American Scientific Research Journal for Engineering, Technology, and Sciences (ASRJETS)
ISSN (Print) 2313-4410, ISSN (Online) 2313-4402

http://asrjetsjournal.org/

A New Taxonomic Survey of *Caulerpa* Lamouroux Species (Chlorophyta, Caulerpales) in the Southern Coasts of Iran

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Abstract

The genus *Caulerpa* (Chlorophyta), a coenocytic marine macroalgae, consists of about 75 species of tropical to subtropical siphonous green algae. *Caulerpa* species inhabit the intertidal and shallow subtidal region along the coast of Iraniansouth. The aim of this research was the taxonomic and florestic study of the genus *Caulerpa* in the southern coast of Iran due to the abundance of this genus, as well as the importance of this genus in terms of food and especially its antioxidant and anti-bacterial properties. In a survey conducted from Febriary 2015 to January 2016, we found seven species as *Caulerpa cupressoides* (vahl.) C. Agardh, *C. peltata* (Lamouroux), *C. racemose* (Forskkal) J. Agardh, *C. fastigiata*Montagne, *C. scalpelliformis* (Turner) *C.* Agardh, *C. sertularioides* (S.G.Gemelin.) Howe;*C. taxifolia* (Vahl) C. Agardh. In conclusion, a little study is known about the diversity of this genus along the coast of Iran, and this study can at least partly be attributed to the complex systematics of the genus, which is characterized by considerable morphological plasticity.

Keywords: *Caulerpa*; Distribution; Iran; Taxonomy.

1. Introduction

Caulerpa (Chlorophyta, Caulerpales) or Briopsidophyceae [1] is one of the most distinctive algal genera, identifiable solely on the basis of its habit (growth form) and internal morphology [2]. All species and subspecies of *Caulerpa* live in marine temperate environments, but some can thrive in brackish lagoons [3,4]. Reports vary on the number of *Caulerpa* species from 70 [5] to approximately 100 [6], most of which inhabit warm waters. Genus *Caulerpa* are common in intertidal and subtidal zones of tropical and subtropical warm waters throughout the world [7,8,9,10].

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Species among this genus are primarily classified, according to the morphological characters. *Caulerpa* species has ant nociceptive and anti-inflammatory activities [11]. Iran has coastal lines about 1260 Km along the Persian Gulf and Oman Sea. The Persian Gulf extended from the Hormoz Island in the south to Shatt Al-Arab in the north. Persian Gulf is a shallow epi-continental sea that formed during the late Pliocene period. Information about the marine flora of the southern coasts is very scarce in the literature. The first reports about marine algae of the Persian Gulf by Endlicher and Deising [12] describing 6 phaeophyceae. Børgesen (1939) [13] described 103 species from seashores of Bushehr and Kish Island. More recent information was provided by Sohrabipour and Rabei [14,15] describing 153 species of marine algae from coastal lines of Iranian Islands and Hormozgan Province, and reported only 3 *Caulerpa* species in the Bandar-Lengeh and Qeshm Island (2004, 2005), and as well as, Rohani and his colleagues [16] published 4 species of *Caulerpa* in this area. Gharanjik and Abkenar [17] reported 5 species of *Caulerpa* in Sistan and Baluchestan province.The southern shores are important because the people that live along these coastal lines are fishermen who get their income mostly from the sea.The habit is typified by a creeping horizontal stem called a rhizome that produces tufts of colorless rhizoids downward and photosynthetic branches or fronds (assimilators) upward [2]. These units, called metameres [18], can potentially regenerate new ramets after a frond or stipe is cut. Gametogenesis involves migration of cytoplasm into unspecialized gametangia where it is transformed into anisogamous gametes [19].The creeping rhizomes typically exhibit indeterminate growth [20]. Photosynthetic assimilators assume many different forms, often with rows or whorls of leaf-like pinnules. Most species are well defended against large grazers by a suite of toxic compounds [21]. Yet some taxonomically perceived species exhibit rampant morphological plasticity and ill-defined taxonomic boundaries. Variability in growth forms and in the photosynthetic performance of *Caulerpa* species seem to be related to substrate, light intensity, and water motion [20,22]. Sectional division among taxa [23,24] is predominantly supported by differences in assimilator morphology. These assimilators, however, can be highly plastic and seem under strong control of the environment [25,26]. The purpose of this study is to identify the diversity of *Caulerpa* in the Persian Gulf and Oman Sea and to provide a sound reference, workable key for the identification of these species. The Persian Gulf is a shallow sea, which experiences very high annual variation in seawater temperature [27,28,29]. These extreme physical conditions impose stress on the scleractinian corals [30] which results in severe competition for space and light with *Caulerpa* which seasonally overgrows the Porites-dominated reefs [27]. So far, a little study is known about the diversity of the genus along the coast of Iran. This can at least partly be attributed to the complex systematics of the genus, which is characterized by considerable morphological plasticity (Fig. 1).

