Indian Journal of Geo Marine Sciences
Vol. 49 (12), December 2020, pp. 1793-1800

Review Article

A review on bioactive secondary metabolites of soft corals (*Octocorallia*) and their distribution in Eritrean coast of Red Sea

M Kasimala*[a,b], B Hari Babu[b], B A Awet[c], G G Henok[c], A H Haile[d] & O M Hisham[e]

[a]Department of Food Science and Technology, Hamelmalo Agricultural College, Keren, Anseba Region – 397, Eritrea

[b]Department of Chemistry, Acharya Nagarjuna University, Nagarjuna Nagar, Guntur, Andhra Pradesh – 522 510, India

[c]Quality Control Laboratory, Ministry of Marine Resources, Massawa – 27, Eritrea

[d]Research Division, Ministry of Marine Resources – 27, Eritrea

[e]Department of Marine Biology and Fisheries, Massawa College of Marine Science and Technology, Massawa – 170, Eritrea

*[Email: madhu.lucky09@gmail.com]

Received 17 December 2019; revised 06 August 2020

Eritrean coast of Red Sea is an epicenter of diversified marine ecosystem with high endemic biota. Environmental and ecological conditions around wide number of Islands in Eritrean coast of Red Sea are conducive for shelter and nourishment of many marine flora and fauna. Bioactive secondary metabolites have an extensive role in treatment of many diseases both in its natural forms and extensive key components in synthetic biomedicine. Soft corals belong to phylum Cnidaria are soft fleshy marine organisms which are abundantly found in Southern Red Sea. Among the 180 species of soft corals found worldwide, approximately 40 % are indigenous to Red Sea. These soft corals are rich in novel bioactive compounds with potential cytotoxic, anti-inflammatory, HIV inhibitory, antibacterial, antitumor and antifungal activity. The most abundant interesting biomedical compounds found in soft corals are steroids, alkaloids, terpenoids, prostaglandins, sterols and steroid glycosides. In the present review different bioactive compounds with novel biomedical applications and abundance of soft corals around Eritrean coast of Red Sea is discussed.

[**Keywords**: Bioactive compounds, Distribution, Eritrea, Soft Coral, Southern Red Sea]

Introduction

Soft corals are marine organisms belonging to the phylum Coelenterates (Cnidaria) class Anthozoa and sub-class Octocorallia[1]. The sub-class Octocorallia comprise of more than 2000 species, with worldwide distribution in different marine habitats[2]. They are also known as Octocorals due to the presence of 8 fold symmetry and are the colonies of small animals named polypoid Cnidarians. Their polyps rarely exceed 5 mm in diameter and are arranged in soft fleshy irregularly shaped colonies up to 1 m in size[3]. Soft corals are generally flexible and do not produce the rigid structural characteristics of hard corals, due to lack of calcium carbonate[4]. Octocorals are copious and widely distributed after hard corals in variety of ecological conditions[5]. They are found in all depths[6] but mostly found on rocky or rubble low tidal areas of 200 m depths by exposing their soft tissues[7]. Depending on the depth that they are growing Octocorals can be of different colors[8].

Most of the Octocorals have separate male and female reproductive structures, though some genera are dominated by hermaphrodites such as species of *Hetroxenia* and *Xenia*[9]. Generally three types of reproduction are occurring in Octocorals *viz.* broadcasting of egg and sperm, internal brooding of larvae and external brooding of larvae. Asexual propagation is common and is the predominant mode of reproduction in soft corals. It is achieved by runner formation, colony fragmentation, fission or budding[10]. The environmental factors, such as temperature, primary and secondary productivity, lunar cycle and depth can affect patterns and behaviors related to gamete and larval release in both shallow-water and deep-sea soft corals[11].

The majority of Octocorals are suspension feeders that filter small food particles from the water including nutrients, plankton, crustaceans and mollusks[12]. Some of the soft corals lives on the reef are seems to posses symbiotic relationship with zooxanthele, dinoflagellates[13] and microorganisms[14]. While the zooxanthele acts as a source of nutrients for soft corals and in return the polyp of soft corals acts as a protection and supplies nutrients like N and

CO_2[15]. Some soft corals in the ocean feed by trapping their prey using stinging cells present in their tentacles called nematocysts. Indeed these tentacles helps the soft corals to trap, immobilize and transfer their pray to their body for digestion[16]. Microorganisms found in soft corals may help the host by protecting them against pathogens[17]. More than half of the soft corals in the great barrier reef are known to contain toxic compounds; which are aimed to be anti-predation and as an adaptation for space competition[18]. The ecological studies from the 1980's predicted that, shifts to the soft corals dominance could be expected due to competition with hard corals for space. Sometimes soft corals may be over tapped by hard corals but due to being hated by many predators they can colonize any space easily within a short time[19].

