OF THE SOUTHERN RED SEA[1]

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ABSTRACT

The species composition of soft corals of the families Tubiporidae, Alcyoniidae, Nephtheidae, and Xeniidae is presented for the Dahlak Archipelago (15–16ºS) in the southern Red Sea in Eritrean waters. A comprehensive collection was made during several field trips (1993–2002) to various sites in this archipelago. Some unexamined specimens obtained during the Israeli South Red Sea expeditions (1962 and 1965) to the region were also included in the study. A systematic list of soft corals is presented, comprising 28 species based on the material and previous literature. The list includes five genera (*Rhytisma, Sinularia, Paralemnalia, Scleronephthya,* and *Heteroxenia*) and sixteen species recorded for the first time in the southern Red Sea. Seven of these species belong to the genus *Sinularia* and three to *Ovabunda*. All the species found belong to the Indo-Pacific faunistic province and have been previously recorded elsewhere in the Red Sea. A distinct north to south latitudinal diversity attenuation of soft corals at both the species and generic levels is evident in the Red Sea. This pattern can be at least partially attributed to differences in environmental conditions between the two extremities of the Red Sea, such as surface temperature, salinity, nutrient concentrations, and turbidity. The biogeographic setting of the southern Red Sea reefs, the gateway to the Indian Ocean, makes them a stimulating target for future research on soft corals. Such studies will contribute to our knowledge on the status of the reefs in this region and will include a temporal scale to provide feedback on reef health for conservation purposes.

INTRODUCTION

Forskål (1775), a pioneer in Red Sea reef surveys, initiated the long history of investigation into the Red Sea soft corals (Octocorallia, Alyconacea). Savigny (1817), Ehrenberg

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(1834), Klunzinger (1877), Kükenthal (1902, 1904, 1913), Thomson and McQueen (1907), Gohar (1940), and others established numerous new taxa of soft corals based on scientific expeditions and investigations in the region. These early investigations into the soft corals formed the cornerstone for later biodiversity and taxonomic studies on this group, not only in the Red Sea, but also throughout the Indian and Pacific Oceans. Later collections made on the Red Sea reefs led to numerous comprehensive studies on the taxonomy of their soft corals (Verseveldt, 1965, 1969, 1970, 1974, 1982; Verseveldt and Cohen, 1971; Verseveldt and Benayahu, 1978, 1983; Benayahu, 1982, 1990; Reinicke, 1997). These publications stimulated an awareness of the high diversity of soft corals in the Red Sea, where they constitute the second most important benthic component on the reefs (e.g., Fishelson, 1970; Benayahu and Loya, 1977, 1981; Shepppard et al., 1992 and references therein). At present, there is no single species inventory of these soft corals.

Although some old records for the Red Sea, mainly for the family Nephtheidae, are doubtful and in need of revision, a high diversity in the soft corals is evident (ca. 200 species; see Benayahu, 1985, 1990; Reinicke, 1997; van Ofwegen, 2000). Most of the aforementioned findings resulted from studies conducted in the northern Red Sea (Gulf of Aqaba, Gulf of Suez, and the southern tip of Sinai). A few studies dealt with the soft corals in the central Red Sea (e.g., Thomson and McQueen, 1907; Verseveldt and Benayahu, 1983; Mergner and Shuhmacher, 1985; Reinicke, 1997). The only study on the soft corals in the southern Red Sea was by Verseveldt (1965), who examined specimens from Eritrea and from the Kamaran Islands, Yemen. He listed 12 species for the region, including two new species, *Stereonephthya cundabiluensis* and *Umbellulifera oreni*. His publication resulted in part from collections made in 1962 by the Israel South Red Sea expedition on the major reef systems in the Dahlak Archipelago, Eritrea, in the southern Red Sea (see also Oren, 1963; Lewinsohn and Fishelson, 1965).