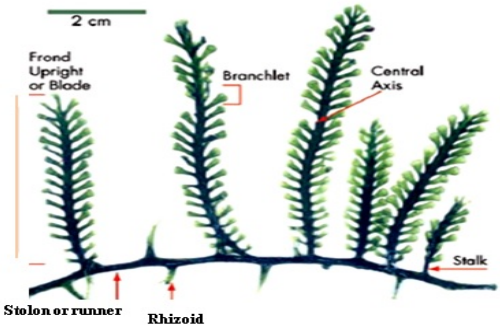

Figure 1: Thallus structure on the *Caulerpa* species.

The aim of this research was the taxonomic and florestic study of the genus *Caulerpa* in the southern coast of Iran due to the abundance of this genus, as well as the importance of this genus in terms of food and especially its antioxidant and anti-bacterial properties. On the other hand, due to the complexity of morphology and taxonomy of this genus, Sometimes it has a problem. The widespread distribution of this algae on the southern coast of Iran sometimes leads to a decrease in the growth of other aquatic plants and seaweeds that can be examined. Therefore, it is better to carry out further research for several consecutive years and complete sampling of the entire southern coast of Iran.

2. Materials and Methods

Specimens of *Caulerpa* were collected from 11 localities between the Sistan va Baluchestan, Bandar-Lengeh province and Qeshm Island during the month of July 2016 to January 2017 (**Fig. 2**).Whole thalli were collected on reef flats at low tide from a variety of habitats down to 3 m depth. Collected samples were fixed in 4% formaldehyde, and the remainder was dried on herbarium sheets. The morphological characters used for analysis were lamina, stipe, stolon, rhizoid, thalli tall. The rhizoids were immersed in a 5% solution of phosphoric acid to remove the sand. Specimens were studied using a Stemi 2000-C Zeiss stereo microscope and photographed with a Canon Power shot G6 camera. Identification of samples were based on the following taxonomic references: [31;13;32;33;34,35;36;38;37;39;40].

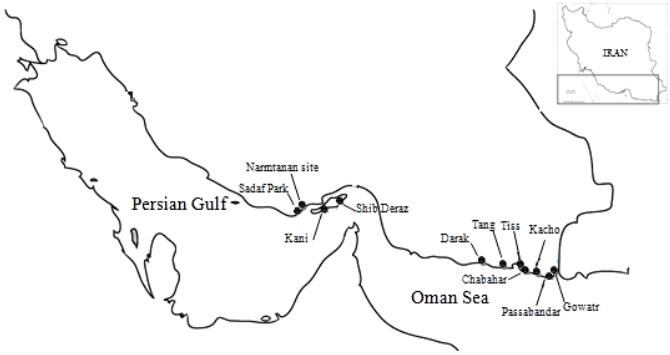

Figure 2: Study area and localities of collection for *Sargassum* along the Persian Gulf and Oman Sea seashore of Iran. Sistan va Baluchestan province (61° 30′ N, 25° 14′ E); Bandar Lengeh (54° 52′ N, 26° 32′ E); Qeshm Island (55° 23′ N, 26° 34′ E)

3. Results

Key to species of *Caulerpa* from Iranian southern coasts

1- Erect branches feather like and bearing short branchlets or ramuli of other form 2

1- Erect branches not feather like and bearing short branchlets or ramuli of other form 4

2- Ramuli in the form of flattened to compressed pinnules or cylindrical teeth 3

2- Ramuli in the form of flattened, distichously arranged pinnules *C. sertularioides*

3- Ramuli in the form of distichouse-pinnatly arranged/compressed teeth *C. taxifolia*

3- Ramuli in the short form, upcurved, cylindrical, distichous to tristrichously C. *cupressoides*

4- Ramuli peltate *C. peltata*

4- Ramuli clavate or with spherical head or short and spinous 5

5- Spherical head of the ramuli not less than 2 mm in diameter *C. racemosa*

5- Spherical head of the ramuli not above 6

6- Algae light green, coenocytic with prostrate rhizomes with ramuli cylindrical, incurved upwards *C. fastigiata*