Some of the physical environmental factors that affect the growth, distribution and diversity of soft corals are tidal range, degree of wave exposure, depth, light, nutrients, sedimentation, salinity, temperature variation, and natural and human induced disturbance[20]. The key factors for the decline in abundance and species richness of soft corals are sedimentation and temperature[21]. Generally soft corals prefer a temperature range of 24.2 – 35.5 ^oC[3] and pH of 8.35 – 8.45[(ref. 22)]. Several biosynthetic studies have been carried out on the metabolites of soft corals and some of those compounds have been proved to possess great potential for the development of new pharmaceuticals compounds[23].

Bioactive compounds from soft corals

The marine environment is a big reservoir of bioactive natural compounds, which produce several novel structures with unique biological properties which may not be found in terrestrial natural products[24]. Marine organisms account for more than half of the world's total biodiversity and marine natural products represent a potentially diverse, rich and largely unexploited source of novel chemical structures and biological activities[25]. Soft corals are common marine organisms; which dwell in tropical and subtropical oceans[26] and are potential sources of marine biomedical compounds with promising medical properties[27].

Despite the lack of efficient physical defense system in the hostile and competitive environment, soft corals relay on the chemical protection mechanism by accumulating secondary metabolites in their bodies or releasing them to the surroundings for survival[22]. These secondary metabolites from soft corals show not only great significance in chemical ecology, but also display interesting various biological activities, such as larvicidal, insecticidal, anti-neoplastic[1], insect growth regulator[24], anti-predatory[28], antimicrobial[29], allopathic[30], anti-fouling[31], antioxidant, antiviral (HIV inhibitor), antifungal[32], antitumor, cytotoxic and anti-inflammatory[33] activities. Among all the biomedical compounds extracted from Cnidarians 94 % were identified from soft corals[34].

The bioactive compounds from soft corals have interesting medical properties. The sterols and lipids are the major (90-95 %) bioactive compounds present in organo-solvent extract of different genera of soft corals, while 10 % are biologically active alkaloids, diterpenes and sesqiterpenes[26], prostaglandins, cembrene derivatives[33], terpenoid compounds, steroid and steroid glycoside[35]. The macrocyclic derivatives of cembrane compounds are the major diterpenoidal metabolites in soft corals[36]. Diterpenes make up to 65 % of bioactive natural products published from soft corals and gorgonians[37].

Soft corals of the genus *Xenia* (family Xeniidae) have proved to be rich sources of terpenoids especially several diterpenes with promising bioactivity. These compounds have shown potential antitumor, anti-bacterial and antifungal activity[38]. Diterpenes extracted from *Xenia elongate* have shown Apoptosis inducing activity[39] and diterpenoids from *X. umbellata* have shown cytotoxicity against cancer cells[40]. The steroids isolated from *Umbellulifera petasites*, namely Petasitosterones A, Petasitosterones B and a spirosteroid Petasitosterone C have inhibited the proliferation of a limited panel of cancer cell lines and anti-inflammatory activity to inhibit nitric oxide (NO) production[29].

Heteroxenia species also possess a variety of bioactive compounds. Various spectral data of *H. fuscescens* have confirmed the presence of 6-Hydroxy -α- Muurolene which has a potential antibacterial and antifungal activity; 1-Nonadecyloxy-2,3-propanediol and N-Hexadecanoyl-2-amino 4,8-octadecadiene-1,3-diol have shown cytotoxic activity against different human tumor cell lines[41]. Along with these compounds the ethanolic extracts of *Heteroxenia* species have reported the presence of Gorgosten-5(E)-3 β-ol, (+)-α-Muurolene and Sarcoaldosterol-A which have shown antioxidant, antipyretic, antiglycemic and anti-inflammatory activity[42]. Ceramide compounds isolated from *H. ghardaqensis* have shown anti Cadmium toxicity, can be used to treat disorders caused by Cadmium uptake[43].

The *Sarcophyton* species contain Sarcotol and 13-membered carbocyclic cembranoid compounds with strong ichthyotoxic activity against Japanese killifish *Oryzia latipes*. Ethyl acetate extract of the Red Sea soft coral *S. glaucum* have shown inhibition of cytochrome P450 1A activity, inducers of glutathione S-transferases (GST), quinonereductase (QR), epoxide hydrolase (mEH), and tumor anti-initiating activity[44]. The Cembranoid diterpene present in *S. glaucum* had found to be potential antitumor agents against melanoma cells[18] and also exhibited potential antifungal activity[45]. Sarcomililatins A and (+)-isosarcophytoxide extracted from the ethanol soluble fraction of acetone extract of *Sarcophyton mililatensis* have shown strong cytotoxic activity and inhibitory activities against the tumor necrosis factor which is a key target for the treatment of inflammatory diseases and cancer[46]. The ethanol, chloroform and distilled water extracts have shown the bioactive metabolites including terpene, alkaloids and tannins having insecticidal activity[24]. The Cembranoids isolated from *S. crassocaule* have shown a significant anti-inflammatory activity and cytotoxic activity against cancer cell lines[47]. While in other cases n-hexane and ethyl acetate extracts of the Red Sea soft coral *S. trocheliophorum* were reported to contain unsaturated fatty acids that are active against brine shrimp and promote paclitaxel cytotoxicity in the human colon cancer cell line[25]. However the concentration of bioactive diterpenes and Cembranoid compounds varies with change in ecological condition like reef flat to deep water[48].