The present study deals with the soft corals of the southern Red Sea, collected on various occasions and deposited at the Zoological Museum, Tel Aviv University (ZMTAU). A comprehensive collection was gathered during several field trips to the Dahlak Archipelago, Eritrea, in 1993, 1998, 2001, and 2002. We have also included some specimens obtained during the 1962 South Red Sea expedition that were not examined by Verseveldt (1965), as well as specimens collected during the 1965 Israeli expedition to the Dahlak Archipelago. We have thus been able to compile a systematic list of the soft corals of the southern Red Sea based on the above-mentioned sources, Verseveldt's (1965) earlier findings, and an additional two *Dendronephthya* species identified by him (unpublished data) and stored in the ZMTAU. These data have enabled us to evaluate their diversity on the reefs and also to examine latitudinal patterns of soft coral diversity in the Red Sea.

MATERIALS AND METHODS

Collecting trips were conducted to the Dahlak Archipelago (Fig. 1) during a joint Israeli and Eritrean expedition (collector YB) in October 1993 and joint South African,

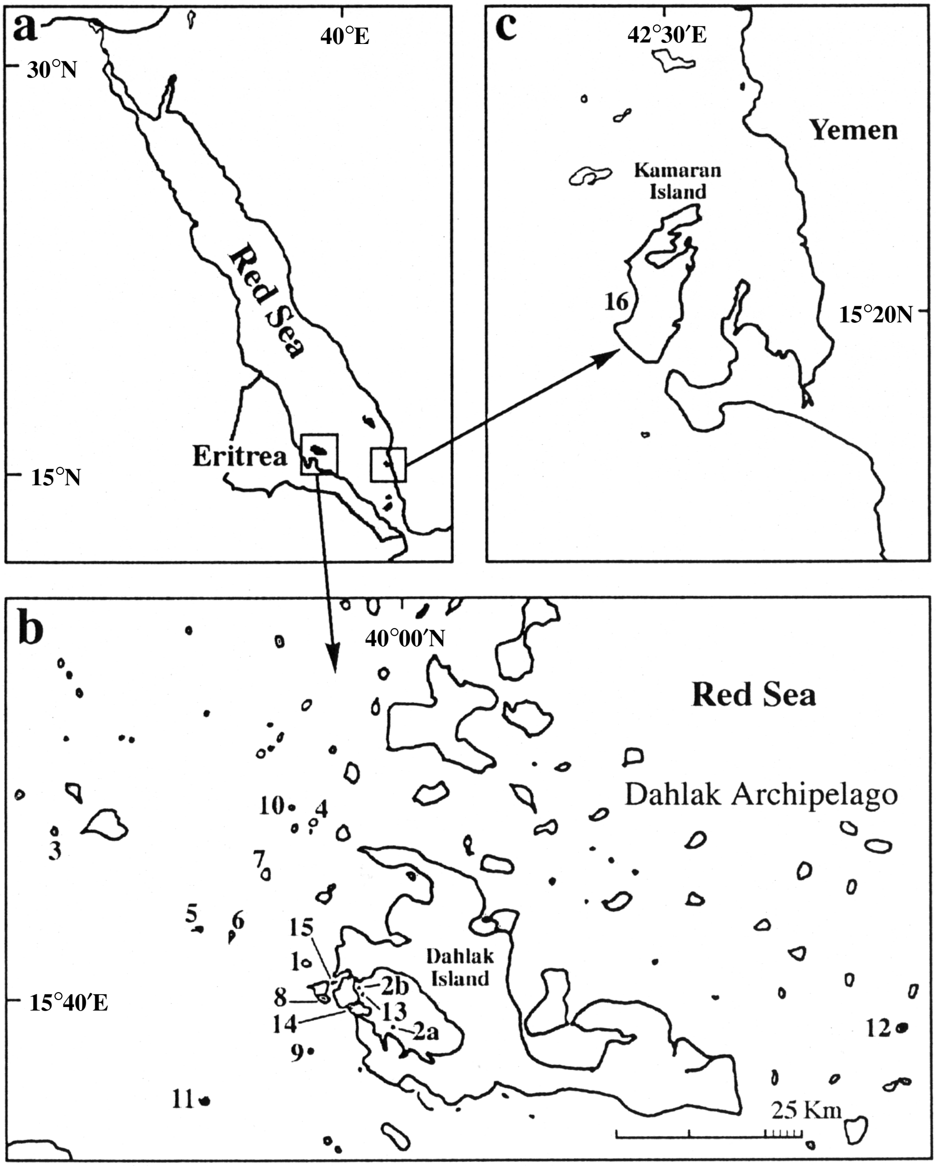

Fig. 1. (a) Map of the study area with the collecting sites indicated by numbers. (b) Dahlak Archipelago (Eritrea): 1. Cundabilu, 2a. British and Italian Shipwrecks, 2b. Dejen Shipwreck, 3. Dahret, 4. Duliacus, 5. Dur Gaam, 6. Dur Ghella, 7. Dhu-rijrij, 8. Entedebir, 9. Enteara, 10. Eucus, 11. Madote, 12. Maharib, 13. Nokra (= Nakuru Gate and Nocra Is.), 14. Sunken Crane, 15. Um Aabak. (c) Kamaran Island (Yemen): 16. Jebel-at Tair. Scale bar in 1b also applies to 1c.

Eritrean, and Israeli collecting trips (collector MHS) in April–May 1997, February 1998, November 2000, and May 2002.

The soft corals were obtained from the 16 sites listed below:

1. Cundabilu: 15º43.49′N; 39º53.136′E
2. Dahlak Island
   British and Italian Shipwrecks: 15º40.5′N; 39º59.5′E
   Dejen Shipwreck: 15º430.144′N; 39º57.100′E
3. Dahret: 15º54.662′N; 39º34.469′E
4. Duliacus: 15º54.535′N; 39º55.757′E
5. Dur Gaam: 15º46.782′N; 39º44.670′E
6. Dur Ghella: 15º47′N; 39º48′E
7. Dhu-rijrij: 15º50.620′N; 39º50.800′E
8. Entedebir: 15º43.020′N; 39º53.465′E
9. Enteara: 15º38.504′N; 39º53.580′E
10. Eucus: 15º53.884′N; 39º53.141′E
11. Madote: 15º35.500′N; 39º46′E
12. Maharib: 15º40′N; 40º37′E
13. Nokra: 15º42.175′N; 39º57.174′E (= Nakuru Gate and Nocra Is.)
14. Sunken Crane: 15º42.903′N; 39º57.085′E
15. Um Aabak: 15º43′N; 39º55′E
