Cryptogamie, Algologie, 2014, 35 (3): 269-283

Cystoseira taxa new for the marine flora of Tunisia

Cyrine BOUAFIF[a], Marc VERLAQUE[b] & Habib LANGAR[a]*

[a]Université de Tunis El Manar, Faculté des Sciences de Tunis,
UR11ES08 Biologie Intégrative et Écologie Évolutive
et Fonctionnelle des Milieux Aquatiques, 2092, Tunis, Tunisie

[b]Institut Méditerranéen d'Océanologie (MIO), Aix-Marseille Université,
CNRS/IRD UM 110, Campus de Luminy Case 901, 13288 Marseille cedex 9, France

Abstract – An inventory of upper subtidal *Cystoseira* (0-5 m depth) of the Tunisian coasts (La Galite Archipelago excluded) was carried out from March 2012 to February 2013. Seven Mediterranean endemic taxa new for Tunisia were collected: 4 species, *Cystoseira algeriensis*, *C. barbatula*, *C. crinitophylla*, *C. susanensis*, and 3 infraspecific taxa, *C. compressa* f. *plana*, *C. foeniculacea* f. *latiramosa* and f. *tenuiramosa*. Each taxon is described and their Tunisian range of distribution is given and discussed.

***Cystoseira* / Fucales / Ochrophyta / Tunisia / First record**

Résumé – Un inventaire des *Cystoseira* de l'infralittoral supérieur (0-5 m de profondeur) du littoral tunisien (à l'exception de l'Archipel de La Galite) a été effectué entre mars 2012 et février 2013. Sept taxa endémiques de Méditerranée nouveaux pour la Tunisie ont été récoltés: 4 espèces, *Cystoseira algeriensis*, *C. barbatula*, *C. crinitophylla* et *C. susanensis*, et 3 taxons infraspécifiques, *C. compressa* f. *plana*, *C. foeniculacea* f. *latiramosa* et f. *tenuiramosa*. La description détaillée de chaque taxon, avec leur répartition en Tunisie sont présentées et discutées.

***Cystoseira* / Fucales / Ochrophyta / Tunisie / Première signalisation**

INTRODUCTION

Cystoseira is one of the most widely distributed genera of the Fucales (Ochrophyta, Phaeophyceae) (Amico, 1995; Draisma *et al*., 2010) and the majority of taxa are found in the Mediterranean Sea and the adjacent Atlantic Ocean (Oliveras & Gómez, 1989; Amico, 1995). The number of species throughout the world is still uncertain. Draisma *et al*., (2010) reported 65 taxa of which 60 identified to species level, while Guiry & Guiry (2014) listed 38 species as "currently accepted taxonomically". In the Mediterranean Sea, 29 species (19 endemic) and 11 infraspecific taxa are present (Ribera *et al*., 1992; Cormaci *et al*., 2012; Taşkin *et al.,* 2012; Guiry & Guiry, 2014). According to Draisma *et al.* (2010), the genus *Cystoseira* in the Mediterranean actually would represent 3 separate genera based on a DNA phylogeny, but an official proposal to split up

* Corresponding author: bouafif.cyrine@gmail.com

doi/10.7872/crya.v35.iss3.2014.269

the genus has not been made due to lack of diagnostic morphological characters and incomplete sampling.

Cystoseira spp. are canopy-forming species of high ecological and economic value. In the Mediterranean Sea, *Cystoseira* species are ranked among the major keystone species (*sensu* Paine, 1969) or engineering species (*sensu* Jones *et al*., 1994) of the upper subtidal zone (0-80 m depth) (Feldmann, 1937; Boudouresque, 1971; Giaccone, 1973; Giaccone & Bruni, 1973; Sales & Ballesteros, 2009). *Cystoseira* assemblages are considered biodiversity and productivity hotspots (*sensu* Myers 1988, 1990) since they provide habitat, food, refuge, spawning and nursery fields for many organisms (Hoffmann *et al*., 1992; Ballesteros *et al*., 1998, 2009; Bulleri *et al*., 2002; Mangialajo *et al*., 2008; Vergés *et al*., 2009; Cheminée *et al*., 2010, 2013; Sales & Ballesteros, 2012).