6- Algae dark green, consisting of horizontally branched stolon, erect foliar branches with toothed edges *C. scalpelliformis*

Description of Caulerpa species

Division: Chlorophyta

Class: Chlorophyceae

Order: Bryopsidales

Family: Caulerpaceae

***Caulerpa fastigiata* Montagne**

Montagne, 1837: 353 [41]; Gilbert, 1942:9; 1961 [25] [42], 436; Reyes, 1976: 154. Pl. 8. Figs. 1, 2 [43]

Thalli filiform, forming thick mats on rocks and sand, to 26 mm high, the terete, creeping stolon with laxly branched, filiform rhizoids borne at the end of descending filaments, branches to 1 mm long with obtuse or rounded apices (**Fig. 3a**).

Ecology: The algae usually grow in the middle portions of intertidal zone on rock or sand substrate. Distribution is more or less in the Hormozgan and Bandar lengeh (Narmtanan and Sadaf Park) province.

***Caulerpa peltata* Lamouroux**

Tseng 1984 [37], 282: pl. 140, Fig.3; Gavino and Trono, 1999 [40], 35: Fig. 21; Coppejans *and his colleagues* 2004 [44], 2984.

Thalli small, spreading slender stolons sparingly provided with erect foliar branches above and rhizoidal branches below, growing on lower intertidal coral reefs covered with sand or sandy-muddy substrate. Erect branches about 1-2 cm in high, bearing one to several peltate branchlets consisting of a slender pedicle 1-2 mm long (**Fig. 3b**).

Ecology: The algae usually grow in the middle portions of intertidal zone on rock or sand substrate. Distribution is more or less in the Hormozgan and Sistan va Baluchestan (Pozm, Chabahar and Tang) province.

***Caulerpa cupressoides* (Vahl.) C. Agardh**.

Tseng 1984 [37], 280: Fig. 4, pl. 139; C. Agardh, 1823 [45]:441; Reyes, 1972 [36]:142; 1976: 155, pl. 8: Fig. 7., Gavino and Trono, 1999 [40], 31: Fig. 18; Coppejans and his colleagues 2004 [44], 2980, Fig. 14; Keppner, 2005 [46], 15, Fig. 7.

Thalli forming extensive colons, with branching stolons several decimetes in length, forming stout descending rhizoid-bearing branches below and erect foliar branches above, growing on sandy lagoon floor. foliar branches simple or branched, with terete or slightly compressed rachis, to 1.5 mm in diameter in larger plants, bearing multiseriate or occasionally pinnate, upcurved, compressed, seminaviculate, ovoid, conical, sometimes linear branchlets, to 2 mm long, not exceeding 0.5 mm at the widest portion, with cuspidate or mucronate tips (**Fig. 3c**).

Ecology: The algae usually grow in the middle portions of intertidal zone on rock or sand substrate. Distribution is more or less in the whole Bandar Lengeh and Sistan va Baluchestan province.

***Caulerpa racemosa* (Forsskål) W.v. Boss**

Tseng 1984 [37], 282: pl. 140, Fig.4; J. Agardh, 1873 [23]:35-36.;Gilbert, 1946 [35]: 78.;Velasquez, 1953 [47]:100; Menez, 1961 [48]: 51; Taylor, 1966 [50]:350; Reyes, 1972 [36]: 142; Trono, 1972 [38]: 96; 1973: 218; Trono and Tuazon, 1978 [50]: 3; Cordero, 1978 [51]: 280., Gavino and Trono, 1999 [40], 36: Fig. 22.; Coppejans and Meinesz 1988 [32]: 191, Figs 22, 23; Littler and Littler 2003 [52]: 226, p. 227; Coppejans and his colleagues 2004 [44], 2985; Keppner 2005 [46], 11, Fig. 5. Thalli wide-spreading, with long, coarsely branching stolons, becoming densely entangled in old colonies, with stout rhizoid-bearing branches below. Consisting of few erect branches, simple or branched, bearing clavate, turbinate, spherical, hemispherical or discoid ramelli, which are stipitate or substipitate, having obtuse or flattened tips; ramelli distichously, multiseriately or imbricately arranged on terete rachis; creeping stolon terete, with short or long descending branches, giving off branched rhizoids at the ends. Erect foliar branches often much crowed on the stolons, growing on middle intertidal rocky-corally substrate. Erect branches 1-9 cm high, the branchlets on them generally not crowded, irregularly disposed or opposite, or sometimes bilateral, generally clavate on a short pedicl, the globular summit 1-2 mm diameter (**Fig. 3d**).