16. Jebel-at Tair, Kamaran Islands (Yemen): 15°20′N; 42°40′E

The collection sites were visited by boat, and a variety of habitats were surveyed by scuba diving or snorkeling on the reefs, in lagoons, and on deep reefs to 22 m depth. Approximately 120 soft coral samples were collected, comprising the full variety of species found on the reefs. Samples were fixed in 4% formalin in seawater, rinsed in fresh water after 24 hours, and then transferred to 70% ethyl alcohol. Sclerites were obtained by dissolving the tissues in 10% sodium hypochlorite. Identification of species in the family Alcyoniidae was in great part facilitated by comparison of the sclerites with permanent preparations of sclerites from type material kept in the ZMTAU where all the samples are housed. Some members of the family Nephtheidae were also collected and are still being examined.

RESULTS

The combined material, including the unexamined samples of Verseveldt (1965, unpublished data) mentioned earlier, yielded 28 species (Table 1). The list includes five genera recorded for the first time in the southern Red Sea (i.e., *Rhytisma, Sinularia, Paralemnalia, Scleronephthya,* and *Heteroxenia*). Although none of the species in the list constitutes a new geographic record for the Red Sea, 16 species were recorded for the first time in the southern part. Most of the species collected during the Israeli 1962 South Red Sea expedition were also found in the later collections (Table 1). Surprisingly, no *Sinularia* specimens were collected during the earlier expedition, yet we identified seven species from the Dahlak reefs in the recent work, of which *Sinularia gravis* Tixier-Durivault, 1970 was dominant. Colonies of this species appear on the reefs as mono-specific aggregations a few square meters in extent. Members of the family Alcyoniidae, including species of *Lobophytum, Rhytisma, Sarcophyton,* and *Sinularia,* were mostly collected in shallow reef habitats (1–3 m). We found three new zoogeographical records for the genus *Ovabunda* (Table 1). Both *Ovabunda* and *Xenia* species commonly grow at the study sites in dense patches down to 12 m. Interestingly, the species assigned to genera recorded for the first time in our study in the southern Red Sea (i.e., *Rhytisma, Paralemnalia, Scleronephthya,* and *Heteroxenia*) were, with the exception of *Sinularia,* extremely rare, and each was encountered only once, despite a careful search of the different reef habitats at a variety of sites.