The soft corals of the genus *Sinularia* are one of the most widespread octocorals having good number of secondary metabolites with potential bioactivities such as anti-inflammatory, cytotoxic activities, antitumor and anti-allergic activities[49]. Chinese soft coral *Sinularia polydactyla* contains 7-hydroxy-8-methoxy-4(1H)-quinolone, which has increased the blood flow rate in the brain and heart of mice, protected against hypoxia and pituitrin-induced acute ischemia in myocardium, and mitigated aconitine-induced arrhythmia[22]. *S. brassica* is a good source of bioactive steroids with methyl ester groups and shown a significant cytotoxic activity, inhibition of elastase release and also inhibit the formation of super oxide anion[50]. The extract of *Sinularia flexibilis* contains terpenoid derivatives Flexibilide and Sinulariolide which have shown antimicrobial activity against fungal pathogens *Candida albicans* and *Aspergillus flavus*[51].

Red Sea soft coral *Lobophytum pauciflorum* contains different bioactive compounds including Nephthenol and Gorgost-5-ene-3β-ol with momentous in-vitro anti-inflammatory activity. Other alcohol compounds like Heptadecan-1-ol and batilol, fatty acids, palmitic acid and stearic acid have shown antimicrobial activity against pathogenic bacteria and fungi[28]. Different Cembranoid compounds have been isolated from *L. crassum* including Lobophyolide A which has an ability to reduce IL – 12 and also shown anti-inflammatory activity[7]. Various solvent extracts of *Lobophytum* spp., from Indonesian coast have shown heme polymerization inhibitory activity which is related to antimalarial potential[52].

The genus *Dendronephthya* is copious and widely distributed throughout the Indo-Pacific Ocean to Red Sea. The secondary metabolites are rich in unique steroids and sesquiterpenes. The Ylangene-type sesquiterpenoids named Dendronephthol A (7,13-dihydroxy-3,4-dihydroylangen-5-one) and Dendronephthol C (6,7,13-trihydroxy-a-ylang-5-one) isolated from chloroform fraction of methanol and acetone extracts of *Dendronephthya* collected from Red Sea have shown cytotoxicity against murine lymphoma cancer cell line[53]. The *Dendronephthya* species from South China Sea has reported to control macrofouling on its surface by producing secondary metabolites. The different organic extracts have inhibited the growth and attachment of bacteria from natural biofilm on rocks[54]. The extracts of unidentified *Nephthea* species contains wax esters, 1-O-alkylglycerols, cholesterol, fatty acids and D(-)-2S,3R-2-aminooctadeca-4E,8E-diene-1,3-diol-N-palmitate. These compounds have shown potential antiviral activity against Ranikhet disease virus *in vitro* condition and Vaccina virus in both *in vitro* and *in vivo* conditions[55].

The Octacorals of *Clavulariidae* family is reported to be a good source of Prostanoids, aromadendrane-type Sesquiterpenoid, Punaglandins and Pregnane-based steroids. The Pregnane-based steroids have shown antileishmanial activity, Punaglandins exhibited antiproliferative properties and the other compounds have elicited to mild toxicity to murine leukemia cells[56].

Soft corals in Eritrean coast of Red Sea

Eritrea is located in horn of Africa (12°45' - 18°03' N; 37°35' - 43°07' E) stretching from Sudan to Djibouti, which retains 3300 km of shoreline along the south-western coast of the Red Sea[57]. In addition to the mainland coastline is of 1950 kilometers; more than 350 islands in Dahlak Archipelagos contributes a shoreline of more than 1350 km to the total seashore of Eritrea[58]. The Red Sea is an epicenter habitat

for unprecedented bio-diversified marine biota. Approximately 40 % of the soft coral species identified so far in world's marine ecosystem are native to the Red Sea[59].

Biogeographically Red Sea can be divided into northern, central, and southern regions. Highly diversified biota of soft corals has been documented from Northern Red Sea, especially Israel coast Red Sea[22]. Central region of Red Sea reefs are concentrated with diversified stony corals. The most plentiful soft coral genera included all over the Red Sea are *Sinularia*, *Xenia*, *Ovabunda*, *Sarcophyton* and *Tubipora*. Species richness of soft corals are limited in southern Red Sea compared to northern Red Sea, it might be due to high temperature; for example average SST in northern Red Sea varies between 21-27 °C[58] where as in southern Red Sea it ranges between 26-32 °C[60]. The global climate change, overexploitation and pollution are also determinant factors for decreased distribution of Octacorallia biota[20].

