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Description of *Ceramium* Roth Species of Turkey with a New Record for the Mediterranean

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Abstract

A guide for species identification of representatives of the genus Ceramium (Roth, 1797) along the Turkish coast is elaborated in this study. Some of the samples used in this study were collected from our previous field studies. However, inappropriate and missing samples in the Herbarium were collected again. The samples were also studied from the personal herbarium of Hüseyin ERDUĞAN. Twenty-six species of genus Ceramium Roth were found and identified along the shores of Turkey, with Ceramium camouii Dawson 1944, being a new record from the Mediterranean. In this study, a catalog based on the morphological and anatomical characteristics of genus Ceramium Roth found on the shores of Turkey is described.

Introduction

Classifications of living organisms began centuries ago and the process of addition of new species and re-examination of the systematic positions of some known species still continues.

Currently, many studies have been used in the diagnosis of algae; for example, Agardh (1894), Kützing (1845-1855, 1856-1860, 1861-1865, 1866-1869), Hauck (1885), Reinke (1892), Schiffner and Vatova (1937), Feldmann-Mazoyer (1940), Kylin (1944), Feldmann (1949), Taylor (1967), and Kjellman (1971). These studies continue to set an example for much of today's research.

The order of *Ceramiales* is composed of four families: *Ceramiaceae*, *Delesseriaceae*, *Dasyaceae* and *Rhodomelaceae*. *Ceramium* is the genus represented by most taxa in the *Ceramiaceae* family. In our country, *Ceramium* species were described in list studies (Aysel & Erdugan, 1995; Aysel, Erduğan, Sukatar, Güner, & Öztürk, 1996; Erduğan, Aysel, & Güner, 1996; Aysel *et al*., 2004; Aysel, Erduğan, & Dural-Tarakçı, 2005; Aysel, Erduğan, Dural-Tarakçı, & Okudan, 2005; Aysel, Erduğan, Okudan, & Erk, 2005; Aysel, Erduğan, & Okudan, 2006a; Aysel, Erduğan, & Okudan, 2006b; Aysel, Okudan, & Erduğan, 2006; Aysel, Erduğan, Dural, & Okudan, 2006a; Aysel, Erduğan, Dural, & Okudan, 2006b; Aysel, Dural, Şenkardeşler, Erduğan, & Aysel, 2008; Aysel, Erduğan, Dural, & Okudan, 2008; Öztürk, 2011; Taşkın, 2014). In spite of this, taxonomic confusion of *Ceramium* species still continues. Today, although 907 *Ceramium* species are given, only 268 of them are currently accepted (Algaebase, 2018).

In this study, the species of genus *Ceramium* Roth were studied along the Turkish coasts. Twenty-six species of genus *Ceramium* are described in terms of

their morphological and anatomical characteristics with photographs. *Ceramium camouii* is also the first record for the Mediterranean.

Materials and Methods

In this study, samples of *Ceramium* species were studied from Hüseyin Erduğan's herbarium. These collections were obtained from all along the coast of Turkey. If any sample was found not suitable (i.e morphologically deformed sample) for the study, it was collected again. The study included the coasts of Antalya, Muğla, İzmir, Balıkesir, Çanakkale, Bursa, İzmit, Kırklareli, Sinop, Trabzon and Rize (Figure 1). Samples were collected from 0-10 m depth using SCUBA equipment and were preserved in 4% formaldehyde. The algae samples were examined according to classical taxonomy rules (morphological and anatomical examination) with the help of the available literature. Macroscopic and microscopic photographs of the algae are provided in detail.

Anatomical sections were obtained using a new and effective method involving Styrofoam, elderberry and razor blade (original). The razor blade is cleaved horizontally from the middle into two pieces and stuck together. This process is used to obtain the best cross section.

For anatomical examination, 10% HCl was added dropwise to the sample and left to stand for 5 minutes. The sample was then crushed between the slide and lamella to separate thallus cells from the cortex. Prepared samples were examined with Zeiss Primostar, Olympus CX31, and Olympus CX21 microscopes. Photographs were taken with Olympus BX51, Novel N-200M and Olympus SZX7 stereomicroscopes. Photographs of unobtained samples were taken from the previous literature.

For species identification, the following literature was used: Altındağ (1976); Aleem (1993); Coppejans (1983); Cribb (1983); Feldmann-Mazoyer (1940); Feldmann (1949); Fisher (1987); Fritsch (1945); Grunow *et al*. (1885); Hiscock (1986); Jaasund (1976); Kapraun (1980); Kjellman (1971); Kornmann and Sahling (1983); Kützing (1843, 1861-1865); Kylin (1944, 1954); Lawson and John (1982); Levring, Hoppe, and Schmid (1969); Littler, Litter, Bucher, and Norris (1989); Maggs and Hommersand (1993); Milchakova (2003); Millan (1990); Newton (1931); Paciente and Cordero (1977); Pankow (1971); Sauvageau (1971); Schiffner and Vatova (1937); Schneider and Searles (1991); Smith (1944); Taylor (1967); and Van Den Hoek, Mann, and Jahns (1995). Algaebase 2018 was used to check the current names of the samples.

Results

In the present study 26 species of *Ceramium* were reported from the Turkish waters. This is compared to Taşkın, Öztürk, Kurt, and Öztürk (2008) who included 21 species of *Ceramium* in the Turkish algae flora list. Among the species of *Ceramium* recorded in the present study, C*. camouii* E.Y.Dawson 1944 is newly reported from the Mediterranean. The species *C. flaccidum* (Harvey ex Kützing) Ardissone from previous studies (Taşkın *et al*., 2008) was named as *Gayliella flaccida* (Harvey ex Kützing) T. O. Cho & L. J. McIvor based on the morphological and molecular findings (Cho *et al*., 2008).

The characteristics of 26 species of *Ceramium* are given in Table 1.

The characteristic of each species is described below:

Ceramium arborescens J. Agardh 1894

The thallus corticization of the *C. arborescens* is very similar to *C. rubrum*, but the thallus lower parts are in loose cortex cell array, like the lower parts of the *C. pseudostrichum* sample. Unlike the *C. rubrum* sample, the branches end towards the corymb and the ends of the branches do not roll inward but are slightly curved (Figure 2: 1-2). In our sample, tetraspores are embedded

Figure 1. Map of Turkish coasts.

Table 1. List of properties belonging to *Ceramium* taxa

Taxa names	Thallus type	Thallus branch	Branch type	Lateral ramuli	Spina	Transparent hairs	Fixed disc formation in the middle of the thallus	Pericentral cell number	Cortex cells around pericentral cells	Cortex cells	Thallus size	Branch diameter of Thallus top point	Branch diameter of Thallus midpoint	Branch diameter of Thallus subspot	Tetraspores in nods	Cystocarp
Ceramium arborescens	The substrate is connected to a single point	Irregular bifurcation	Usually corymb	Has	Hasn't	Hasn't	Hasn't	8	2 sequence	Continuous throughout the Thallus	8-15cm	100-250µ	500-625µ	800µ	Single-row or double-row	Surrounded by 3-4 branches
Ceramium camouii	Stolon thallus on substrate	Irregular bifurcation	Usually simple (without bifurcation) and erect, slightly	Has	Hasn't	Hasn't	Has	5-7		Not continuous throughout the Thallus	1-5mm	60-80µ	50-150µ		Single-row	Surrounded by a few branches
Ceramium ciliatum* var. *ciliatum	The substrate is connected to a single point	Regular bifurcation	Bifurcation, curved to inside and rarely erect	Has	Has (3-4 cells) verticillate	Hasn't	Hasn't	8	2 sequence	Not continuous throughout the Thallus	5-15cm	100-125µ	200-400µ		Single-row (alternate)	Surrounded by 2-4 branches
Ceramium ciliatum* var. *robustrum	The substrate is connected to a single point	Regular bifurcation	Bifurcation, curved to inside and rarely erect	Has	Has (4-5 cells) verticillate	Hasn't	Hasn't	8	2 sequence	Not continuous throughout the Thallus	5-15cm		200-400µ		Single-row (alternate)	Surrounded by 2-4 branches
Ceramium cimbricum* f. *cimbricum	The substrate is connected to a single point	Regular bifurcation	Erect, bifurcation, slightly curved to inside and	Has	Hasn't	Hasn't	Hasn't			Not continuous throughout the Thallus	4-12,5cm	100µ	80-200µ		Single-row	Surrounded by 2-3 branches
Ceramium cimbricum* f. *flaccidum	The substrate is connected to a single point	Regular bifurcation	Erect, bifurcation and curved to inside	Hasn't	Hasn't	Hasn't	Hasn't	5-6	1 sequence	Not continuous throughout the Thallus	1-7cm	60µ			Single-row	Surrounded by a few branches
Ceramium circinatum	The substrate is connected to a single point	Regular bifurcation	Branch tips are pinched and curved to inside	Has	Hasn't	Görülebilir bazen görülmez	Hasn't	7-9	1 sequence	Not continuous throughout the Thallus	8-20cm	200µ	475-500µ		Single-row or irregular	Surrounded by 2-3 branches
Ceramium codii	Stolon thallus on substrate	Irregular bifurcation	Generally simple straight ends, slightly curved or flat	Hasn't	Hasn't	Hasn't	Has	5	Hasn't	Not continuous throughout the Thallus	1cm		23-50µ		Single-row	Rare
Ceramium deslongchampii	The substrate is connected to a single point	Regular bifurcation	Erect bifurcation and get thinner to the top of branch	Has	Hasn't	Hasn't	Hasn't	7	1 sequence	Not continuous throughout the Thallus	4-12,5cm	65-70µ	150-200µ	450µ	Single-row	
Ceramium diaphanum var. decipiens	The substrate is connected to a single point	Regular bifurcation pinnate or alternate	Young branch tips in the form of two pliers				Hasn't			Not continuous throughout the Thallus						
Ceramium gaditanum* var. *gaditanum	The substrate is connected to a single point	Regular bifurcation	Bifurcation, curved to inside, complicated cortical and	Has	Has (5-8 cells)	Hasn't	Hasn't			Continuous throughout the Thallus	5-8cm				Single-row	Surrounded by 3 branches
Ceramium gaditanum* var. *mediterraneum	The substrate is connected to a single point	Regular bifurcation	Bifurcation, curved to inside, complicated cortical and	Has	Has (Generally 5, 4-8 cells)	Hasn't	Hasn't			Continuous throughout the Thallus	1cm	80µ	200-300µ		Single-row	
Ceramium pseudostrictum	The substrate is connected to a single point	Regular bifurcation	Branch tips are pinched and curved to inside	Has	Hasn't	Hasn't	Hasn't	8	1 sequence	Continuous throughout the Thallus	3-4cm		300-325µ		Single, double, triplet row	Surrounded by 4-5 branches