Because of (i) their endemic status or their rarity at Mediterranean level (Rodríguez-Prieto & Polo, 1996; Alongi *et al*., 1999; Antonioli *et al*., 1999), (ii) the degree of threat (Bellan-Santini, 1968; Hoffman *et al*., 1988; Ballesteros *et al*., 1998; Benedetti-Cecchi *et al.,* 2001; Thibaut *et al*., 2005; Serio *et al*., 2006) and (iii) their structuring nature (Ballesteros *et al*., 1998; Ruitton *et al*., 2000; Benedetti-Cecchi *et al*., 2001; Bulleri *et al*., 2002), all the *Cystoseira* species of the Mediterranean Sea (except *C. compressa*) are listed in the amended Annex II (List of Endangered and Threatened Species) of the Protocol of the Barcelona Convention concerning Specially Protected Areas and Biological Diversity in the Mediterranean (SPA/BD protocol) (UNEP-PAM-RAC/SPA, 2012).

Referring to a bibliographical checklist of the Tunisian benthic marine flora (Ben Maiz *et al*., 1987), an inventory of *Cystoseira* species of the Gulf of Gabès (SE Tunisia) (Hamza, 1987) and to literature reviews on Mediterranean's Phaeophyceae (Ribera *et al*., 1992) and on *Cystoseira* in the western Mediterranean Sea (Báez *et al*., 2005) we listed 18 taxa of *Cystoseira* for Tunisia reported as accepted taxa in Guiry & Guiry (2014) (Tab. 1).

However the privileged geographical position of this country at the crossroads between the eastern and western Mediterranean basins suggests that this number could be an underestimate. The aim of this paper is to update our knowledge on Tunisian *Cystoseira* taxa and their ecology, and to contribute to the knowledge of the Mediterranean biogeography of the genus.

MATERIAL AND METHODS

Sampling took place from March 2012 to February 2013. Specimens were collected at 16 localities by snorkeling in the upper subtidal zone (0-5 m depth) along the Tunisian coast (with the exception of La Galite Archipelago), from the Algerian border (Melloula Bay, 36° 57' 46.65"N; 8° 42' 55.35"E) to the Libyan border (Tunisian port of El Ketef, 33°10'54.77" N; 11°29'3.49" E) (Fig. 1). In each locality, 10 specimens of each species encountered were collected if possible.

Fresh samples were transported to the laboratory in plastic bags with seawater. *Cystoseira* species were immediately cleaned and thoroughly rinsed with freshwater to remove epiphytes. For each specimen, small fragments were preserved in absolute Ethanol (for later DNA isolation), while the rest were either preserved in 4% buffered formalin/seawater or pressed, air dried and prepared as a herbarium specimen.

Table 1. Critical review of *Cystoseira* species previously recorded from Tunisia