Early exploration on soft corals in the southern Red Sea around Eritrean coast was done for the first time by Verseveldt in 1962[(ref. 61)]. These soft corals are mainly found in different depths around Dhalak Archipelago in Southern Red Sea. The members of the Alcyoniidae are fast growing organisms, able to grow effectively in moderately turbid and well-lit coastal areas[20]. Hence the species of *Lobophytum*, *Rhytisma*, *Sarcophyton* and *Sinularia* are mostly found in shallow reef habitats of 1–3 m depth. While the species of *Ovabunda* and *Xenia* commonly grows in dense patches down to 12 m[(ref. 5)]. Though diversified soft coral biota is found in Eritrean reefs, not even single soft coral species has been catalogued till date[62]. The most abundantly found soft corals around islands of Eritrean Red Sea are given in Plate 1[(ref. 63)].

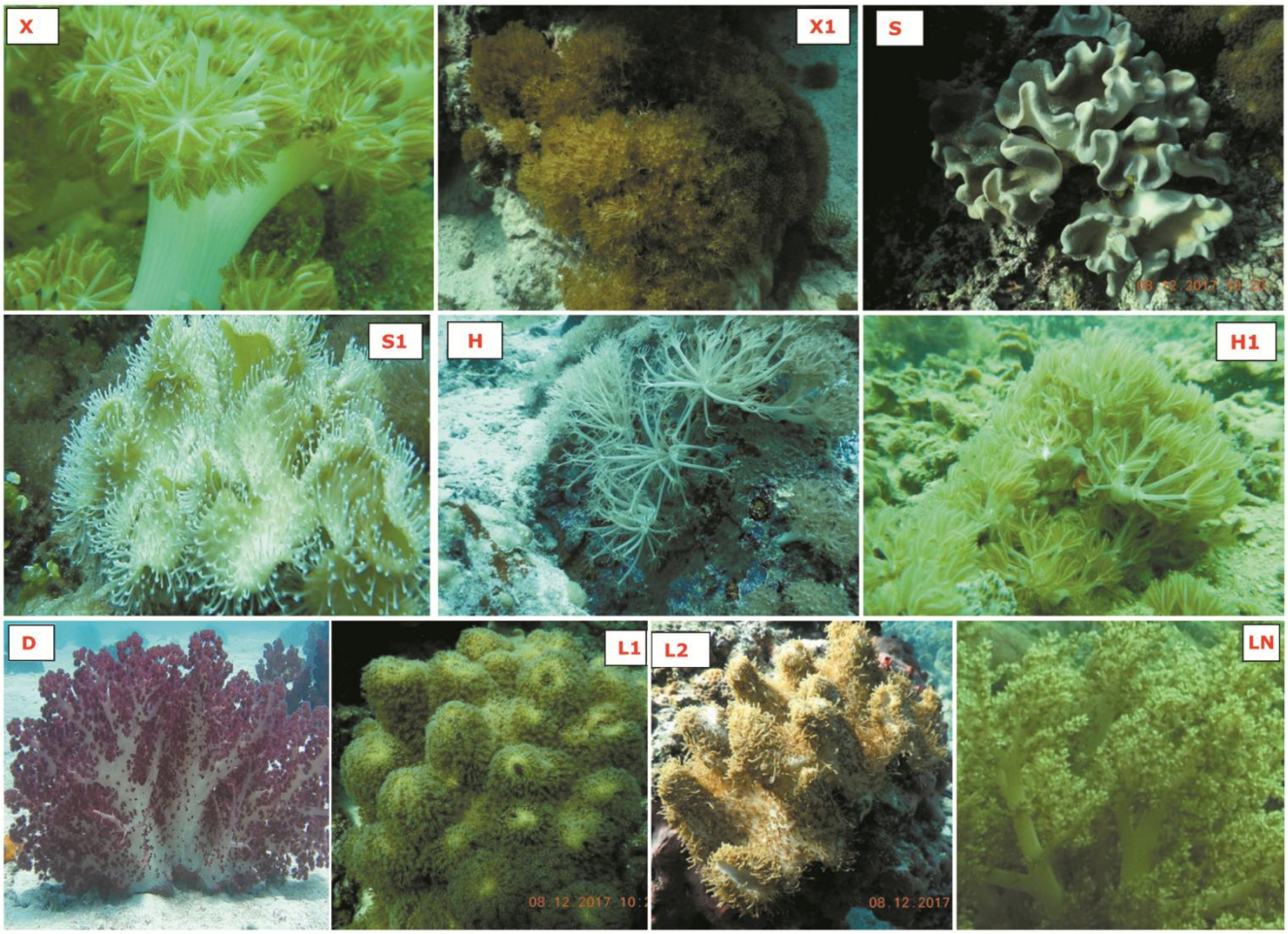

Plate 1 — Abundant soft corals distributed in Eritrean coast of Red Sea, X = *Xenia* species; X1 = *Xenia* species 1; S = *Sarcophyton* species; S1 = *Sarcophyton* species 1; H = *Heteroxenia* species; H1 = *Heteroxenia* species 1; D = *Dendronepthya* species; L1 = *Lobophytum* species 1; L2 = *Lobophytum* species 2; LN = *Lemnalia* species (Source: Ministry of Marine Resources[63], Eritrea)