Ecology: The algae usually grow in the middle portions of intertidal zone on rock or sand substrate. Distribution is more or less in the Bandar Lengeh and Sistan va Baluchestan (Pozm, Tang and Chabahar) province.

***Caulerpa scalpelliformis* (Turner) C. Agardh.**

C. Agardh, 1823 [45]:443 ; Keppner 2005 [46], 16, Fig.8

Recognized forms and varieties (as listed in Guiryand Dhonncha 2004)

Caulerpa scalpelliformis var. *denticulata* (Decaisne) Weber-van Bosse

Caulerpa scalpelliformis var. *intermedia* Weber-vanBosse

Caulerpa scalpelliformis f. *dwarkensis* Børgesen

Caulerpa scalpelliformis f. *denticulata* (Decaisne)Svedelius

Caulerpa scalpelliformis f. *intermedia* (Weber-vanBosse) Svedelius

Thalli dark green in color, consisting of horizontally branched stolon. The erect branches simple, flat and long. Erect foliar branches generally with toothed edges tapering toward the tip. Main branches 10-15 cm in high and 1-1.5 cm in width (**Fig. 3e**). It closely resembles *C. taxifolia* but can be distinguished by the form of its branches, which are curved towards the interior in the latter and straight in the former. The rachis of the fround is quite dominant and thicker than the pinnules

Ecology: The algae usually grow in the middle portions of intertidal zone on rock/sand or soft mud substrate. Distribution is in the whole Sistan va Baluchestan province.

***Caulerpa sertularioides* (S.G.Gmelin.) Howe**

Tseng,1984 [37], 284: pl. 141, Fig.2; Gilbert, 1946 [35]:78; 1961 [25]:441; Menez, 1961 [48]: 52; Taylor, 1966 [49]: 351; Reyes, 1972 [36]:143; Trono, 1972 [38]: 96; Cordero, 1978 [51]: 280; Coppejans and Meinesz, 1988 [32]: 192, Figs 29; Coppejans and Beeckman 1990 [53], 120, Figs. 26, 27; Littler and Littler 2003 [52]: 232, p. 233; Coppejans and his colleagues 2004 [44], 2987, Fig. 16; Keppner 2005 [46], 18, Fig. 11.

Recognized forms (as listed in Guiry and Dhonncha 2004)

Caulerpa sertularioides f. *longipes* (J. Agardh) Collins

Caulerpa sertularioides f. *brevipes* (J. Agardh) Svedelius

Caulerpa sertularioides f. *longiseta* (Bory de Saint-Vincent) Svedelius

Caulerpa sertularioides f. *corymbosa* W. R. Taylor

Caulerpa sertularioides f. *farlowii* (Weber-van Bosse) Børgesen

Caulerpa sertularioides f. *flagellata* (Weber-van Bosse) Weber-van Bosse

Caulerpa sertularioides f. *umbellata* (Weber-van Bosse) Svedelius

Thalli wide-spreading with coarse, naked, branching stolons, forming erect foliar branches above and stout rhizoid-bearing branches below, creeping on middle to lower intertidal coral reefs covered with sand. Stolon elongation length for *C. sertularoides* growing in deep water ranging from 0.93 to 1.92 cm Erect foliar branches flat, simple, rarely proliferous, to 4 cm high, stalk to 3 mm long; and bearing regularly placed, long, linear-cylindrical pinnules, to 5 mm (**Fig. 3f**). **Ecology:** The algae usually grow in the middle portions of intertidal zone on rock/sand or soft mud substrate. Distribution is more or less in the whole Bandar Lengeh and Sistan va Baluchestan province and Qeshm Island.

***Caulerpa taxifolia* (Vahl.) C. Agardh**

Tseng, 1984 [37], 284: pl. 141, Fig.3, Gavino and Trono, 1999 [40], 42: Fig. 25; Coppejans and his colleagues 2004 [44], 2988.; Keppner, 2005 [46], 7, Fig.3. Thalli with wide-spreading naked stolons, forming erect foliar branches above and rhizoid-bearing branches below, growing on lower intertidal sand or sandy rocks. Erect branches often closely together, with stalks 1-2.5 cm long, simple or sparingly branched. The branchlets sickle-shaped, about 5 mm long and 1 mm broad, flat linear-oblong to linear, regularly oppositely pinnate, usually markedly upwards, strongly compressed, contracted at the base, tapering toward the tip and mucronate (**Fig. 3g**). **Ecology:** The algae usually grow in the middle portions of intertidal zone on rock/sand or soft mud substrate. Distribution is more or less in the Sistan va Baluchestan (Jood and Gowatr) province, Bandar Lengeh and Qeshm Island.