Table 1. Continued

Taxa names	Thallus type	Thallus branch	Branch type	Lateral ramuli	Spina	Transparent hairs	Fixed disc formation in the middle of the thallus	Pericentral cell number	Cortex cells around pericentral cells	Cortex cells	Thallus size	Branch diameter of Thallus top point	Branch diameter of Thallus midpoint	Branch diameter of Thallus subspot	Tetraspores in nods	Cystocarp
Ceramium virgatum* var. *virgatum	The substrate is connected to a single point	Regular bifurcation	Bifurcation and curved to inside	Has (Low)	Hasn't	Hasn't	Hasn't	8	2 row	Continuous throughout the Thallus	4-30cm	100-150µ	200µ	280-800µ	Irregular	Surrounded by 3-7 branches
Ceramium rubrum* var. *barbatum	The substrate is connected to a single point	Regular bifurcation	Bifurcation and curved to inside	Has (Very)	Hasn't	Hasn't	Hasn't	8	2 row	Continuous throughout the Thallus	6-7cm	175µ	450-600µ		Irregular	Surrounded by 3-5 branches
Ceramium virgatum* var. *implexocontortum	The substrate is connected to a single point	Regular bifurcation	Bifurcation and curved to inside	Has	Hasn't	Has (along thallus)	Hasn't	8	2 row	Continuous throughout the Thallus	4-5cm	150µ	425-450µ	1375µ	Irregular	Surrounded by 2-4 branches
Ceramium secundatum	The substrate is connected to a single point	Regular bifurcation	Bifurcation and curved to inside	Has	Hasn't	Hasn't	Hasn't	8	2 row	Continuous throughout the Thallus	3-8cm	100-150 µ	625-750µ		Single-row, double-row or irregular	Surrounded by 3-4 branches
Ceramium siliquosum* var. *siliquosum	The substrate is connected to a single point	Regular bifurcation and can be alternate	Bifurcation, slightly curved to inside and serrated edges	Has	Hasn't	Hasn't	Hasn't	7	2 row	Not continuous throughout the Thallus	4-20cm	40-125µ	375-500µ		Single-row or double-row	Surrounded by 2-4 branches
Ceramium siliquosum* var. *elegans	The substrate is connected to a single point	Regular bifurcation	Bifurcation and curved to inside	Has (Low)	Hasn't	Hasn't	Hasn't	7	2 row	Not continuous throughout the Thallus	7-8cm	125-150µ	250-350µ		Regular double-row	Surrounded by 2-4 branches
Ceramium siliquosum* var. *lophophorum	The substrate is connected to a single point	Regular bifurcation	Bifurcation, curved to inside, the secretion cells on the outer surface form a toothed ridge	Hasn't	Hasn't	Hasn't	Hasn't	8	2 row	Not continuous throughout the Thallus	1-2cm	50-100µ	100-150µ	175-200µ	Single-row	Surrounded by 2-4 branches
Ceramium siliquosum* var. *zostericola* f. *zostericola	The substrate is connected to a single point	Regular bifurcation	Bifurcation, less threaded, thin and erect	Has	Hasn't	Has	Hasn't	5	2 row	Not continuous throughout the Thallus	6cm	50-100µ	250-275µ		Single-row	
Ceramium diaphanum* var. *zostericola* f. *acrocarpum	The substrate is connected to a single point	Regular bifurcation	Bifurcation and adventive branch tips are paraspores	Has	Hasn't	Hasn't	Hasn't			Not continuous throughout the Thallus	3cm		150-200µ			Always on branch tips
Ceramium siliquosum* f. *minusculum	The substrate is connected to a single point	Regular bifurcation	Upright forked, ends in lace of the folds can be seen	Hasn't	Hasn't	Has (Generally in the lower part of the thallus)	Hasn't	6-7	1 row	Not continuous throughout the Thallus	1-1,5cm	50-75µ	100-175µ	200µ	Single-row	Surrounded by 1-2 branches
Ceramium tenerrimum* var. *tenerrimum	Stolon thallus on substrate	Regular bifurcation	In the form of pliers, slightly curved to inward, flat on the edges	Has (Rare)	Hasn't	Has	Has	7-8	1 row	Not continuous throughout the Thallus	2.5cm	80-100µ		125-150µ	Single-row	
Ceramium tenerrimum* var. *brevizonatum	Stolon thallus on substrate	Regular bifurcation	Bifurcation and curved to inside	Hasn't	Hasn't	Has	Has			Not continuous throughout the Thallus			50-100µ		Single-row	

in the cortex and are in a single row around the axis (Figure 2: 3-5). In the thallus cross section, 8 pericentral cells and 2 rows of cortical cells were arranged around the central cell (Figure 2: 6). The width at the top of the thallus is 250 µm and the middle is 500-625 µm.

Ceramium camouii E.Y.Dawson 1944

This sample is partly similar to the *C. codii* taxon. This similarity to the sample of *C. camouii* can only be said to exist for secondary branches (Figure 3: 5, 8-12). The major axis of this sample was more developed than the cortical cords of the *C. codii* strain (Figure 3: 6-7) and banding was achieved with a greater number of cortical cells. If the thallus cannot be obtained as a whole, it may be confused with the *C. codii* species (Figure 3: 3-4). It has a kind of stolon thallus. As a result, the majority of nodes on the thallus appear to have an adherent disk formation (Figure 3:1-4). It is a small structured sample. Branch tips are erect (Figure 3: 3, 7-9). Main axis diameter is 100 µm in the node, 80 µm in the internode, 80 µm for node of lateral branches and 60 µm for internode of the lateral branches. The internodes can be up to 6 times the height of the nodes. The main axis nodes form a band with 3-4 rows of cells, with bands of 1-2 rows of cells in the side branches (Figure 3: 4-12). This taxon was collected from Yapıldak shore in the Dardanelles.

Ceramium ciliatum* var. *ciliatum (J. Ellis) Ducluzeau 1806

In the cross section of the thallus, 7-8 pericentral and 2 cortical cells are seen around the central cell (Figure 4: 5-6). When central and pericentral examinations are performed on *Ceramium* samples, it should involve taking several sections from various sections of the thallus regardless of section. When multiple sections were taken from thallus of most *Ceramium* species, it was identified that there were different numbers of pericentral cells (Figure 4: 5-6). Axial diameters to branch tips are 125 µm at nodes and 100 µm in internode.

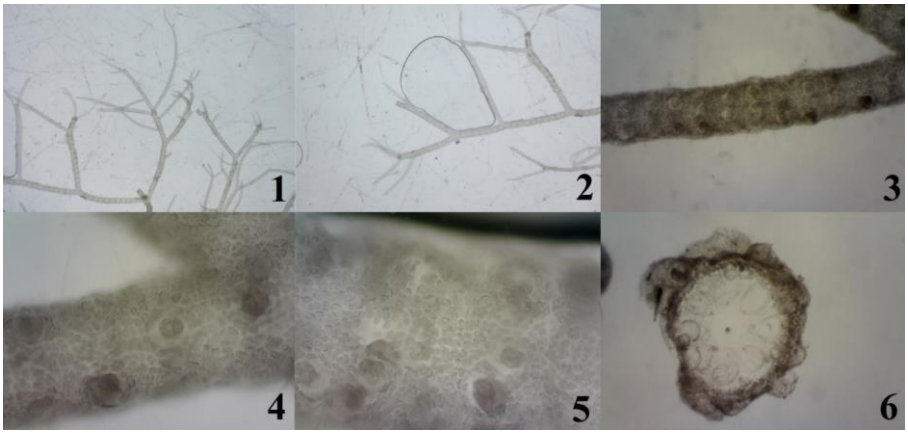

Figure 2. C. arborscens 1-2: Thallus general appearance and corymbic structure of branch tips (stereo microscope), 3: Tetraspores in thallus (4x), 4-5: Tetraspores embedded in cortex (10x), 6: Thallus cross section (4x) (Original).

Figure 3. C. camouii 1-3: Thallus general appearance (4x), 4: Main axis filament and lateral branch (10x), 5-6: lateral branch extending from node and the node internode separation (40x), 7-9: The end of the major and lateral branches (10x), 10: Adherent disc structure (4x), 11-12: Cortex structure in lateral branch (10x) (Original).

Ceramium ciliatum* var. *robustum (J. Agardh) Mazoyer 1973

This sample has the same characteristics as the *C. ciliatum* taxon. The only difference is that the needles are usually 5-cell and rarely 4-cell (Figure 5: 1,3). Tetraspores have inflated nodes and verticillate in a row (Figure 5: 2). Thallus sections are similar to *C. ciliatum* taxa. Pericentrals can be 7-8 (Figure 5: 4-5). There are two rows of cortex around the pericentral cells (Figure 5: 5-6). Diameter of the middle part of thallus is 300 µm at the nodes and 250 µm in the internodes. Diameter of tetrasporic midpoint of thallus is 400 µm at the nodes and 250 µm in the internodes.

Ceramium cimbricum* f. *cimbricum H. E. Petersen 1924

Branch tips are inclined slightly inward, do not roll in, have equal height, with edges slightly serrated (Figure 6: 1). The number of cortical cells in the

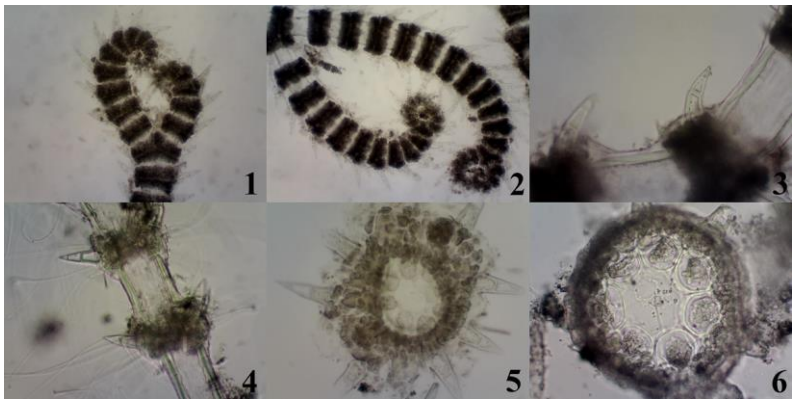

Figure 4. C. ciliatum 1-2: End sections such as the pincer (4x), 3-4: Thallus middle sections (10x), 5-6: Thallus cross section (10x) (Original).