Table 1 — Soft coral species distributed in Eritrean coast of Red Sea (Source: Verseveldt[61], Benayahu *et al.*[62] and Ministry of Marine Resources[63])

Family name	Genus name	Species	Location
Tubiporidae	*Tubipora*	*Tubipora musica*	Dejen shipwrecks
	Lobophytum	*Lobophytum pauciflorum*	DurGaam Island
	Rhytisma	*Rhytisma fulvumfulvum*	Harat and shumua Islands
	Sarcophyton	*Sarcophyton ehrenbergi*	Harat and shumua Islands
		Sarcophyton glaucum	DurGaam, Durguham and Dehil Islands
		Sinularia compressa	Cundabilu Island
Alcyoniidae		*Sinularia erecta*	Cundabilu Island
		Sinularia gardineri	Cundabilu Island
	Sinularia	*Sinularia gravis*	Cundabilu Island
		Sinularia leptoclados	Cundabilu Island
		Sinularia macrodactyla	Cundabilu Island
		Sinularia polydactyla	Cundabilu Island
		Dendronephthya formosa	Cundabilu, Madote and Dahret Islands
		Dendronephthya klunzingeri	Harat and Dehil Islands
	Dendronephthya	*Dendronephthya pharonis*	Cundabilu and Durguham Islands
		Dendronephthya sinaiensis	Cundabilu Island
Nephtheidae		*Dendronephthya hamprichii*	Cundabilu and Durguham Islands
	Paralemnalia	*Paralemnalia thyrsoides*	Cundabilu, Madote and Harat Islands
	Scleronephthya	*Scleronephthya corymbosa*	Cundabilu, Madote and Harat Islands
	Stereonephthya	*Stereonephthya cundabiluensis*	Duliacus Island
	Umbellulifera	*Umbellulifera oreni*	Durguham Island
Nidallidae	*Siphonogorgia*	*Siphonogorgia mirabilis*	Durguham Island
	Heteroxenia	*Heteroxenia fuscescens*	Harat Island
		Ovabunda farauensis	Madote and Dahret Islands
	Ovabunda	*Ovabunda obscuronata*	Madote and Dahret Islands
		Ovabunda verseveldti	Madote and Dahret Islands
Xeniidae		*Xenia blumi*	Madote and Dahret Islands
		Xenia hicksoni	Cundabilu and Madote Islands
	Xenia	*Xenia umbellata*	Dahret, Cundabilu and Dehil Islands
		Xenia elongata	Shaek Sied island, Madote, Dahret and Cundabilu Islands

Dendronephthya is a colourful soft coral familiar as carnation coral in the aquarium trade. These corals are green, yellow, pale orange, pink, purple, maroon and mix of these colours as well[64]. *Dendronephthya* colonies were occasionally found on the reef flat to reef slope, edge and sometimes on sandy bottoms[5] and on the shipwrecks at depths of 1–8 m and even deeper. Usually *Nephthea* colonies were frequently observed at various sites growing together with the colonies of *Xeniidae*. *Xenia* is the most dominant genera of soft corals in all the reef sites of Dhalak archipelago[65]. Combined data given by Verseveldt[61], Benayahu *et al.*[62] and Ministry of Marine Resources[63] resulted to the compilation of 30 species of soft corals in Eritrean coast of Red Sea, details of which are given in Table 1.

Conclusion

The important secondary metabolites with biological activity from unexploited marine resources, soft corals and their distribution in Eritrean coast of Red Sea have been reviewed. Numerous genera of soft corals and several species of *Sinularia* are distributed around the Cundabilu Island. Soft coral species, *Xenia elongate* is distributed from the coast to deep waters and islands of Dahlak archipelago; while the other species are distributed only in deep Sea Islands with less anthropogenic stressors reduced eutrophic conditions and minimum sedimentation rate. A thorough submarine study has to be taken to investigate the effect of pollutants and anthropogenic effects on the distribution of soft corals. Though soft corals are the best candidates for potential bioactive

compounds, the biological activity of soft corals from the Eritrean coast has to be investigated.

Acknowledgements

We wish to express our thanks to Yohannes Teclemariam Mebrahtu, Director, Research Division of Ministry of Marine resources, Eritrea for providing relevant information on Red Sea soft corals along Eritrean coast. We extend our gratitude to Dr. Zekeria Abudulkerim Zekeria, Dean of Massawa College of Marine Science and Technology for his encouragement and support to write this review.

Conflict of Interest

The Authors declare no conflict of interest.

Author Contributions

MK: Conceived, designed and wrote the paper, prepared photographs and tables; BH: Wrote, reviewed and edited the paper; BAA and GGH: Collected the data, and helped in writing the paper; AHH and OMH: Collected the photographs and distribution information.

References

1 Cita Y P, Syarmalina & Abdillah S, Antibacterial activities of bacterial symbionts of soft corals collected from the water of Wai-Sai Island, Papua, *Der Pharm Lett*, 6 (6) (2014) 8-13.