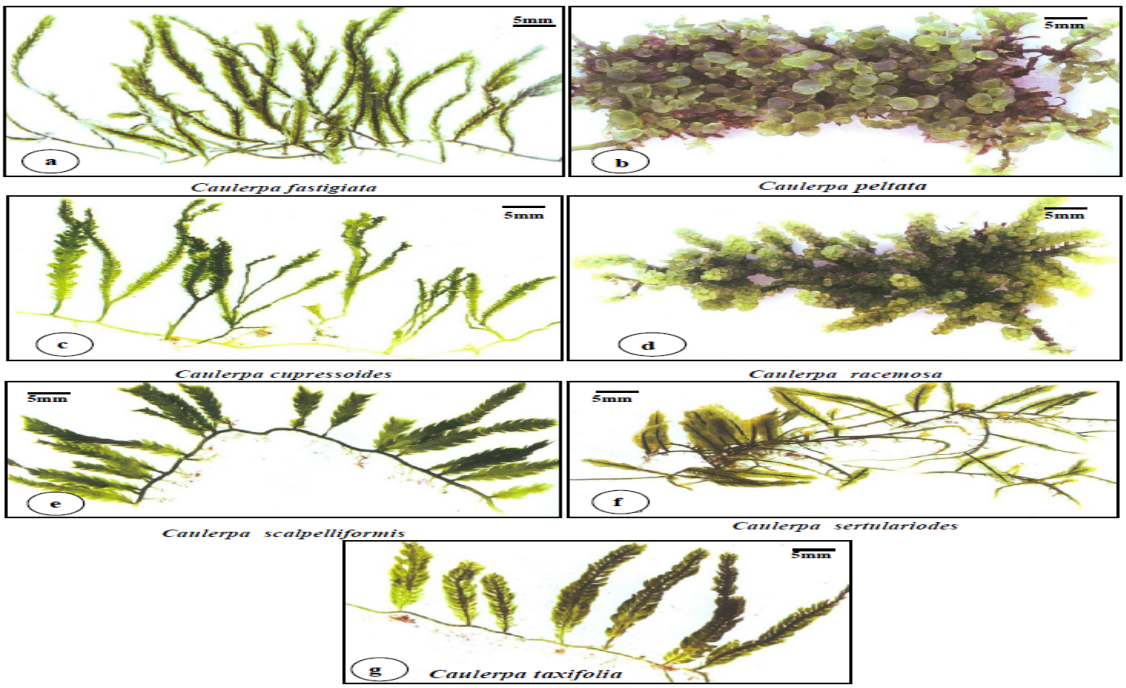

Figure 3: The habitate and morphology of *Caulerpa* species of Iranian seashores.

4. Discussion

Persian Gulf and Oman Sea are richness from seaweeds especially green algae. This study will provide the baseline data for future studies on economic importance of *Caulerpa* species diversity in the southern coasts of Iran. The most of observed *Caulerpa* species in Iran were reported in the neighbor country as Pakistan, India, Bahrain, Kuwait and Saudi Arabia. Among of determined species, C. *sertularioides; C.racemose, C. cupressoides and C. taxifolia* showed the highest frequency and density in the most stations. These field observations indicated that assignment of some specimens to one of the forms is difficult, especially when two growth forms occur on the same stolon or branchlets. It is unclear which environmental factor induces the development of one of these morphologies.*C. taxifolia* has been cultivated in aquariums of Europe since the late 1960s [5]. A particularly cold tolerant strain of *C. taxifolia*, the Mediterranean strain, was first noticed in the wild, off the Mediterranean coast, in 1984 [5], and this species was also found growing off the southern Australia coast [54].