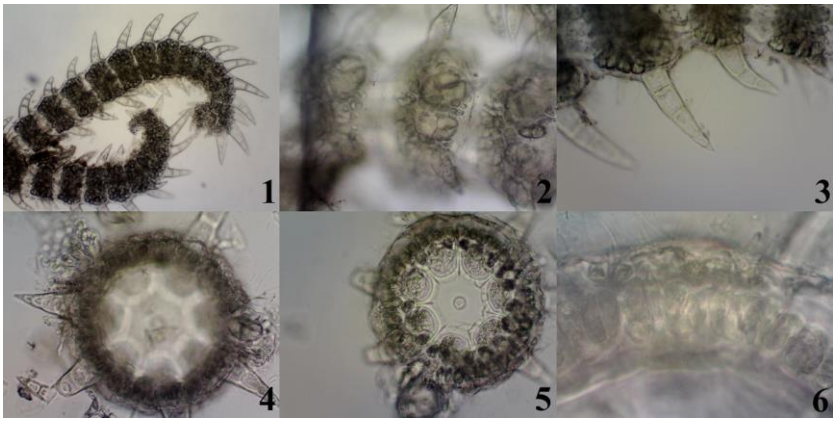

Figure 5. C. ciliatum var. robustrum 1: Barbed branch ends (4x), 2: tetraspores at the node (10x), 3: Lower parts of thallus (10x), 4-5: Thallus cross section (10x), 6: Cross-sectional cortical cells around pericentral cells (40x) (Original).

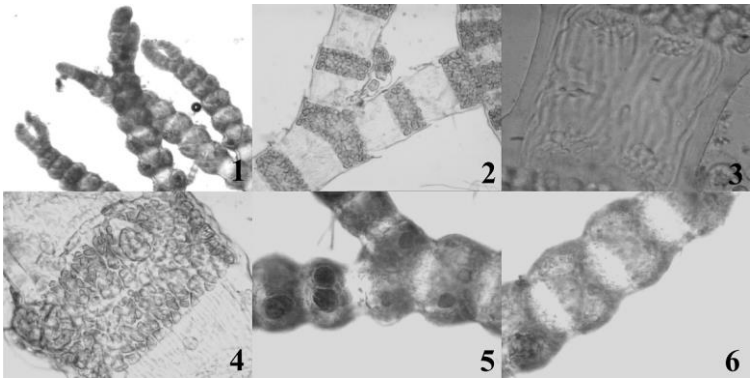

Figure 6. C. cimbricum f. cimbricum 1: Tetrasporated and swollen branch tips (4x), 2: Node internode distinctions (10x), 3-4: Internode and node (40x), 5-6: Tetrasporal thallus fragments (10x) (Original).

tetrasporophyte stage increases and changes the shape of the thallus (Figure 6: 1, 4-6). Thallus corticalization is very low (Figure 6: 2). Although the internodes are transparent, they appear to have line-shaped waves (Figure 6: 3). At branch tips, node internode width is equal and 100 µm. The internodes can be up to 4 times the height of the nodes.

Ceramium cimbricum* f. *flaccidum (H. E. Petersen) Furnari & Serio 1996

Branch tips are bifurcated to almost the same size with a slight curvature. The cortex at the tip of the branches is considerably reduced (Figure 7: 1). Corticalization of nodes is characteristically quite small (Figure 7: 2-3). The nodes are usually banded with 2 rows of cortical cells, sometimes banded with 3 rows of cells (Figure 7: 4). Transparent structures can emerge from the nodes (Figure 7: 2). In cross sections taken from thallus, we can see 5 pericentral cells around the central cell and an outermost single-row cortex cells (Figure 7: 5-6). In some Ceramium specimens, the outer cortices can be separated or dispersed from the pericentral cells because the cortex is loose in the node (Figure 7: 6). For this reason, sections should be taken several times and examined. The node and internode widths at the ends are 60 µm. The sample is tiny and has almost the same width throughout the thallus. Internodes can be up to 6-8 times the height of nodes. The nodes approach each other towards the branch ends.

Ceramium circinatum (Kützing) J. Agardh 1851

This sample can be likened to *C. pseudostrictum* as a sample, but the branch ends are split in this sample and bent inward, and cortical cells may form a slightly serrated edge at the ends of the branches (Figure 8: 1-2). The branch ends of the *C. pseudostrichum* sample are separated into two, then two again, before rolling inward and straightening at the edges. *C. circinatum* cortex is not constant in the upper parts of the thallus, internodes are transparent. Transparent internodes increase in the lower parts while the cortical cells in the nodes extend to the middle parts and partly cover the internodes (Figure 8: 3-4). For this reason, in the case of *C. pseudostrictum*, the lower parts of the thallus are similar to the lower parts of the *C. circinatum* strain, but the upper parts of the thallus consist of a continuous cortex, such as in the *C. rubrum* specimen. Regardless of the point at which the *Ceramium* specimens are examined, the thallus should be examined thoroughly and carefully. Otherwise, systematic errors may occur.

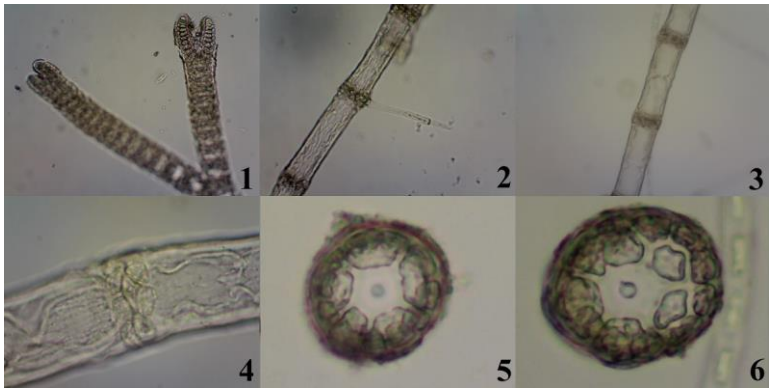

Figure 7. C. cimbricum f. flaccidum 1: Branch tips form a sling (10x), 2-3: Node internode separation (10x), 4: Cortication in the node (40x), 5-6: Thallus cross section (40x) (Original).

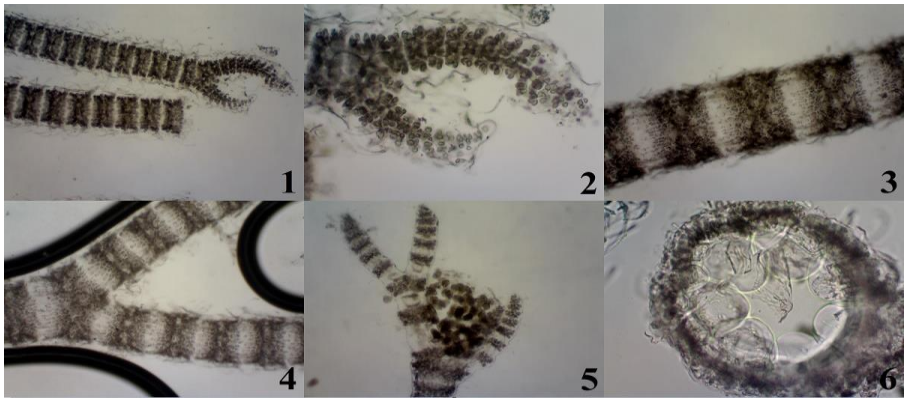

Figure 8. C. circinatum 1: Branch tip (4x), 2: Branch tip (10x), 3-4: Cortex cells which characteristically extend to internodes (4x), 5: Cystocarp structure (4x), 6: Thallus cross section (10x) (Original).

In this sample, the cystocarp can be surrounded by 1-4 small branches (Figure 8: 5). In the thallus sections 7-8 pericentral cells are observed and 2 rows of cortical cells are outermost (Figure 8: 6). Thallus cross sections are similar in most *Ceramium* species. The internodes can be up to 2 times the height of the nodes, but usually are equal or internodes are smaller. In the middle part of the thallus, the diameter of the node is 500 µm and the diameter of the internode is 475 µm.

Ceramium codii (H. Richards) Mazoyer 1938

It is usually epiphytic and is the smallest *Ceramium* species. It is characterized by branch ends that are steep or slightly inclined with weak cortex and little branching (Figure 9: 1-3). Node diameter is 40 µm; internode diameter is 30 µm. They are usually found in low light areas, in the basal parts of rocky areas. Our sample is an epiphyte of the taxa of *Flabellia petiolata* (Turra) Nizamuddin 1987, *Codium adhaerens* C.Agardh 1822, *Halimeda tuna* (J.Ellis & Solander) J.V.Lamouroux 1816 and *Peyssonnelia squamaria* (S.G. Gmelin) Decaisne 1842.

Ceramium deslongchampsii Chauvin ex Duby 1830

The most characteristic feature is that the branches end in a steep and conical shape (Figure 10: 1). The tips of the branch ends are terminated by a cell (Figure 10: 2). When the sample was first collected, red lines were observed in the internodes. Internodes can be up to 2-3 times the nodes. At the tip of the branches, the node diameter is 70 µm and the internode diameter is 65 µm. There is an obvious node-internode distinction (Figure 10: 3-4). The cortices in the nodes are weak and the cortical cells in the center of the nodes are large while cortex cells at the edges are small (Figure 10: 5-6).

Ceramium diaphanum* var. *decipiens Schiffner 1932

C. diaphanum taxon has pinnate and alternate branching; however, this plant should be studied in a significant way. The young branch tips are in the form of two pliers, probably similar in character to *C. strictum* and *C. orthocladum* f. *maxima* species. The nodes are fairly straight like *C.pseudostrictum*, but the tetrasporophyte stage is often small-branched such as in *C. orthocladium* (Schiffner & Vatova, 1937). This taxon was not found in our samples. No photos of this taxon have been found.

Ceramium gaditanum (Clemente) Cremades 1990

This taxon is matte red, more or less gigantic and fragile, without clusters, 5-8 cm in length, with filaments tapered upward. Branching is irregular and dichotomous, arranged in two rows, repeatedly forked. The branches in the upper part carry simple or forked branches. Standing or slightly open side branches are

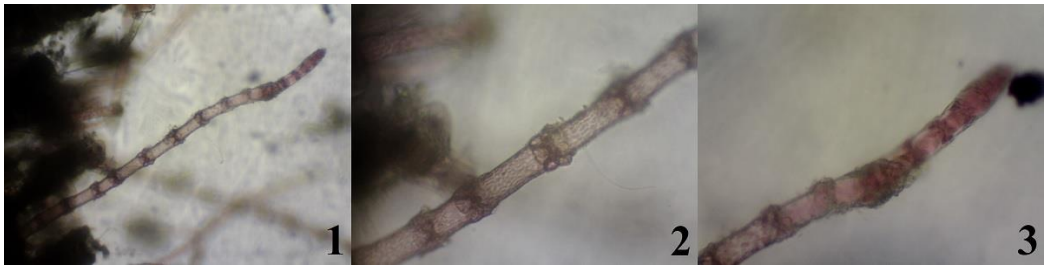

Figure 9. C. codii 1: Thallus general appearance (4x), 2: Node internode separation (10x), 3: Branch tip (10x) (Original).