We did not identify specimens of the genera *Dendronephthya* and *Nephthea* (Nephtheidea) to species level in the current survey since they need a thorough revision. *Dendronephthya* colonies were occasionally encountered on the reefs at depths of 1–8 m, and even deeper (including on the shipwrecks). *Nephthea* colonies were collected at various sites, commonly growing together with *Xenia* species.

DISCUSSION

The present study increases to 28 the number of soft coral species recorded in the southern Red Sea (Table 1). All these species belong to the Indo-Pacific faunistic province and have been previously recorded elsewhere in the Red Sea. In fact, several widely distributed species such as *Lobophytum pauciflorum* von Marenzeller, 1816, *Sarcophyton glaucum* (Quoy and Gaimard, 1833), and *Sinularia polydactyla* (Ehrenberg, 1834) are found in the Dahlak Archipelago (see Benayahu, 2002). Of the species listed in Table 1, only *Umbellulifera oreni* Verseveldt, 1965 has a distribution confined to the southern Red Sea. This species was dredged from 60 m (Verseveldt, 1965), an insufficiently explored depth in the Red Sea. Despite the difference in geographic setting, the southern Red Sea soft corals (15ºN) are, in principle, thus indistinguishable from those of the northern Red Sea (29ºN). However, there is a distinct latitudinal diversity attenuation of soft corals at both the species and generic levels within the Red Sea.

Although some old records for the Red Sea, mainly of the family Nephtheidae, are doubtful and in need of revision, the high diversity in the Red Sea soft corals is based in greater part (families Alcyoniidae and Xeniidae) on more recent identifications and revisions (ca. 200 species; see, e.g., Benayahu, 1985, 1990; Reinicke 1997; van Ofwegen, 2000). Among the 23 genera, including *Tubipora,* found in the entire Red Sea (Verseveldt, 1965; Benayahu, 1985), only twelve are found in its southern part where the much lower species richness of only 28 species was found (Table 1). Some genera such as *Klyxum (*which comprises some species previously assigned to *Alcyonium*; see Alderslade, 2000), *Cladiella*, *Anthelia,* and *Sympodium*, which are often encountered in the northern Red Sea (Benayahu, 1985), have not been recorded to date in the south. Their absence in Dahlak is the more conspicuous, as the Red Sea is the type locality of certain species of these genera that have a wide distribution in the Red Sea and

Table 1
List of Octocorallia of the order Alcyonacea Lamouroux, 1816 (amended by Bayer, 1981) from the southern Red Sea, with museum inventory numbers (ZMTAU)

Classification	New record in southern Red Sea
Tubiporidae Ehrenberg, 1828	
Genus *Tubipora* Linnaeus, 1758	
Tubipora musica Linnaeus, 1758	
ZMTAU Co 28534, 28586, 28551, 28573, 30029, 910030*, 901926, 902277	
Alcyoniidae Lamouroux, 1812	
Genus *Lobophytum* von Marenzeller, 1886	
Lobophytum pauciflorum (Ehrenberg, 1834)	
ZMTAU Co 28565, 28572, 28589, 28603, 28605, 28608, 28875, 30030, 30031, 30034, 30045, 30129, 901920*, 910140*	
Genus *Rhytisma* Alderslade, 2000	
Rhytisma fulvum fulvum (Forskål, 1775)	NR
ZMTAU Co 30046	
Genus *Sarcophyton* Lesson, 1834	
Sarcophyton ehrenbergi von Marenzeller, 1886	
ZMTAU Co 28533, 28535, 28537, 28563, 28872, 28578, 28604, 28607, 30028, 30035, 30041, 30044, 910031*	
Sarcophyton glaucum (Quoy and Gaimard, 1833)	
ZMTAU Co 28536, 28540, 28577, 28590, 28602, 30027, 30032, 30033, 30036, 30037, 30039, 30040, 30042, 30043, 30047, 30126, 30130, 901939*, 910155*	
Genus *Sinularia* May, 1898	
Sinularia compressa Tixier-Durivault, 1945	NR
ZMTAU Co 28601, 30068, 30069, 31612, 31618	
Sinularia erecta Tixier-Durivault, 1945	NR
ZMTAU Co 28569, 28873, 28576, 28579, 30038	
Sinularia gardineri (Pratt, 1903)	NR
ZMTAU Co 28580, 31234.	
Sinularia gravis Tixier-Durivault, 1970	NR
ZMTAU Co 28542, 28570, 28582, 28583, 28588, 28595, 28600, 28606, 28874, 28876, 30024, 31613, 31614, 31615, 31616, 31617, 31619, 31620	
Sinularia leptoclados (Ehrenberg, 1834)	NR
ZMTAU Co 28581, 28584, 30127, 30131	
Sinularia macrodactyla Kolonko, 1926	NR
ZMTAU Co, 28593, 30025, 30026	
Sinularia polydactyla (Ehrenberg, 1834)	NR
ZMTAU Co 28571, 31609, 31610, 991742	
Nephtheidae Gray, 1862	
Genus *Dendronephthya* Kükenthal, 1905	
Dendronephthya formosa Gravier, 1908	NR
ZMTAU Co 991816**	