Ben Maiz et al., *1987*	*Hamza, 1987*	*Ribera* et al., *1992*	*Báez* et al., *2005*	*Accepted names*
C. stricta (Montagne) Sauvageau, *C. stricta* var. *amentacea* (Bory) Giaccone	*C. stricta* (Montagne) Sauvageau, *C. spicata* Ercegovič	*C. amentacea* Bory, *C. amentacea* Bory var. *spicata* (Ercegovič) Giaccone and var. *stricta* Montagne	*C. amentacea* Bory	*C. amentacea* (C. Agardh) Bory de Saint-Vincent var. *stricta* Montagne
C. barbata (Goodenough & Woodward) C. Agardh, *C. hoppii* Valiante [1]	*C. barbata* (Goodenough & C. Woodward) C. Agardh	*C. barbata* (Stackhouse) C. Agardh	*C. barbata* C. Agardh	*C. barbata* (Stackhouse) C. Agardh
C. caespitosa Sauvageau	–	*C. brachycarpa* J. Agardh emend. Giaccone var. *balearica* (Sauvageau) Giaccone	*C. brachycarpa* J. Agardh emend. Giaccone	*C. brachycarpa* J. Agardh
C. compressa (Esper) Gerloff & Nizamuddin	*C. fimbriata* (Desfontaines) Bory	*C. compressa* (Esper) Gerloff & Nizamuddin	*C. compressa* (Esper) Gerloff & Nizamuddin	*C. compressa* (Esper) Gerloff & Nizamuddin
C. crinita (Desfontaines) Bory	*C. crinita* (Desfontaines) Bory	*C. crinita* (Desfontaines) Bory	*C. crinita* (Desfontaines) Bory	*C. crinita* Duby
C. dubia Valiante	*C. fucoides* Ercegovič	*C. dubia* Valiante	*C. dubia* Valiante	*C. dubia* Valiante
C. elegans Sauvageau		*C. elegans* Sauvageau	*C. elegans* Sauvageau	*C. elegans* Sauvageau
C. ercegovicii Giaccone, *C. schiffneri* Hamel	*C. discors* (Linnaeus) C. Agardh, *C. schiffneri* Hamel	*C. schiffneri* Hamel	*C. schiffneri* Hamel	*C. foeniculacea* f. *schiffneri* (Hamel) Gómez Garreta *et al.*
C. humilis var. *myriophylloides* (Sauvageau) Price & John	–	*C. humilis* var. *myriophylloides* (Sauvageau) Price & John	*C. humilis* Kützing	*C. humilis* var. *myriophylloides* (Sauvageau) J.H.Price & D.M.John [2]
C. mediterranea Sauvageau	*C. mediterranea* Sauvageau	*C. mediterranea* Sauvageau	*C. mediterranea* Sauvageau	*C. mediterranea* Sauvageau [3]
C. montagnei J. Ag. *emend.* Montagne	*C. montagnei* J. Agardh	*C. montagnei* J. Agardh (Inquirenda)	–	*C. montagnei* J. Agardh
C. sauvageauana Harnel	*C. selaginoides* Naccari [4]	*C. sauvageauana* Hamel	*C. sauvageauana* Hamel	*C. sauvageauana* Hamel
C. sedoides (Desfontaines) C. Agardh	*C. sedoides* (Desfontaines) C. Agardh	*C. sedoides* (Desfontaines) C. Agardh	*C. sedoides* (Desfontaines) C. Agardh	*C. sedoides* (Desfontaines) C. Agardh
C. spinosa Sauvageau	*C. spinosa* Sauvageau	*C. spinosa* Sauvageau	*C. spinosa* Sauvageau	*C. spinosa* Sauvageau
C. ericoides (Linnaeus) C. Agardh	*C. ericoides* (Linnaeus) C. Agardh	–	*C. tamariscifolia* (Hudson) Papenfuss	*C. tamariscifolia* (Hudson) Papenfuss [3]
C. zosteroides (Turner) C. Agardh	–	*C. zosteroides* C. Agardh	*C. zosteroides* C. Agardh	*C. zosteroides* C. Agardh
–	*Cystoseira corniculata* Hauck	–	–	*Cystoseira corniculata* (Turner) Zanardini [5]
C. nodicaulis (Withering) M. Roberts	–	*C. nodicaulis* (Withering) M. Roberts	–	*C. nodicaulis* (Withering) M. Roberts [5]

1. Probably *C. hoppei* C. Agardh. 2. Probable misidentification of *C. compressa* var. *pustulata* Ercegovič that we consider as an accepted taxon. 3. Presence to confirm. 4. Probably *C. selaginoides* auct. non *C. selaginoides* Naccari. 5. Doubtful record.