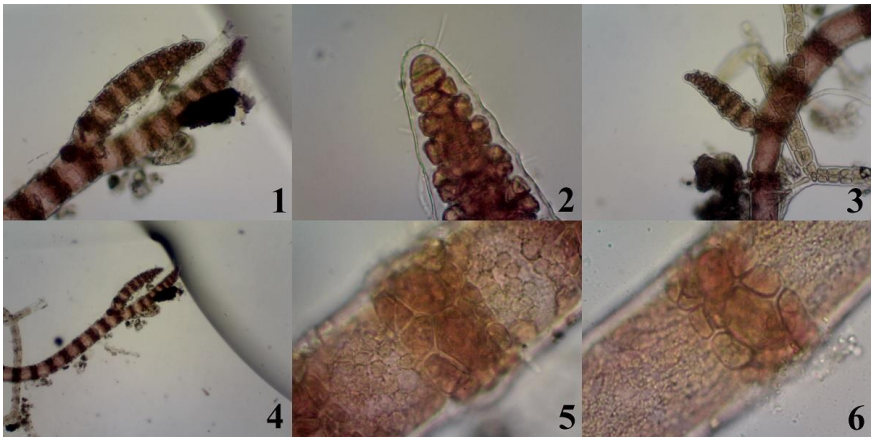

Figure 10. C. deslongchampsii 1: Steep and conical branch tips (10x), 2: Branch tip (40x), 3: Side dichotomy (10x), 4: Thallus general appearance (4x), 5-6: Cortical cells in the node (40x) (Original).

slightly narrower at the bottom, distinctly sparse and the end part is suddenly sharp. The branch tip is usually scattered and sometimes slightly curled, but never inwardly curved like a hook. The head spines are limited to the axis of the base. The head spines are spaced with vague highly pigmented basal cells. The knuckles and crusts occur on all thallus. This situation is two times wider in the lower part. The length and width of thallus are equal at the extreme end. Each node has a sharp edge with a structure like a small thorn. Together with several long-cell cystocarps surrounded by several upper lateral branches, pointed tetrasporangium occupies the entire node as a ring. It is often seen on top of other algae. Epiphytic small algae are found between the tide lines. It is not uncommon, but it is widely distributed (Hiscock, 1986; Newton, 1931).

This taxon was not found in our samples. The branch tips of the *C. gaditanum* taxon and the characteristic multi-cell irregularly arrayed needle structure are shown in Figure 11: 1-2.

Ceramium gaditanum* var. *mediterraneum (Debray) Cremades 1990

This alga height appears as a 1 cm thallus bundle. The diameter of the thallus at the base and central region is 200-300 µm. The diameter of the lateral branches reaches 80 µm. There is no continuous corticalization on the tips, which are flat and needle-free. Single-level cortical ones are bent and twisted. Needles usually consist of five cells; very rarely 4-8 cells. These needles are measured as 20 µm, 28 µm, and 45 µm at the base; however, they reach 35 µm, 75 µm, and 100 µm length in other regions. The smallest of the cortex cells are located on the upper edges of the nodes. The mean size is 4x6 µm and the largest can be measured as 15x20 µm. The width of the axis cells is equal to their height (Feldmann-Mazoyer, 1940).

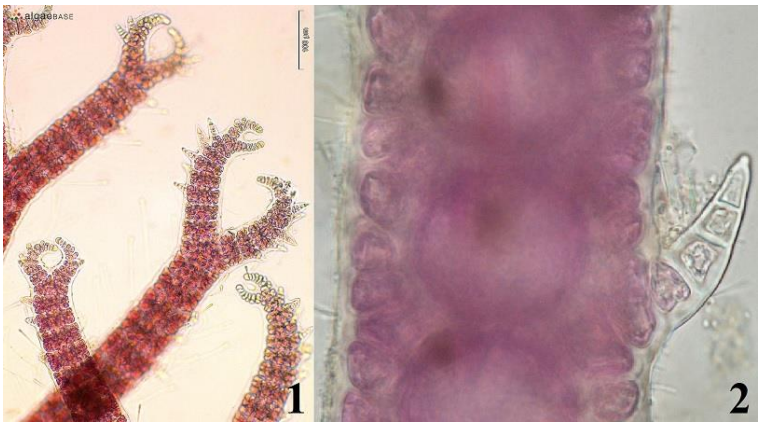

Figure 11. C. gaditanum 1: irregular thorn structure at the edge of the pincers (10x), 2: Spine structure extending from the thallus (40x) (Guiry M.D. in Guiry M.D. and Guiry G.M., 2014.Algae Base).

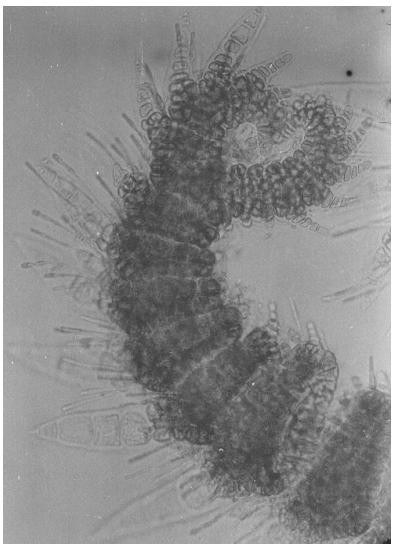

Figure 12. *C. gaditanum* var. *mediterraneum* branch tips and thorn structure (Güner 1987).

This taxon was not found in our samples. A visual example is given in Figure 12 (Güner & Aysel, 1987).

Ceramium pseudostrictum Schiffner 1938

At first sight thallus is strongly reminiscent of the *C. rubrum* taxon (Figure 13: 1,4). When the lower parts of the thallus are examined, unlike the *C. rubrum* taxon, loose alignment is observed in the cortex cells and tight nodes become slightly distant from each other with internodes becoming more apparent. In this case, a structure such as *C. circinatum* appears in internodes (Figure 13: 5-7). Branch tips are slightly rounded and fork-like tips are more or less the same size (Figure 13: 2-3). In the thallus cross section 8 pericentral cells with cortex cells outermost are present around the central cell (Figure 13: 8). In the middle part of the thallus, the diameter of the nodes is 325 µm and the diameter of the internodes is 300 µm.

Ceramium virgatum Roth 1797

C. rubrum and *C. siliquosum* are most prominently classified according to the length of the tip cells and whether or not corticalization is continuous throughout the entire thallus (Hiscock, 1986). Our findings are similar for this taxon. Corticalization is continuous throughout the thallus (Figure 14: 1-3). The tetrasporic thallus is highly swollen and the axis edges are projecting and indented (Figure 14: 4-5). The cystocarps can even be found in the middle of the thallus and are surrounded by 3-7 ramuli (Figure 14: 6-8). The central cell is surrounded by 8 pericentral cells and an outer two rows of cortical cells in thallus transverse section (Figure 14: 9). The diameter of the upper part of the thallus is 125 µm, and the middle part is 200 µm.

Ceramium rubrum* var. *barbatum G.Feldmann-Mazoyer 1941 nom. illeg.

Extreme small branching at the bottom of the thallus is shown in Figure 15: 1-5. Large differences were

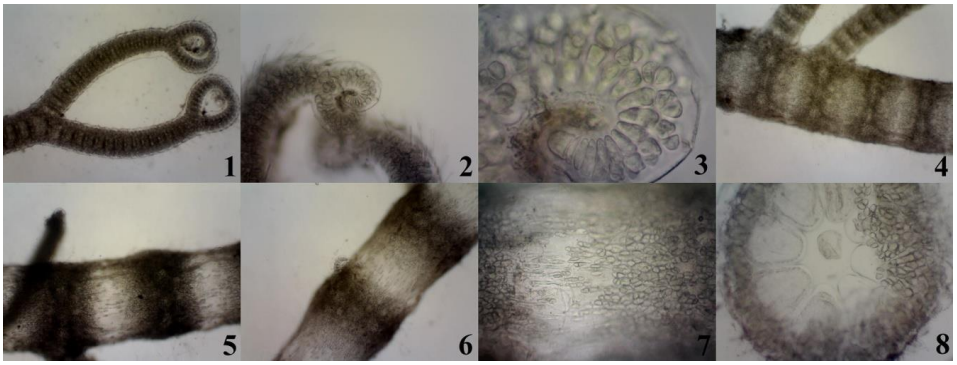

Figure 13. C. pseudostrictum 1: Thallus tip (4x), 2: Branch tips (10x), 3: Hook construction (40x), 4: Cortical structure of upper parts of thallus (10x), 5-6: Cortical structure in lower parts of thallus (10x), 7: Loose cell line with weak cortication at the bottom of the thallus (40x), 8: thallus cross section (40x) (Original).

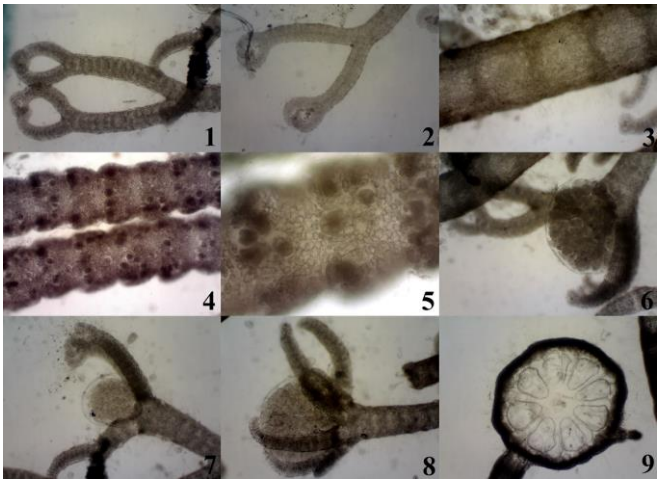

Figure 14. C. virgatum 1-2: Thallus upper part (4x), 3-4: Non-tetrasporous filament and tetrasporous filament (10x), 5: Irregular tetraspores in the cortex (40x), 6-8: Cystocarps surrounded by ramuli (4x), 9: Thallus cross-sectional, central and pericentral cells (10x) (Original).

found in the cortices of two different *C. rubrum* var. *barbatum* specimens in the cystocarpal chamber of samples taken from the Çanakkale coast on May 12, 2013 from Yapıldak altı and Sarı sığlık stations. In the sample taken from the Sarı sığlık station, a structure such as gall formation is observed in the thallus nodes unlike the sample taken from Yapıldak altı station (Figure 15: 1-2, 4-5). Thallus variant differentiation is common in cases taken from various regions like this. *Ceramium* species are easily differentiated according to environmental conditions. If the examinations of the samples are not done carefully, it is possible to provide different names. The thallus cross section is similar to the *C. rubrum* taxon (Figure 15: 6-7). Tetraspores are present irregularly in the nodes (Figure 15: 8). The cystocarp is surrounded by 4-5 ramuli (Figure 15: 9). The upper part of the thallus has a diameter of 175 µm, and the middle part has an axis diameter of 450 µm.