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Table 1 *continued*

Classification	New record in southern Red Sea
Dendronephthya hemprichi (Klunzinger, 1877)	
ZMTAU Co 25003*, 903064*, 903080*, 910028*, 910165*, 910166*, 910087*, 910095*	
Dendronephthya klunzingeri (Studer, 1888)	
ZMTAU Co 901900*	
Dendronephthya pharonis (Thomson and Macqueen, 1911)	NR
ZMTAU Co 991405**, 991409**, 991411**	
Genus *Paralemnalia* Kükenthal, 1913	
Paralemnalia thyrsoides (Ehrenberg, 1834)	NR
ZMTAU Co 31621	
Genus *Scleronephthya* Studer, 1887	
Scleronephthya corymbosa Verseveldt and Cohen, 1971	NR
ZMTAU Co 30066	
Genus *Stereonephthya* Kükenthal, 1905	
Stereonephthya cundabiluensis Verseveldt, 1965	
ZMTAU Co 903881*	
Genus *Umbellulifera* Thomson & Dean, 1931	
Umbellulifera oreni Verseveldt, 1965	
ZMTAU Co 25005*	
Nidallidae Gray, 1869	
Genus *Siphonogorgia* Kölliker, 1874	
Siphonogorgia mirabilis Klunzinger, 1877	
ZMTAU Co 25007*, 25010*	
Xeniidae Ehrenberg, 1828	
Genus *Heteroxenia* Kölliker, 1874	
Heteroxenia fuscescens (Ehrenberg, 1834)	NR
ZMTAU Co 30060	
Genus *Ovabunda* Alderslade, 2001	
Ovabunda farauensis (Verseveldt and Cohen, 1971)	NR
ZMTAU Co 28587, 30050, 30052, 30056, 30058, 30061, 31611	
Ovabunda obscuronata (Verseveldt and Cohen, 1971)	NR
ZMTAU Co 28559, 28574, 28575, 28592, 30053	
Ovabunda verseveldti (Benayahu, 1990)	NR
ZMTAU Co 28560, 30054	
Genus *Xenia* Lamarck, 1816	
Xenia blumi Schenk, 1896	
ZMTAU Co 901908*, 901909*, 901014*	
Xenia hicksoni Ashworth, 1899	
ZMTAU Co 25008*, 25009*, 28539, 28556, 28561, 28596, 30055, 30057, 30059	
Xenia umbellata Lamarck, 1816	
ZMTAU Co 28554, 30048, 30049, 910045*, 910047*, 991817	

NR = New record in southern Red Sea. *Specimens identified in Verseveldt, 1965. **Unpublished data.

elsewhere [e.g., *Cladiella pachyclados* (Klunzinger, 1877) (see Benayahu, 2002), *Anthelia glauca* (Lamarck, 1816), and *Sympodium caeruleum* (Ehrenberg, 1834) (see Reinicke, 1997)].