2 Grossowicz M & Benayahu Y, Differential morphological features of two *Dendronephthya* soft coral species suggest differences in feeding niches, *Mar Biodiv*, 42 (2012) 65-72.

3 Ellis S & Sharron L, *The Culture of Soft Corals (Order: Alcyonacea) for the Marine Aquarium Trade*, (CTSA Publication No. 137), 1999, pp. 8.

4 Cooper E L, Hirabayashi K, Strychar K B & Sammarco P W, Corals and their potential applications to integrative medicine, *Evid Based Complement Alternat Med*, (2014) 1-9.

5 Kumar Y J S, Geetha S, Raghunathan C & Sornaraj R, A note on shallow water Octocorollia from Nicobar Islands, India, *Indian J Geo-Mar Sci*, 47 (1) (2018) 60-66.

6 Bryce M & Sampey A, Kimberly marine biota, historical data: soft corals and sea fans (Octocorallia), *Records of the West Aus Mus*, Supplement 84 (2014) 101-110.

7 Lai K H, You W J, Lin C C, El-Shazly M & Liao Z J, *et al.*, Anti-Inflammatory Cembranoids from the Soft Coral *Lobophytum crassum*, *Mar drugs*, 15 (2017) 327-340.

8 Warren R, Baea P & Albert J, Solomon island aquarium farming hard and soft coral identification guide, (CRISP, Project 3C13), 2011, pp. 77-78.

9 Vorgelegt V & Hoang B X, *Soft coral (Octocorallia, Alcyonacea) diversity and distribution along a latitudinal environmental gradient and the role of their chemical defense against predatory fish in the Red Sea*, Ph.D. thesis, Kiel University, Germany, 2014.

10 Walker T A & Bull D D, A newly discovered method of reproduction in gorgorian coral, *Mar Ecol Prog Ser*, 12 (1983) 137-143.

11 Sun Z, Hamel J F & Mercier A, Planulation, larval biology, and early growth of the deep-sea soft corals *Gersemia fruticosa* and *Duva florida* (Octocorallia: Alcyonacea), *Invert Biol*, 130 (2) (2011) 91-99.

12 Tadesse M, *Antimicrobial natural products from Arctic and sub-Arctic marine invertebrates*, Ph.D. thesis, University of Tromoso, Norway, 2010.

13 Evans A J, Steer M D & Belle E M S, The Alcyonacea (soft corals and sea fans) of Antsiranana Bay, northern Madagascar, *Madag Conserv Dev*, 6 (1) (2011) 29-36

14 ElAhwany A M D, Ghozlan H A, ElSharif H A & Sabry S A, Phylogenetic diversity and antimicrobial activity of marine bacteria associated with the soft coral *Sarcophyton glaucum*, *J Basic Microb*, 55 (2015) 2-10.

15 Fact sheet about coral reefs, *International Coral Reef Information Network* (ICRIN), retrieved from http://www.coralreef.org on May 2018, pp. 3.

16 Student fact files, Corals, *Great Barrier Reef marine park authority*, Government of Australia, 2005, pp. 1-2.

17 Berrue F, Withers S T, Haltli B, Withers J & Kerr R G, Chemical screening method for the rapid identification of microbial sources of marine invertebrate-associated metabolites, *Mar Drugs*, 9 (2011) 369-381.

18 Barnes R & Hughes R, *An Introduction to Marine Ecology*, 3rd edn, (Blackwell Science Inc, USA), 1999, pp. 117-141.

19 Baum G, Januar I, Ferse S C A, Wild C & Kunzmann A, Abundance and physiology of dominant soft corals linked to water quality in Jakarta Bay, Indonesia, *Peer J*, (2016) 1-29.

20 Dar M A, Mohamad T A & El-Saman M I, Geomorphic and geographic distributions of reef- building and soft coral communities in the inshore zone of the Red Sea, *Egypt J Aqua Res*, 38 (2012) 105-117.

21 Goh B P L, Tan G E & Tan L T, Diversity, distribution and biological activity of soft corals (*Octocorallia, Alcyonacea*) in Singapore, *J Coastal Deve*, 12 (2) (2009) 89-98.

22 Selim N M A, *Chemical and bioactivity studies of the Red Sea Soft Corals: Sinularia polydactyla (Ehrenberg) and Lobophytum crassum (Marenzellar) (Fam. Alcyoniidae)*, Ph.D thesis, Cairo University, Egypt, 2012.

23 Rocha J, Peixe L, Gomes N C M & Calado R, Cnidarians as a source of new marine bioactive compounds-An overview of the last decade and future steps for bioprospecting, *Mar Drugs*, 9 (2011) 1860-1886.

24 Momtaz A S K, Soft corals *Sarcophyton glaucum* as insecticide against Rice weevils *Sitophilus oryzae* (Coleoptera: Curculionidae), *IOSR J Environ Sci, Toxic & Food Tech*, 10 (11) (2016) 10-14.

25 El-Seedi H R, Gomaa M, Salem M M, Benchoula K & Keshk H M, *et al.*, Cytotoxic effects of the Red Sea soft coral *Sarcophyton trocheliophorum*, *Acta Poloniae Phar - Drug Res*, 73 (6) (2016) 1587-1592.