Ceramium virgatum* var. *implexocontortum (Solier) G. Furnari 2003

In this sample, thallus differentiation was observed depending on stations similar to *C. rubrum* var *barbatum* (Figure 16: 3-5). The most distinctive difference from the *C. rubrum* taxon is the presence of transparent hairs throughout the thallus (Figure 16: 1-3). At the beginning of the cystocarp, the branch tips can be seen to be perpendicular (Figure 16: 6). Stages of cystocarp formation are given in Figure 16: 6-9. The diameter of the thallus is 150 µm in the upper part, 450 µm in the middle part and 1.375 mm in the lower part.

Ceramium secundatum Lyngbye 1819

Morphology of this sample is partly similar to the *C. rubrum* taxon, but when carefully considered, the motif of corticalization is different and cortical cells are larger and more pronounced (Figure 17: 3-4). The

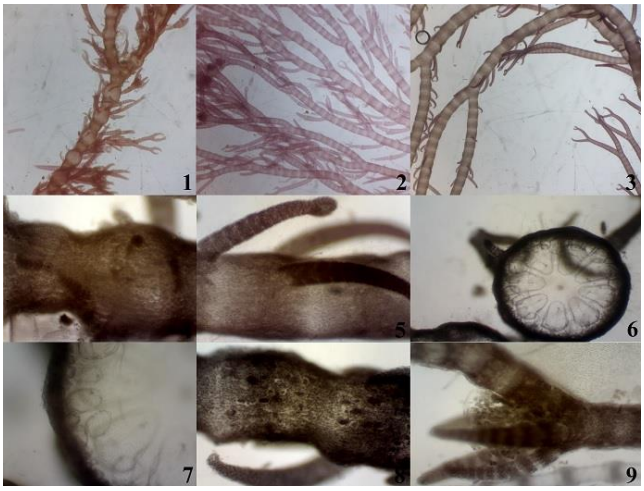

Figure 15. *C. rubrum* var. *barbatum* 1-3: Samples of variants with different appearance (stereo microscope), 4-5: The same specimen shows different appearance of variants (4x), 6: Thallus cross section (4x), 7: Thallus cross section (10x), 8: Tetrasporated filament (4x), 9: Cystocarp surrounded by small branches (4x) (Original).

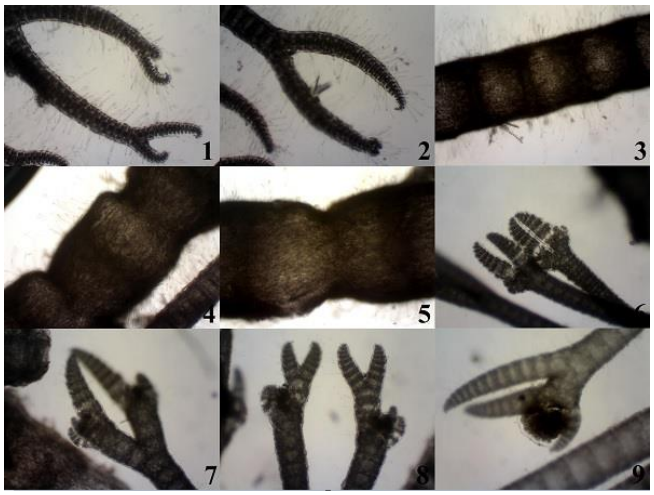

Figure 16. *C. virgatum* var. *implexo-contortum* 1-3: Transparent hairs on thallus (4x), 3-5: Different filaments of the same sample (4x), 6-9: Cystocarp formation stages (4x) (Original).

corticalization covers the whole of the thallus. The characteristic feature is sequential (unidirectional) branching (Figure 17: 1-2). Thallus cross-sections show 7-8 pericentral cells around the central cell and two rows of outer cortical cells (Figure 17: 5-6). Branches end in different lengths and are rounded inward (Figure 17: 3). The diameter of the thallus is 125 µm in the upper part and 625-750 µm in the middle part.

Ceramium siliquosum (Kützing) Maggs & Hommersand 1993

This sample is quite similar to the *C. siliquosus* var. *elegans* taxon. The ends of the branches are rounded and the edges are serrated (Figure 18: 1-2). The edges of branch tips of *C. siliquosus* var. *elegans* tend to be flatter. Node-internode distinction is evident (Figure 18: 3-7). Tetraspores are single, double, and circumferentially sequenced in the nodes (Figure 18: 4-7). In the species of *C. siliquosus* var. *elegans*, tetraspores are arranged in 2 rows in the nodes. In the thallus cross-section, there are 7 pericentral cells and two rows of cortical cells around the central cell (Figure 18: 8-9). The internodes can be up to 3 times the size of the nodes. Node-internode is almost equal in thickness. The diameter of the thallus is 125 µm in the upper part and 375-500 µm in the middle part.

***Ceramium siliquosum* var. *elegans* (Roth) G.Furnari**

The ends of the branches are rounded inward (Figure 19: 1, 4-5). Even if the nodes do not contain tetraspores, they are more swollen than internodes (Figure 19: 1, 6-7). Tetraspores are arranged in two rows in the nodes (Figure 19: 1, 2-3). In the thallus cross-section, there are 7 pericentral cells and two rows of cortical cells around the central cell (Figure 19: 8-9). The cystocarps are surrounded by 2-4 ramuli (Figure 19: 10-12). In the upper part of the thallus diameter are 150 µm in the nodes and 125 µm in the internodes, In the middle part it is 300 µm in the nodes and 250 µm in the internodes.

Ceramium siliquosum* var. *lophophorum (Feldman-

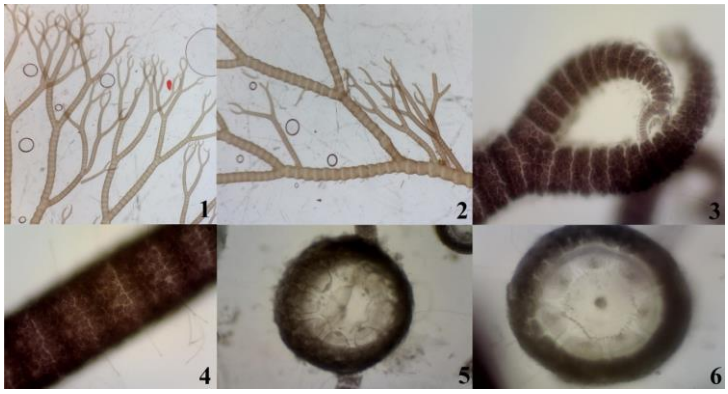

Figure 17. *C. secundatum* 1-2: Thallus branch and general shape (stereo microscope), 3: Branch tips (4x), 4: Filament cortex (4x), 5-6: Thallus cross section (4x) (Original).

Figure 18. *C. siliquosum* var. *siliquosum* 1: Branch tips (4x), 2: Serrated structure on the edges of the branch tips (10x), 3: Node and internode view in the filament (10x), 4-6: External factors result in differentiated tetrasporal thallus (4x), 7: Single row tetraspore structure in the nodes (10x), 8-9: Thallus cross section (10x) (Original).

Mazoyer) Serio

Branches are bifurcated and curled inward (Figure 20: 1-2). It is characterized by the secretory cells on the edges of the branch tips forming a serrated structure (Figure 20: 1-3). The internodes can be up to 5 times the size of the nodes. In some nodes, the cortex appears to be incomplete (two-sided concave lens) (Figure 20: 4-6). It is seen that on one side of some nodes there are smaller cortical cells than normal cortical cells (Figure 20: 7-8). The cystocarps are wrapped by 3-5 ramuli (Figure 20: 10-11). Tetraspores are circumferentially seen in a single row in the nodes (Figure 20: 12). Nodes and internodes are the same width. Thallus diameter is 100 µm in the upper part and 200 µm in the lower part.

Ceramium siliquosum* var. *zostericola (Feldman-Mazoyer) G.Furnari 1999

Branch tips are steep and slightly inclined (Figure 21: 1). Thallus is larger than *C. siliquosum* var. *zostericola* f. *minuscula* and *C. siliquosum* var. *zostericola* f. *acrocarpum*. But these three species generally are small and live as epiphytes. Internodes can be up to two times the size of the nodes. The nodes are separated from internodes by a sharp boundary (Figure 21: 2). Tetraspores highly disrupt the cortex structure of the nodes and are circumferentially sequenced in a single row (Figure 21: 3-4). In the transverse sections taken from the thallus, 5 pericentral cells and 2 rows of cortical cells were seen around the central cell (Figure 21: 5-6). The diameter of the thallus is 100 µm at the tip and 250 µm at the bottom.

Ceramium diaphanum* var. *zostericola* f. *acrocarpum (Kützing) Feldmann-Mazoyer 1941

This *Ceramium* species is about 3 cm high, consists of several small ramuli showing dichotomous branching. The ends of the branches are terminated with parasporal mass. The nodes are very obvious. Nodes can be clearly observed on the entire surface of the algae. The height between two nodes is almost equal. Height (375x350µm) of the nodes is equal at the bottom. Nodes are 150 with 175 µm height and between 150 and 200 µm wide in the middle region. The lower part of the nodes is very clearly bounded. Cortex cells extend along the length of the upper edge, and then continue afterwards at intervals. The following cells of the cortex

Figure 19. *C. siliquosum* var. *elegans* 1,4: Branch tips (4x), 2: Side branches from the thallus (4x), 3: Double row tetraspores in the nodes (10x), 5: Branch tips (10x), 6: Node and internode view of the thallus (4x), 7: Node and internode view of the thallus (10x), 8: Thallus cross section (10x), 9: Thallus cross section (40x), 10-11: Cystocarp formation stages (4x) (Original).