Taylor [55] states about *Caulerpa racemose*; this famous, ubiquitous tropical species is among the most variable in its variable genus. This variability has been confirmed by many studying this genus in any part of the world. Weber-van Bossc [24] describes a huge number of varieties and forms, but most of the authors also mention intermediate growth forms. In spite of the morphological plasticity of *C. racemosa*, fieldwork proves that the present of a certain “variety” is linked to a kind of habitat [56]. Growth of *C. racemosa* has been shown to increase as density increases, but to a lesser degree than with *C. taxifolia* that these results was resemble to Piazzi and Ceccherelli 2002. In general, *C. taxifolia* and *C. racemosa* occur together, *C. racemosa* will be the favored species as observation of Piazzi and Ceccherelli 2002. *C. cupressoides*has demonstrated the ability to grow rapidly under tolerable conditions [57].

5. Conclusion

This study concluded that seven species of *Caulerpa* identified which it provide the baseline data for future studies on economic importance of *Caulerpa* species diversity in the southern coasts of Iran. Also, morphological variability might be due to environmental factors. More experiment about the influence of salinity, hydro dynamism, emersion time, on the habit of *C. racemosa* might prove even more relationships between ecological factors and morphology of this species. So, taxonomic study of *Caulerpa* specices can be contribute to the species richness of the country and maintain the country's genetic reserve. Therefore, it is better to carry out further research (phylogeography, phylogeny and molecular reserch) for several consecutive years and complete sampling of the entire southern coast of Iran.

6. Recommendations

-Performing molecular and phylogenic studies to complete the algal flora of this genus.

-Performing ecological studies to optimize the growth condition of algae.

-Performing phytochemical and pharmaceutical studies on this genus.

References

[1] C. Van Den Hoek, A.M. Breeman and W.T. Stam, The Geographic Distribution of Seaweed Species in Relation To Temperature: Present and Past, in J.J Beukema and J.J.W.M. Brouns (eds) Expected effects of climatic change on marine coastal ecocystem (Dordrecht: Kluwer Academic Publishers), 1990, pp. 55-67.

[2] P.C. Silva, Overview of the Genus Caulerpa: Herbarium of the University of California, Berkeley (CA) USA. 2002.

[3] R. Dalton, Researchers Criticize Response to Killer Algae. Nature. pp. 406- 447, 2000.

[4] J. Kaiser, California Algae May be Feared European Species. Science. Vol. 289, pp. 222–223, 2000.

[5] A. Meinesz, Introduction for the International Caulerpa taxifolia Conference. IN: International Caulerpa taxifolia Conference Proceedings January 31-February 1, 2002. San Diego, CA, U.S.A. 2002.

[6] O. Dumay, G. Pergeni, C. Pergent-Martini and P. Amade, Variations in Caulerpenyne Contents in Caulerpa taxifolia and C. racemose, Journal of Chemical Ecology. Vol. 28, pp. 343-352, 2002.

[7] C.J. Dawes, Marine Botany, 2nd ed. John Wiley & Sons, Inc., New York. 1998.

[8] C.H. Hay, N.M. Adams, and M.J. Parsons, Marine Algae of the Sub Antarctic Islands of New Zealand, National Museum of New Zealand Misc. 1985.

[9] A. Meinesz, and C.F. Boudoureseque, Sur l'origine de Caulerpa taxifolia en Méditerranée. C. R. Acad. Sci. Paris, Sciences de la Vie, 319, pp. 603–613, 1996.

[10] J.A.H. Benzie, I.R. Price, and E. Ballment, Population Genetics and Taxonomy of Caulerpa (Chlorophyta) from the Great Barrier Reef, Australia, Journal of Phycology. 33, pp. 491–504, 1997.

[11] C.B.B. Matta, É.T. De Souza, A.C. De Queiroz D.P. De Lira, M.V. De Araújo, L.H.A. Cavalcante-Silva, G.E. De Miranda, J.X. De Araújo-Júnior J.M. Barbosa-Filho B.V. De Oliveira Santos M.S. Alexandre-Moreira, Antinociceptive and Anti-Inflammatory Activity from Algae of the Genus Caulerpa, Drugs. 9, pp. 307-318, 2011.

[12] S.L. Endlicher, and C.M. Diesing, Enumeratio Algarum, Quas ad Oram Insulae Karek, Sinus Persici, legit Theodorus Kotschy, Botanische Zeitung. 3, pp. 268- 269, 1845.

[13] F. Børgesen, Marine Algae From the Iranian Gulf. Scientific investigations in Iran (K. Jessen and R. Sparck, Eds.). Einar, Munksgaard, Copenhagen, Denmark. 1, pp. 47-141, 1939.