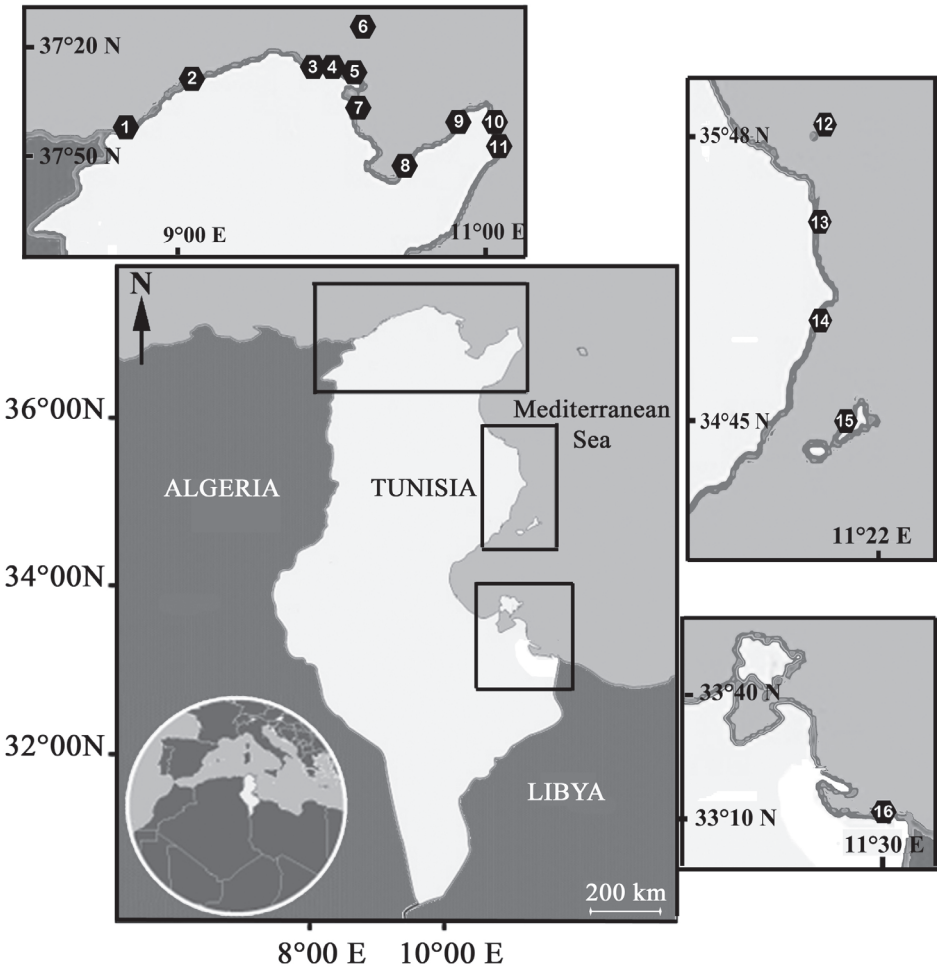


Fig. 1. Location of sampling sites: north coast and Cap Bon Peninsula (**1.** Melloula Bay; **2.** Sidi Mechreg; **3.** Errimel ; **4.** Ras Jebel; **5.** Cap Zebib; **6.** Cani Island; **7.** La Marsa; **8.** Sidi Rais; **9.** Sidi Daoud; **10.** Dar Allouche; **11.** Kelibia); Eastern coast (**12.** Kuriat Islands; **13.** Salakta; **14.** Melloulèche; **15.** Kerkannah Islands); Southern coast (**16.** El Ketef).

Despite the large number of studies focused on the genus *Cystoseira*, identifying species remains difficult due to the high variability in morphology mainly dependent on seasons and on environmental conditions (Roberts, 1967; Jégou *et al*., 2010). Major criteria used for species identification were: the number of axes (single or caespitose), the morphology of axes, the occurrence of tophules and their characteristics, the branching pattern (primary, secondary and ultimate), the occurrence of spine-like branchlets, the arrangement of cryptostomates, the occurrence of aerocysts and the morphology and the location of reproductive organs (Sauvageau, 1912, 1920; Hamel, 1931-1939; Ercegovič, 1952; Gómez-Garreta *et al*., 2001; Cormaci *et al*., 2012; Taşkin *et al.,* 2012).

Voucher specimens were deposited in the Herbarium of the Faculty of Sciences of Tunis in the Department of Biology, Tunis, Tunisia.