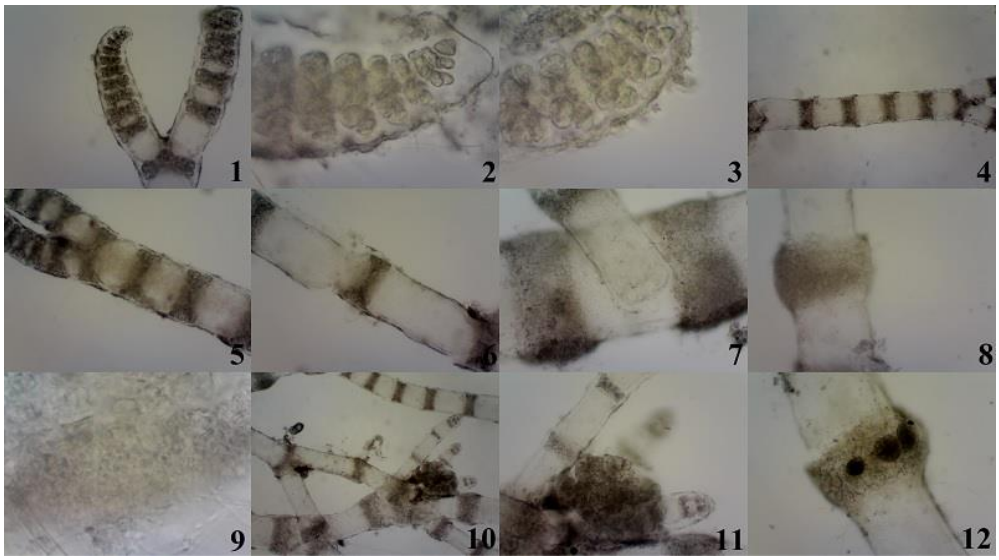

Figure 20. *C. siliquosum* var. *lophophorum* 1: Branch tips (10x), 2-3: Branch end secretory cells (40x), 4: Thallus node and internode view (4x), 5-6: Thallus node and internode view (10x), 7-8: Small sized cortical cells at the node edges (10x), 9: Small sized cortical cells at the edges of the node (40x), 10: Cystocarp structure (4x), 11: Cystocarp structure (10x), 12: Single row of tetraspores in the node (10x) (Original).

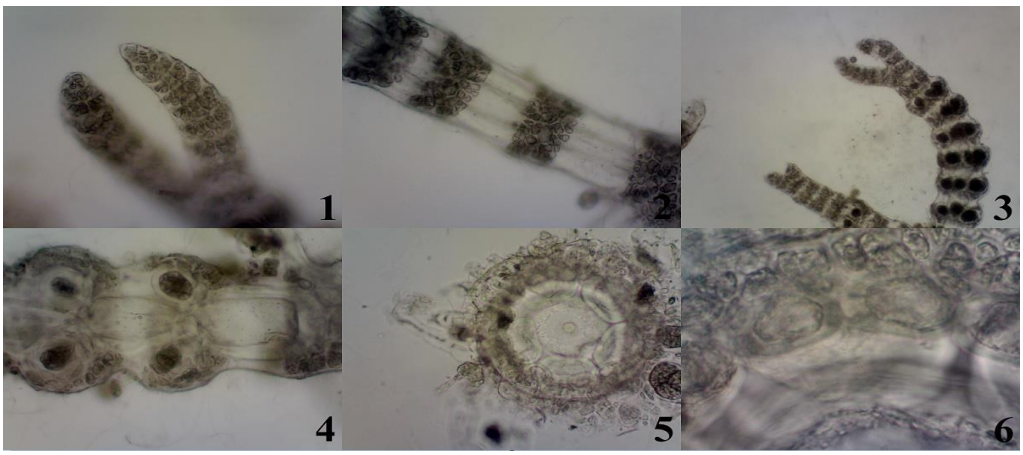

Figure 21. *C. siliquosum* var. *zostericola* 1: Branch tips (10x), 2: Thallus node and internode view (10x), 3: Single row arrayed tetraspores in the node (4x), 4: Single row tetraspores in the node (10x), 5: Body cross section (10x), 6: Body cross section (40x) (Original).

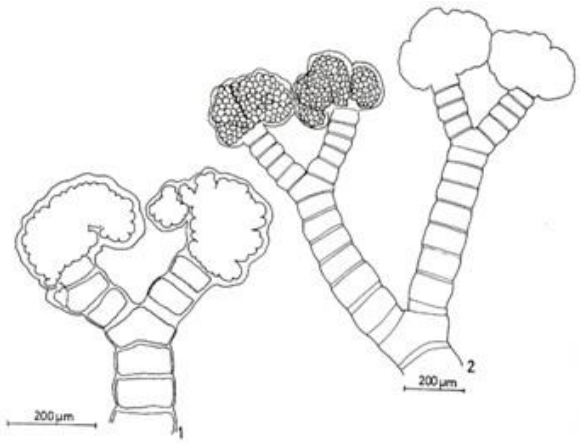

Figure 22. *C. diaphanum* var. *zostericola* f. *acrocarpum* 1: Thallus general appearance and characteristic branch tips, 2: Lobed paraspores in branch tips (Coppejans 1983).

edge are 8x10µm, 8x12 µm, and 10x15µm, with cells in the upper edge are 6x30µm, 8x30µm, and 5x16µm. The adventive branches are from 100 to 120 µm wide and from 400 µm to 1 mm high. These ramuli often result in lobed parasporal masses. They are 200 µm wide and 160 µm high. The diameter of the paraspores is 20-25 µm. These forms are distinguished from other species by the height of their nodes and the presence of their paraspores (Feldmann-Mazoyer, 1940).

This taxon was not found in our samples. Images are taken from Coppejans (1983) (Figure 22).

***Ceramium siliquosum* f. *minusculum* (G. Mazoyer) Garreta *et al*. 2001**

Branch tips are vertical, slightly inclined, and edges of the branch tips are transparent and serrated (Figure 23: 1-5). The internodes can be 1-2 times size of the nodes. The distinction between node and internode is very clear (Figure 23: 6-8). Tetraspores are arrayed in a single row in the nodes (Figure 23: 9-11). The cystocarps are surrounded by 2-4 ramuli (Figure 23: 12-13). In transverse sections taken from the thallus, 6-7 pericentral cells and single-row cortex cells are arranged

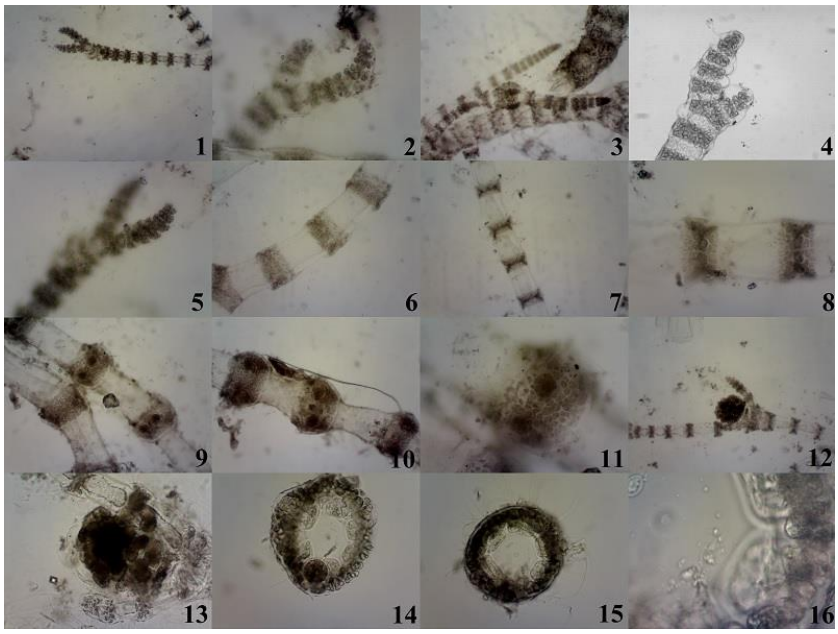

Figure 23. *C. siliquosum* f. *minusculum* 1, 3: Branch tips (4x), 2, 4-5: Branch tips (10x), 6-7: Thallus node and internode view (4x), 8: Thallus node and internode view (10x), 9-10: Tetraspores in a single row in the node (4x), 11: Tetraspores in a single row in the node (10x), 12: Cystocarp structure (4x), 13: Cystocarp structure (10x), 14-15: Thallus cross section (10x), 16: Thallus cross section (40x) (Original).

Figure 24. *C. tenerrimum* 1: Branch tips (4x), 3: Branch tips and transparent feather structure (10x), 2, 4: Thallus node-internode view and transparent extensions from nodes (4x), 5-6: Transparent extensions from the thallus nodes (10x), 7-8: Thallus cross section (10x) (Original).

around the central cell (Figure 23: 14-16). The diameter of the thallus is 75 µm in the upper part of the alga and 200 µm in the lower part.

Ceramium tenerrimum (G. Martens) Okamura 1921

The branch tips are curved inward. Branches and thallus have ciliate-like structures (Figure 24: 1-3, 6). In the lower parts of the thallus, transparent extensions protrude like rhyzoid from the nodes (Figure 24: 4-5). Internodes can be 4-5 times the size of the nodes. The diameter of the thallus is 100 µm in the nodes at the upper part of the alga, and 80 µm in the internodes. The diameter of the thallus is 150 µm in the nodes in the lower part of the alga and 125 µm in the internodes. There are 7-8 pericentral cells around the central cell and an outermost single-row of cortical cells are seen in the thallus cross-section (Figure 24: 7-8).

Ceramium tenerrimum* var. *brevizonatum (H.E. Petersen) Feldmann-Mazoyer

Thallus is small and epiphytic. Our sample is the epiphyte of *Jania rubens* (Linnaeus) J.V.Lamouroux (Figure 25: 2, 4-5). The thallus is stolon-like and the holding disk protrudes from most of the nodes (Figure 25: 2, 4-5). Transparent protrusions are present almost everywhere in the thallus (Figure 25: 1-5). The nodes are

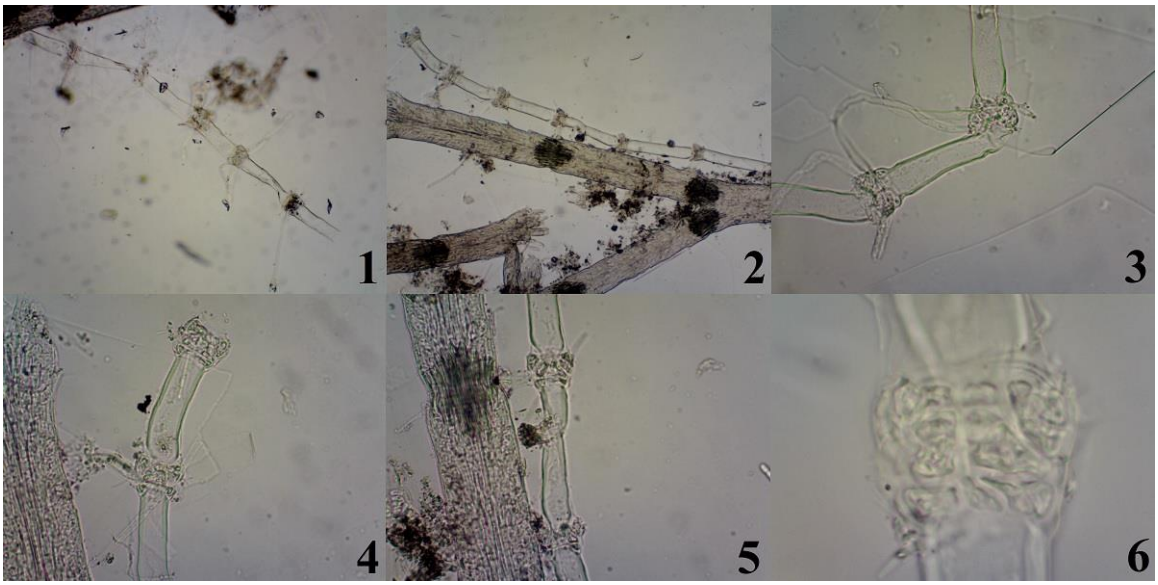

Figure 25. *C. tenerrimum* var. *brevizonatum* 1-2: Transparent protrusions and holding discs on thallus (4x), 3-5: Transparent protrusions and holding discs on thallus (10x), 6: Thallus node and internode view (40x) (Original).