[14] J. Sohrabipour, and R. Rabii, A List of Marine Algae of Seashores of Persian Gulf and Oman Sea in

the Hormozgan Province, Iranian Journal of Botany. 8, pp. 131-162, 1999.

[15] J. Sohrabipour, T. Nejadsattari., M. Asadi, and R. Rabii, The Marine Algae of the Southern Coast of Iran, Persian Gulf, Lengeh area, Iranian Journal of Botanical. 10, pp. 83-93, 2004.

[16] K. Rohani, I. Rajabi, H. Rameshi, S. Behzadi, R. Dehghani, S. Tamadoni, and M.R. Hossaini, Study on Distribution and Biomass Estimation of Seaweeds in Hormozgan Coastal Waters and Some of Persian Gulf Islands, Journal of Iranian Science Fisheries. 15, pp. 59–68, 2007.

[17] B.M. Gharanjik, and A.M. Abkenar, Determination of Seaweeds in Sistan va Baluchestan Coasts, Iranian Journal of Fisheries. 1, pp. 37-48, 2000.

[18] J. White, The Plant as A Metapopulation. Annual Review of Ecology, Evolution and Systematics, 10**,** pp. 109-145, 1979.

[19] S. Enomoto, and H. Ohba, Culture Studies on Caulerpa (Chlorophyceae, Caulerpales). I. Reproduction and development of C. racemosa var. laetevirens, Japanese Journal of Phycology. 35, pp. 167-177, 1987.

[20] L. Collado-Vides, and D. Robledo, Morphology and Photosynthesis of Caulerpa (Chlorophyta) in Relation to Their Growth form, Journal of Phycology. 35, pp. 325-330, 1999.

[21] V.J. Paul, and W. Fenical, Chemical Defense in Tropical Green Algae, Order Caulerpales, Marine Ecology Progress Series. 34, pp. 157-169, 1986.

[22] E. Garcia, C. Rodriguez-Prieto, O. Delgado, and E. Ballesteros, Seasonal Light and Temperature Responses of Caulerpa taxifolia from the North Western Mediterranean, Aquatic Botany. 53, pp. 215-225, 1996.

[23] J.G. Agardh, Till Algernes Systematik, I: Caulerpa., II: Zonaria., I l l : Sargassum. Lunds Universitets Arsskrift, 1873.

[24] A. Weber-van Bosse, Monographic des Caulerpes, Annates dujardin Botanique de Buitenzorg. 15, pp. 243-401, 1898.

[25] W.J. Gilbert, An Annotated Checklist of Philippine Marine Chlorophyta, The Philippine Journal of Science. 88, pp. 413-449, 1961.

[26] H.E. Calver, Culture Studies on Some Florida Species of Caulerpa: Morphological Responses to Reduced Illumination, Journal of Phycology. 11, pp. 203-214, 1976.

[27] C.R.C. Sheppard, A.R.G. Price, and C. Robert, Marine ecology of the Arabian region Patterns and processes in extreme tropical environments. London, Academic Press. 1992.

[28] S.A. Azarma, Thermal Structure in Coastal Waters of Central Bushehr (Iran/Persian Gulf), Iranian Journal of Marine Science. 37, pp. 273-278, 2008.

[29] S.M. Musaddad, Temperature and Salinity Variations in the Persian Gulf. International Conference on Life Science and Technology. Singapore. 2011.

[30] P.W. Basson, J.E. Burchard., J.T. Hardy and A.R.G. Prica, Biotopes of the western Arabian Gulf. Dhahran. Aramco. 1977.

[31] C.A. Agardh, Species Algarum. Fucoideae. Berling, Lund, 1820, pp.169–398.

[32] E. Coppejans, and M. Meinesz, Marine Algae of Papua New Guinea (Madang Prov.) Caulerpaceae (Chlorophyta-Caulerpales), Blumea. 33, pp. 181-196, 1988.

[33] M. Nizamuddin, and F. Gessner, The Marine Algae of the Northern Part of the Arabian Sea and the Persian Gulf. "Meteor" Forschungsergebnisse, Reihe D, Biologie. 1970, pp. 1-42.

[34] W.M.R. Taylor, Species of Caulerpa (Chlorophyceae) Collected on the International Indian Ocean Expedition, Blumea. 15, pp. 45-53, 1967.

[35] W.J. Gilbert, Studies on Philippine Chlorophyceae, II: Survey of Literature and List of Recorded Species Prior to 1940. Bulletin of the Torrey Botanical Club, 73, pp. 73-79, 1946.