26 He Q, Sun R, Liu H, Geng Z & Chen D, *et al.*, NMR-based metabolomic analysis of spatial variation in Soft Corals, *Mar drugs*, 12 (2014) 1876-1890.

27 Shahbudin S, Deny S, Zakirun A M T, Haziyman T A H & Akbar J B, *et al.*, Antioxidant properties of soft coral *Dendronephythya spp*., *Int J Phara*, 7 (2) (2011) 263-267.

28 Hassan M H A, Mohammed R, Hetta M H, Abdelaziz T A & El-Gendy A O, *et al.*, Biological and chemical investigation of the soft coral *Lobophytum pauciflorum* collected from the

Egyptian Red Sea, *Int J Pharmacognosy Phytochemical Res*, 8 (6) (2016) 906-911.

29 Huang C, Chang C, Tseng Y, Lee J & Sung P, *et al.*, Bioactive steroids from the formosan Soft Coral *Umbellulifera petasites*, *Mar drugs*, 14 (2016) 180-191.

30 Kawung N J, Mangindaan R E P, Rompas R M, Chasanah E & Januar H I, *et al*., Impact on increasing anthropogenic pressure to the variability of cembranoid compounds derived of soft coral *Sinularia* species from Manado the waters and their antitumor activity, *Int J Info Res Review*, 3 (12) (2016) 3304-3308.

31 Soliman Y A A, Brahim A M, Moustafa A H & Hamed, M A F, Antifouling evaluation of extracts from Red Sea soft corals against primary biofilm and biofouling, *Asian Pac J Trop Biomed*, 7 (11) (2017) 991-997.

32 Afifi R, Abdel-Nabi I M & El-Shaikh K, Antibacterial activity from soft corals of the Red Sea, Saudi Arabia, *J Taibah Univ Sci*, 10 (2016) 887-895.

33 Setyaningsih I, Nurhayati T, Nugraha R & Gunawan I, Comparative evaluation of the antibacterial activity of Soft corals collected from the water of Panggang Island, Kepulauan Seribu, *Int J Compreh Pharm*, 6 (3) (2012) 1-3.

34 Putra M Y, Wibowo J T & Murniasih T, A review of chemistry and biological activities of the Indonesian Octocorallia, *J App Pharm Sci*, 7 (5) (2017) 219-227.

35 Chao C, Chou K, Huang C, Wen Z & Hsu C, *et al.*, Bioactive Cembranoids from the Soft Coral *Sinularia crassa*, *Mar Drugs*, 9 (2011) 1955-1968.

36 Lin W, Chen B, Huang C, Wen Z & Sung P, *et al.*, Bioactive Cembranoids, Sarcocrassocolides P–R, from the Dongsha Atoll Soft Coral *Sarcophyton crassocaule*, *Mar Drugs*, 12 (2014) 840-850.

37 Matulja D, Markovic M K, Ambrožic G, Laclef S & Pavelic S K, *et al.*, Secondary metabolites from Gorgonian corals of the genus *Eunicella*: Structural characterizations, biological activities, and synthetic approaches, *Molecules*, 25 (129) (2020) 1-26.

38 Sharma N S, Krishna M S, Pasha G S K, Rao T S P & Venkateswarlu Y, *et al*., Marine metabolites: The Sterols of Soft Coral, *Chemical Rev*, 30 (2008) 1-26.

39 Andrianasolo E H, Haramaty L, White E, Lutz R & Falkowski R, Mode of action of diterpene and characterization of related metabolites from the soft coral, *Xenia elongate*, *Mar Drugs*, 12 (2014) 1102-1115.

40 Duh C, El-Gamal A A H, Chiang C, Chu C & Wang S, *et al.*, New cytotoxic xenia diterpenoids from the formosan soft coral *Xenia umbellate*, *J Nat Prod*, 65 (2002) 1882-1885.

41 Mohammed R, Seliem M A E, Mohammed T A A, Abed-ElFatah A & Abo-Youssef A M, *et al*., Bioactive secondary metabolites from the Red Sea soft coral *Heteroxenia fuscescens*, *Int J Appl Res Nat Prod*, 4 (4) (2012) 15-27.

42 Edrada R A, Wray V, Witte L, Ofwegen L V & Proksch P, Bioactive Terpenes from the soft coral *Heteroxenia* sp. from Mindoro, Philippines, *Verlag der Zeitschrift für Naturforschung, Tübingen*, 55 (c) (2000) 82-86.

43 Elshamy A I, Nassar M I & Farrag A H, *Bioactive compounds and Extracts of Hetroxenia ghardaqensis*, (Lambert Academic Publishing), 2015, pp. 209-222.

44 Hegazy M F, Eldeen A M G, Shahat A A, Abdel-Latif F F & Mohamed T A, *et al.*, Bioactive Hydroperoxyl Cembranoids from the Red Sea Soft Coral *Sarcophyton glaucum*, *Mar Drugs*, 10 (2012) 209-222.