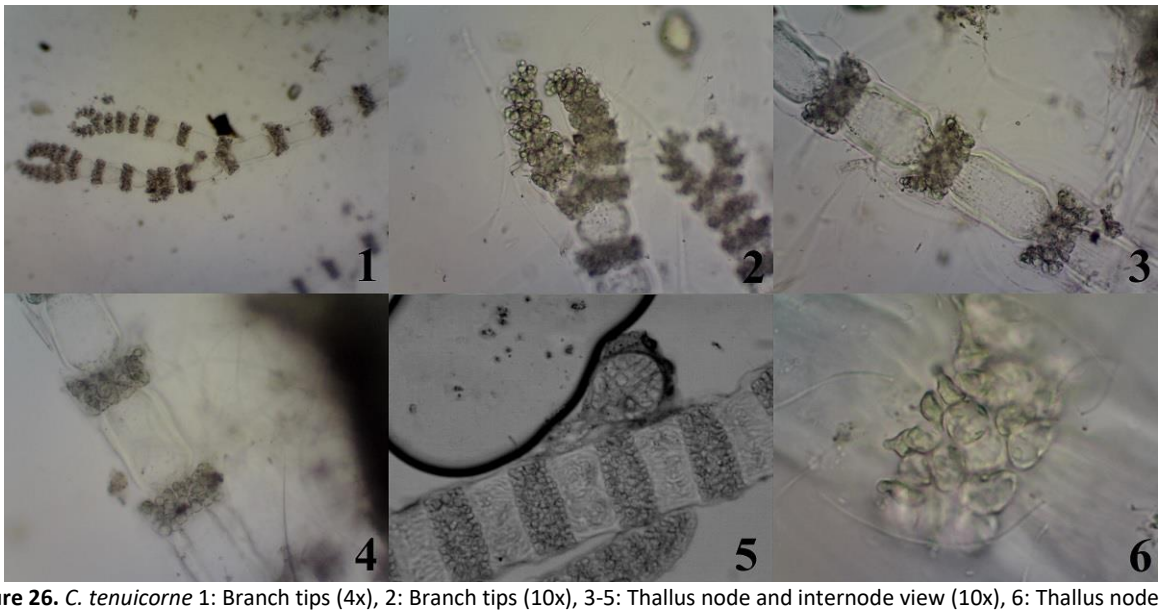

Figure 26. *C. tenuicorne* 1: Branch tips (4x), 2: Branch tips (10x), 3-5: Thallus node and internode view (10x), 6: Thallus node and internode view (40x) (Original).

more swollen than internodes (Figure 25: 6). The internodes can be 7 times the size of the nodes. The diameter is almost the same for the whole thallus. Nodes are 75-100 µm, internodes are 75-50 µm. Corticalization is very weak. There are small cortex cells at the top of the node and large cortical cells at the bottom.

Ceramium tenuicorne (Kützing) Waern 1952

Branch tips are vertical, slightly inclined and the edges protrude (Figure 26: 1-2). The internodes can be twice as many as the nodes. Nodes are larger than internodes (Figure 26: 3-6). Some amorphous cortical cells protrude from the nodes (Figure 26: 6). Ball-shaped structures may extend from the nodes (Figure 26: 5).

Discussion

The information on species of *Ceramium* related to distribution, population sizes and trends is sparse. As mentioned in the introduction, although there are studies about *Ceramium* species in Turkey, there is no study including the descriptive properties and photos of all species together. In this study, *Ceramium* species were described with distinguishing features and images reflecting these features. However, species identification based on morphological and anatomical characteristics has been either approved or disapproved through studies of molecular analyses in recent years. For example, the species identified as *Ceramium flaccidum* (Harvey ex Kützing) Ardissone on the basis of molecular analysis has now been named as *Gayliella flaccida* (Harvey ex Kützing) T.O.Cho & L.J.McIvor (Cho *et al*., 2008). Therefore, there is a need to perform molecular analyses of the *Ceramium* species identified using morphological and anatomical characteristics in the present study as such data will be more reliable and useful. Small taxon groups such as *Ceramium* may be affected morphologically by environmental conditions and thus may show morphological differences in the same species (Kützing, 1841; Agardh, 1894; Dixon, 1960; Womersley, 1978; Rueness, 1992; Boo & Lee, 1994; South & Skelton, 2000; Cho, Riosmena-Rodriguez, & Boo, 2002; Maggs, McIvor, Evans, Rueness, & Stanhope, 2002). An attempt has been made to illustrate these differences with images. For example, small differences were observed in the cortex structures, in the nodes, and in the branches of samples of *Ceramium rubrum* var. *barbatum* and *Ceramium siliquosum* collected from two different spots along the Çanakkale coast in the same period. The formation of such minor differences may lead to different nomenclature of these species and thus lead to systematic confusion (De Barros-Barreto, McIvor, Maggs, & Gomes Ferreira, 2006; South & Skelton, 2000). Another reason for taxonomic problems relates to the lack of objective criteria for determining whether these are due to different phenotypes or result from environmental interactions (Maggs *et al*. 2002). Therefore, detailed taxonomic features of the samples in this study are given with tables and photographs to avoid such problems.

Previous systematic studies are very important in terms of determining the flora when systematic data are presented with photographs and supported by molecular studies, more reliable and more useful databases will be created.

In conclusion, systematic studies of species identification should be carried out in more detail and supported by molecular studies. Thus, the molecular database for the Turkish marine flora can be created and DNA sequences of the samples detected in subsequent studies can be compared with sequences of the samples in the GenBank database to allow verification of the species.

References

Agardh, J. G. (1894). Analecta Algologica; Observationes de Speciebus Algarum Minus Cognitis Earumque Dispositione. Lund, Sweden, Lunds Universitets Arsskrift., 144pp.

Aleem, A.A. (1993). The marine algae of Alexandria. Egypt, Egyptian Book Court., 135pp.

Altındağ, S. (1976). *Some Species of Ceramium in Western Black Sea* (Unpublished Master's Thesis). Ege University, İzmir.

Aysel, V., & Erduğan, H. (1995). Check-list of Blacksea Seaweeds, Turkey (1823-1994). *Turkish Journal of Botany*, *19*(5), 545-554.

Aysel, V., Erduğan, H., Sukatar, A., Güner, H., & Öztürk, M. (1996). Bartin Marine Algae. *Turkish Journal of Botany, 20*(3), 251-258.

Aysel, V., Erduğan, H., Dural-Tarakçı, B., Okudan, E.Ş., Şenkardeşler, A., & Aysel F. (2004). Marine Flora of Sinop (Black Sea, Turkey). *Ege University Journal of Fisheries & Aquatic Sciences, 21*(1-2), 59-68.

Aysel, V., Erduğan, H., & Dural-Tarakçı, B. (2005). Marine flora of Kastamonu (Black Sea, Turkey). *Journal of the Black Sea/Mediterranean Environment, 11*, 179-194.

Aysel, V., Erduğan, H., Dural-Tarakçı, B., & Okudan, E.Ş. (2005). Marine Algae and Seagrass of Giresun Shores (Black Sea, Turkey). *Journal of the Black Sea/Mediterranean Environment, 11*, 271-285

Aysel, V., Erduğan, H., Okudan, E.Ş., & Erk H. (2005). Bozcaada (Çanakkale, Ege Denizi, Türkiye) Deniz Algleri ve Deniz Çayırları. *Ege Üniversitesi Su Ürünleri Dergisi, 22*(1-2), 59-68.

Aysel, V., Erduğan, H., & Okudan, E.Ş. (2006a). Marine Algae and Seagrass of Adana (Mediterranean, Turkey). *Journal of the Black Sea/Mediterranean Environment*, *12*(1), 35-57.

Aysel, V., Okudan, E.Ş., & Erduğan, H. (2006). Marine Algae and Seagrass of Mersin Shore (Mediterranean, Turkey). *Journal of the Black Sea/Mediterranean Environment*, *12*(1), 79-97.

Aysel, V., Erduğan, H., Dural, B., & Okudan, E.Ş. (2006a). Marine Algae and Seagrass of Tekirdağ (Black Sea,

Turkey), *Journal of the Black Sea/Mediterranean Environment*, *12*, 251-267.

Aysel, V., Erduğan, H., & Okudan, E.Ş. (2006b). Marine Algae and Seagrasses of Hatay. *Journal of the Black Sea/Mediterranean Environment*, *12*, 159-179.

Aysel, V., Erduğan, H., Dural, B., & Okudan, E.Ş. (2006b). İstanbul Çevresinde Deniz Algleri ve Deniz Çayırları İncelemesi. *Journal of the Black Sea/Mediterranean Environment, 14*, 129-144.

Aysel, V., Dural, B., Şenkardeşler, A., Erduğan, H., & Aysel F. (2008). Marine Algae and Seagrass of Samsun (Black Sea, Turkey). *Journal of the Black Sea/Mediterranean Environment*, *14*, 53-67.

Aysel, V., Erduğan, H., Dural, B., & Okudan E.Ş. (2008). A Survey of Marine Algae and Seagrasses of İstanbul. *Journal of the Black Sea/Mediterranean Environment*, *14*. 129-145.

Boo, S. M., & Lee, I. K. (1994). Ceramium and Campylaephora (Ceramiaceae, Rhodophyta). In Biology of Economic Algae. Hague, Holland, SPB Academic Publishers., 33pp.