[36] A.Y. Reyes, A Survey of the Littoral Benthic Algae of the Coastal Areas of Dumaguete City, The Philippine Journal of Science. 99, pp. 131-163, 1972.

[37] C.K. Tseng, Common seaweeds of China. Beijing: Science Press, China. 1984.

[38] G.C., Jr. Trono, Annotated Checklist of Some Marine Benthic Algae from Tawi-Tawi, Sulu Archipelago, University of the Philippines Natural and Applied Science Bulletin. 24 , pp. 85-112, 1972.

[39] O. De Clerck, and E. Coppejans, Marine Algae of the Jubail Marine Wildlife Sanctuary, Saudi Arabia. A marine wildlife sanctuary for the Arabian Gulf. Environment research and conservation following the 1991 Gulf War Oil Spill. NCWCD, Riyadh and Senckenberg Research Institute, Frankfurt. 1996, pp. 199- 289.

[40] C. Gavino, and J. Trono, Diversity of the Seaweed Flora of the Philippines and its Utilization, Hydrobiologia. 399, pp. 1-6, 1999.

[41] J.F.C. Montagne, Centurie de Plantes Cellulaires Exotiques Nouvelles. Annates des Sciences Naturelles (Botanique), 8, pp. 345-370, 1837.

[42] W.J. Gilbert, Notes on Caulerpa from Java and the Philippines. Papers of the Michigan Academy of Sciences, Arts and Letters. 27, pp. 7-26, 1942.

[43] A.Y. Reyes, The Littoral Benthic Algae of Siquijor Province, I: Cyanophyta and Chlorophyta, The PhilippineJournal of Science. 105, pp. 133-191, 1976.

[44] E. Coppejans, F. Leliert, H. Verbruggen, O. De Clerck, T. Schils, T. De Vriese, and D. Marie, The Marine Green and Brown Algae of Rodrigues (Mauritius, Indian Ocean). Journal of Natural History. 38, pp. 2959-3020, 2004.

[45] C.A. Agardh, Species Algarum Rite Cognitae Cum Synonymis, Differentis Specificis et Descriptionibus Succinctis. Lund. 1, pp. 169-521, 1823.

[46] S.M. Keppner, Ntional Management Plan for the Genus Caulerpa.U.S. Fish and Wildlife Service Lower Great Lakes Fishery Resources Office. 2005.

[47] G.T. Velasquez, Seaweed Resources of the Philippines. In Proceedings of the First International Seaweed Symposium, Institute of Seaweed Research, Scotland, 100-101, 1953.

[48] E.G. Menez, The Marine Algae of the Hundred Islands, Philippines, The Philippine Journal of Science. 90, pp. 37-86, 1961.

[49] W.R. Taylor, Records of Asian and Western Pacific Marine Algae, Particularly Algae from Indonesia and the Philippines, Pacific Science. 20, pp. 342-359, 1966.

[50] G.C., Jr. Trono, and A. Tuazon, Notes on Some Marine Benthic Algae from Bakawan and Sula Islands, Province of Catanduanes, Philippines. University of the Philippines Natural Science Research Center Technical Report, 1978.

[51] P.A., Jr. Cordero, Phycological Observations, VI: Mangrove-Associated Algae from Aklan, Philippines. Kalikasan, Philippine Journal of Biology. 7, pp. 275-296, 1978.

[52] D.S., Littler, and M.M. Littler, South Pacific Reef Plants (Washington, DC: Offshore Graphics), 2003.

[53] E. Coppejans, and T. Beekman, Caulerpa (Chlorophyta, Caulerpales) from the Kenyan Coast, Nova Hedwigia. 50, pp. 111–125, 1990.

[54] A. Millar, and B. Talbot, The Introduction of Caulerpa taxifolia in New South Wales, Australia. Royal Botanic Garden Sydney-Aus. 2002.

[55] W.M.R. Taylor, Marine Algae of the Eastern Tropical and Subtropical Coasts of the Americans. Univ. Michigan Press, Ann Arbor. 1960.

[56] L. Egerod, Marine Algae of the Andaman Sea of the Thailand: Chlorophyceae, Botanica Marina. 18, pp. 41-66, 1975.

[57] S.L. Williams, and W.C. Dennison, Light Availability and Diurnal Growth of a Green Macroalgae (Caulerpa cupressoides) and a Seagrass (Halophila decipiens), Marine Biology. 106, pp. 437-443, 1990.