Latitudinal species attenuation is evident in all three major soft coral families (Benayahu, 1985; this study, Table 1). For example, among the Alcyoniidae, in contrast to the 46 *Sinularia* species found in the northern Red Sea (van Ofwegen, 2000; Benayahu, work in progress), only seven were found in the south. Furthermore, they often form patches and cover large areas in mono-specific carpets on the Sinai reefs (Benayahu and Loya, 1977), a feature rare in the Dahlak Archipelago. Unlike the numerous *Dendronephthya* species that form dense assemblages in the northern part of the Red Sea (Benayahu, 1985), this genus is rare and less diverse in the south. Reinicke (1997) revised the Xeniidae of the Red Sea, listing 25 *Xenia* species for the region. Recently, Alderslade (2001) established the new genus *Ovabunda,* which includes several species previously assigned to *Xenia.* Only six species of the two genera were recorded in the Dahlak Archipelago (this study).

The Red Sea is biogeographically divisible into northern, central, and southern regions, of which the central region has the greatest concentration of reefs and the highest diversity of stony corals (Sheppard et al., 1992; Veron, 1995). The zoogeography and diversity of reef biota in the Arabian region has also been evaluated, including its species endemism and intra-regional diversity (Sheppard et al., 1992 and references therein). In these studies it is claimed that it is possible to define stony coral communities in the entire Red Sea according to latitude. Nonetheless, the Dahlak Archipelago was not included in this analysis due to a lack of adequate data. Up to now, the north–south data on the Red Sea soft corals was limited and prevented such analyses. Our findings are thus the first indication of distinct differences in species diversity of soft corals between the northern and southern regions of the Red Sea.

The current findings of a latitudinal attenuation in soft coral diversity can be attributed, at least in part, to differences in environmental conditions between the two extremities of the Red Sea, which extends across18º in latitude. These include surface temperature, salinity, nutrient concentration, and turbidity (Sheppard et al., 1992). For example, seawater temperature varies between 21–27 ºC at Elat in the northern Red Sea (Lindell and Post, 1995), while at Dahlak it varies between 26–32 ºC (Klein et al., 1997). Since a global elevation in temperature constitutes a critical parameter in reef health, mainly as a devastating cause of coral bleaching (e.g., Brown et al., 2000), it is vital to monitor its effect on the southern Red Sea reefs. Even a small temperature increase is expected to have a dramatic effect in this region. Turbidity is another parameter that increases further south, in this case abruptly below ~20ºN. This marks the northernmost point reached by nutrient-rich water flowing from the Gulf of Aden. We suggest that the latitude-related distribution in soft corals demonstrated in our study is caused by such ecological, latitude-related factors, the effects of which are speculative at this stage.

At present it is premature to evaluate the degree of soft coral endemism in the Red Sea. Many species that were originally described from the Red Sea, in particular its northern region, were also later recorded in the Indian and Pacific Oceans (Benayahu, 1985; work in progress). Furthermore, a patchy distribution observed in many taxa (Benayahu and Loya, 1977, 1981) demands extensive reef surveys to evaluate their abundance and establish whether they occur throughout the region. While we do not exclude the possibility of endemism among the Red Sea soft corals, further research is required before any conclusions can be drawn concerning the precise faunal characteristics of the Red Sea.

The Eritrean coral reefs are found mainly around the 350 islands that constitute the Dahlak Archipelago. These reefs comprise a globally significant reservoir of marine biodiversity and consisted of relatively pristine reefs (Pilcher and Alsuhaibany, 2000) until depredation by crown-of-thorns starfish (Schleyer, 1998) and coral bleaching following the 1998 El Niño Southern Oscillation event (Schleyer, pers. obs.). The southern Red Sea reefs also include those of the Farasan Islands off Saudi Arabia, Yemen, and Djibouti, but, to the best of our knowledge, no information is available on their soft coral fauna. Further surveys of the reefs in this region will permit a better evaluation of the spatial patterns in soft coral diversity on the southern Red Sea reefs, as well as an assessment of the parameters that regulate them. The biogeographic setting of the reefs at the entrance to the Red Sea makes them a stimulating target for future research on soft corals. Such studies will contribute to our knowledge on the status of the reefs in the region and should include a temporal scale to provide feedback on reef health for conservation purposes.

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