Cho, T. O., Riosmena-Rodriguez, R., & Boo, S. M. (2002). Developmental Morphology of a Poorly Documented Alga, Ceramium recticorticum (Ceramiaceae, Rhodophyta) from the Gulf of California, Mexico. *Cryptogamie Algologie 23*, 277–289.

Cho, T.O., Boo, S.M., Hommersand, M.H., Maggs, C.A., McIvor, L., & Fredericq, S. (2008). Gayliella Gen. Nov. in the Tribe *Ceramieae* (*Ceramiaceae*, *Rhodophyta*) Based on Molecular and Morphological Evidence. *Journal of Phycology*, *44*(3), 721-738. http://dx.doi.org/10.1111/j.1529-8817.2008.00505.x

Coppejans, E. (1983). Iconographie d'algues Méditerranéennes. Vaduz, Germany, J. Cramer., 317pp.

Cribb, A.B. (1983). Marine Algae of the Southern Great Barrier Reef. Part 1. Rhodophyta. Brisbane, Avustralya, Australian Coral Reef Society, Incorporating the Great Barrier Reef Committee., 173pp.

De Barros-Barreto, M. B., McIvor, L., Maggs, C. A., & Gomes Ferreira, P. C. (2006). Molecular Systematics of Ceramium and Centroceras (Ceramiaceae, Rhodophyta) from Brazil. *Journal of Phycology*, *42*(4), 905-921. http://dx.doi.org/10.1111/j.1529-8817.2006.00237.x

- Dixon, P. S. (1960). Studies on Marine Algae of the British Isles: The genus Ceramium. *Journal of the Marine Biological Association of the United Kingdom 39*, 331–374. http://dx.doi.org/10.1017/S0025315400013370

Erduğan, H., Aysel, V., & Güner, H. (1996). Rize-Sarp Arası Deniz Algleri, Karadeniz, Türkiye. *Turkish Journal of Botany*, *20*, 103-108.

Erduğan, H. (1998). *Sinop Trabzon Arası Deniz Alglerinin Taksonomisi* (Doktora Tezi). Ege Üniversitesi, İzmir, Türkiye.

Feldmann - Mazoyer, G. (1940). Recherches Sur Les Céramiacées de la Méditerranée Occidentale. Rue Clauzel, France, Alger Imprimerie Minerva., 510 pp.

Feldmann, J. (1949). Une Nouvelle Espece de Chondria des Cotes d'Algerie. *Memoires Societe Histoire Naturelle Afrrica du Nord*, *2*, 95-101.

Fisher, W. (1987). Mediteranne Et Mer Noir., Zone De Peche 37. Volume I. Vegetaux Et Invertebres. Publication préparée per la FAO, résultant d'un accord entre la FAO et la Commission des Communautés européennes (Projet GCP/INT/422/EEC) et financée conjointement par ces deux organisations. Rome, Italy., 136 pp.

Fritsch, F.E. (1945). The Structure and Reproduction of the Algae, Volume II, Foreward, Phaeophyceae, Rhodophyceae, Myxophyceae. Great Britain, Cambridge University Press., 939 pp.

Grunow, A., Hauck, F., Limpricht, G., Luerssen, Ch., Richter, P., & Winter G. (1885). Dr. L. Rabenhorst's Kryptogammen-Flora von Deutschland, Oesterreich unde der Schweiz (2. Auflage). Leipzig, Germany, Verlag von Edward Krummer., 570 pp.

Guiry M.D. in Guiry M.D., & Guiry G.M. (2018). Algae Base. World-wide Electronic Publication, National University of Ireland, Galway. http://www.algaebase.org, searched on 20 June 2018.

Güner, H., & Aysel V. (1987). Marmara Denizi'nin Sahil Algleri Üzerinde Taksonomik ve Ekolojik Araştırmalar (Türkiye Bilimsel ve Teknik Araştırma Kurumu Temel Bilimler Araştırma Grubu Proje No: TBAG-599). İzmir, Türkiye, 192pp.

Hauck, F. (1885). Die Meeresalgen Deutschlands und Oesterreichs. Leipzig, Germany, Verlag von Eduard Kummer., 575pp.

Hiscock, S. (1986). A Field Key to the British Red Seaweeds (Rhodophyta). Occasional Publications No. 13. Field Studies Council. Dorchester, England, Dorset Press., 100pp.

Jaasund, E. (1976). Intertidal Seaweeds in Tanzania: a Field Guide. Tromsø, Norway, Tromsø University., 160pp.

Kapraun, D.F. (1980). An Illustrated Guide to the benthic marine algae of coastal North Carolina I. Rhodophyta. North Carolina, USA, University of North Carolina Press., 206pp.

Kjellman, F.R. (1971). The Algae of the Arctic Sea. A Survey of the Species, Together with an Exposition of the General Characters and the Development of the Flora. Konigstein, Germany, Otto Koeltz., 350pp.

Kornmann, P., & Sahling, P.H. (1983). Meeresalgen von Helgoland, Benthische Grün-, Braun-und Rotalgen (2.Druck)., Hamburg, Germany, Biologische Anstalt Helgoland., 289pp.

Kützing, F. T. (1841). Ueber Ceramium Ag. *Linnaea 15*, 727–746.

Kützing, F.T. (1843). Phycologia Generalis. oder Anatomie, Physiologie und Systemkunde der Tange. Leipzig, Germany, F.A. Brockhaus., 458pp.

Kützing, F.T. (1845-1855). Tabulae Phycologicae oder Abbildungen der Tange. Nordhausen, Germany, Gedruckt auf Kosten des Verfassers., 672pp.

Kützing, F.T. (1856-1860). Tabulae Phycologicae oder Abbildungen der Tange. Nordhausen, Germany, Gedruckt auf Kosten des Verfassers.,704pp.

Kützing, F.T. (1861-1865). Tabulae Phycologicae oder Abbildungen der Tange. Nordhausen, Germany, Gedruckt auf Kosten des Verfassers., 664pp.

Kützing, F.T. (1866-1869). Tabulae Phycologicae oder Abbildungen der Tange. Nordhausen, Germany, Gedruckt auf Kosten des Verfassers., 593pp

Kylin, H. (1944). Die Rhodophyceen der Schwedischen West Küste. Lund, Sweden, CWK Gleerup., 104pp

Kylin, H. (1954). Die Gattungen der Rhodophyceen. Lund, Sweden, CWK Gleerups Forlag., 673pp.

Lawson, G.W., & John D.M. (1982). The Marine Algae and Coastal Environment of Tropical West Africa. Germany, J. Cramer Publisher., 450pp.

Levring, T., Hoppe, H.A., & Schmid, O.T. (1969). Marine Algae, A Survey of Research and Utilization. Hamburg, Germany Cram, De Gruyter & Co., 421pp.

Littler, D.S., Littler, M.M., Bucher, K.E. & Norris J.N. (1989). Marine Plants of the Caribbean, A Field Guide From Folrida to Brazil. Washington, USA, Smithsonian Institution Press., 263pp.

Maggs, C.A., & Hommersand, M.H. (1993). Seaweeds of the British Isles. Volume 1. Rhodophyta. Part 3A. Ceramiales. London, England, London HMSO., 444pp.

Maggs, C A., McIvor, L. M., Evans, C. E., Rueness, J. & Stanhope, M. J. (2002). Molecular Analyses Elucidate the Taxonomy of Fully Corticated, Nonspiny Species of Ceramium (Ceramiaceae, Rhodophyta) in the British Isles. *Phycologia 41*, 409–420. http://dx.doi.org/10.2216/i0031-8884-41-4-409.1

Milchakova, N.A. (2003). Red Algae (Rhodophyceae) of the Black Sea. Ceramiales. Taxonomic Composition and Distribution. *International Journal on Algae*, *5*(4), 1-13. http://dx.doi.org/10.1615/InterJAlgae.v5.i4.10

Millan, A.J.K. (1990). Marine Red Algae of the Coffs Harbor Region, Northern New South Wales. *Australian Systematic Botany*, *3*(3), 293-593.

Newton, L. (1931). A Handbook of the British Seaweeds. London, England, British Museum., 478pp.

Öztürk, A. (2011). *Çanakkale Boğazı'nda (Türkiye) Yayılış Gösteren Bazı Ceramium Roth Türlerinin Moleküler Sistematiği* (Yüksek Lisans Tezi). Çanakkale Onsekiz Mart Üniversitesi, Çanakkale.

Paciente, A., & Cordero, Jr. (1977). Studies on Philippine Marine Red Algae. Hiroshima, Japan, Adigaku Letterpress Co ltd., 258pp.

Pankow, H. (1971). Algenflora der Ostsee I. Benthos (Blau-, Grün-, Braun- und Rotalgen). Stuttgart, Germany, G. Fischer., 419pp.

Reinke, J. (1892). Atlas Deutscher Meeresalgen. Berlin, Germany, Paul Parey.,70pp.

Rueness, J. (1992). Ceramium cimbricum (Rhodophyceae, Ceramiales) from Scandinavia; Structure, Reproduction and Systematics. *Nordic Journal of Botany 12*, 135-140. http://dx.doi.org/10.1111/j.1756-1051.1992.tb00209.x

Sauvageau, C. (1971). Sur Quelques Myrionemacees. New York, USA, Wheldon & Wesley ltd., 807pp.

Schiffner, V., & Vatova A. (1937). Le Alghe Della Laguna di Venezia. Venezia, Italy, Officine Grafiche Ferrari., 174pp.

Schneider, C.W., & Searles, R.B. (1991). Seaweeds of the Southeastern United States: Cape Hatteras to Cape Canaveral. United States of America, Duke University Press., 553pp.

Smith, G.M. (1944). Marine Algae of the Monterey Peninsula California. California, USA, Stanford University Press., 622pp.

South, G. R., & Skelton, P. A. (2000). A Review of Ceramium (Rhodophyceae, Ceramiales) from Fiji and Samoa, South Pacific. *Micronesica 33*(1/2), 45-98.

Taşkın, E., Öztürk, M., Kurt, O., & Öztürk, M. (2008). The Check-list of the Marine Flora of Turkey. Manisa, Turkey, Ecem Kırtasiye., 87pp.

Taşkın, E. (2014). Interpretation of Turkish Marine Algae in Lamouroux (1822). *Bağbahçe Bilim Dergisi*. *1*(2), 14-23.

Taylor, WM.R. (1967). The Marine Algae of Florida with Special Reference to the Dry Tortugas. Germany, Verlag von J. Cramer., 219pp.

Van Den Hoek, C., Mann, D.G., & Jahns, H.M. (1995). Algae: An Introduction to Phycology (Second Edition). United Kingdom, Cambridge University Press., 627pp.

Womersley, H. B. (1978). Southern Australian Species of Ceramium Roth (Rhodophyta). *Australian Journal of Marine & Freshwater Research, 29*, 205–257.