45 Hegazy M F, Mohamed T A, Alhammady M A, Shaheen A M & Reda E, *et al.*, Molecular architecture and biomedical leads of terpenes from Red Sea marine invertebrates, *Mar Drugs*, 13 (2015) 3154-3181.

46 Li S, Ye F, Zhu Z, Huang H & Mao S, *et al*., Cembrane-type diterpenoids from the South China Sea soft coral *Sarcophyton mililatensis*, *Acta Pharm Sinica B*, 8 (6) (2018) 944-955.

47 Lin W, Lu Y, Su J, Wen Z, Dai C, *et al.*, Bioactive Cembranoids from the Dongsha Atoll Soft Coral *Sarcophyton crassocaule*, *Mar Drugs*, 9 (2011) 994-1006.

48 Farag M A, Porzel A, Al-Hammady M A, Hegazy M F & Meyer A, *et al.*, Soft Corals biodiversity in the Egyptian Red Sea: A Comparative MS and NMR Metabolomics approach of wild and aquarium grown species, *J Proteome Res*, 15 (2016) 1274-1287.

49 Chen W, Lee Y & Guo Y, Terpenoids of *Sinularia* soft corals: Chemistry and bioactivity, *Acta Pharma Sinica B*, 2 (3) (2012) 227-237.

50 Huang C, Su J, Liaw C, Sung P & Chiang P, *et al.*, Bioactive steroids with methyl ester group in the side chain from a reef soft coral *Sinularia brassica* cultured in a Tank, *Marine Drugs*, 15 (2017) 280-291.

51 Putri D A, Radjasa O K & Pringgenies D, Effectiveness of marine fungal symbiont isolated from soft coral *Sinularia* sp., from Panjang Island as antifungal, *Procedia Envir Sci*, 23 (2015) 351-357.

52 Putra M Y, Murniasih T, Swasono R T, Wibowo J T & Saputri A N C, *et al.*, Secondary metabolites and their biological activities in Indonesian soft coral of the genus *Lobophytum Asian Pac J Trop Biomed*, 6 (11) (2016) 909-913.

53 Elkhayat E S, Ibrahim S R M, Fouad M A & Mohamed G A, Dendronephthols A-C, new sesquiterpenoids from the Red Sea soft coral *Dendronephthya* sp., *Tetrahedron*, 70 (2014) 3822-3825.

54 Dobretsov S & Qian P Y, The role of epibotic bacteria from the surface of the soft coral *Dendronephthya sp.* in the inhibition of larval settlement, *J Exp Mar Biol Ecol*, 299 (2004) 35-50.

55 Patra A & Majumdar A, Secondary metabolites of a soft coral (*Nephthea* sp.) of the Bay of Bengal, A*RKIVOC*, 11 (2003) 133-139.

56 Almeidaa M T R, Moritz M I G, Capel K C C, Pérez C D & Schenkel E P, Chemical and biological aspects of Octocorals from the Brazilian coast, *Rev Bras Farmacogn*, 24 (2014) 446-467.

57 Jeudy de Grissac A & Nugussie K, Eritrea's Coastal Marine and Island BiodiversityConservation Project (ECMIBC): An UNDP project report submitted on December 2007.

58 Project global, Global by-catch assessment of long- lived species, *Country profile: Eritrea*, by Blue Ocean Institute, 2007, pp. 1-2.

59 El-Ezz R F A, Ahmed S A, Radwan M M, Ayoub N A & Afifi M S, *et al*, Bioactive cembranoids from the Red Sea soft coral *Sarcophyton glaucum*, *Tetra Let*, 54 (2012) 989-992.

60 Ateweberhan M, Bruggemann J H & Breeman A M, Seasonal patterns of biomass, growth and reproduction in *Dictyota cervicornis* and *Stoechospermum polypodioides*

(Dictyotales, Phaeophyta) on a shallow reef flat in the southern Red Sea (Eritrea), *Bot Mar*, 48 (2005) 8-17.

61 Verseveldt J, Report on the Octocorallia (Stolonifera and Alyonacea) of the Israel south Red Sea expedition 1962, with notes on other collections from the Red Sea, Sea fisheries research station, Haifa, *Bulletin*, 40 (1965) 28-48.

62 Benayahu Y, Yosief T & Schileyer M H, Soft corals (Octocorallia, Alcyonacea) of the Southern Red Sea, *Isr J Zool*, 48 (2002) 273-283.

63 *Annual report on Corals and Soft corals*, (Ministry of Marine Resources, Eritrea; Unpublished data), 2018.

64 Kumar Y J S, Geetha S, Raghunathan C & Sornaraj R, Two new records of *Dendronephthya* octocorals (Family: Nephtheidae) from Andaman and Nicobar Islands, India, *Indian J Geo-Mar Sci*, 48 (3) (2019) 343-348.

65 Mebrahtu Y T, Director, Research division, Ministry of Marine Resources, Eritrea, (Personal communication), 2018.