RESULTS AND DISCUSSION

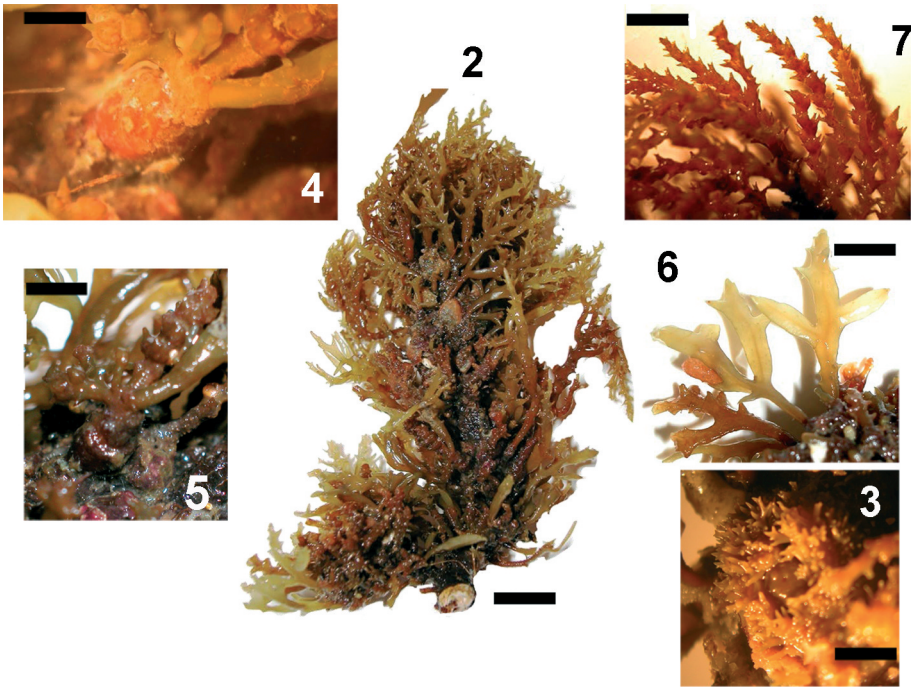
Seven taxa of *Cystoseira* have been identified for the first time from Tunisia.

Cystoseira algeriensis J. Feldmann — Figs 2-7

Material studied. Melloula Bay: July 2012, 1m depth, rocky shores, exsiccata ref. A2581; Sidi Daoud: May 2012, 0.5 m depth, littoral pools, exsiccata ref. A2447; Kelibia: May & July 2012, between 0.5 and 1 m depth, rocky shores, exsiccata ref. A2570.

Description. Plants not caespitose, up to 20 cm high, greenish-brown with greenish-blue iridescence underwater, attached to the substrate by a robust discoid holdfast; axis up to 10 cm high, branched, with smooth and not protruding apices; tophules ovoid, 7-6 × 5-4 mm, smooth to rugged, occasionally slightly spinose; young lower primary branches foliaceous, 2-3 mm wide, alternately branched in one plane, and with a distinct midrib; higher primary branches and branches of upper orders cylindrical with spine-like appendages; cryptostomates scattered along branches; receptacles diffuse at the apices of terminal branches; conceptacles differentiated at the base of spine-like appendages.

Comment. Our specimens agree well with the original diagnosis of *C. algeriensis*, except for tophules that were only smooth on the original material (Feldmann, 1945, pp. 7-10, fig. 1). However, smooth, rugged or sometimes slightly spinose tophules were afterwards reported on *C. algeriensis* (Gómez-Garreta *et al*., 2001;



Figs 2-7. *Cystoseira algeriensis* (Kelibia, A2570, July 2012). **2.** Habit; scale bar = 2 cm. Fig. **3.** Detail of a smooth apex; scale bar = 2 mm. **4-5.** Detail of smooth to rugged tophules; scale bar = 2 mm, 5 mm. **6.** Foliaceous young branches; scale bar = 1 cm. Fig. **7.** Fertile branchlets with terminal spinose receptacles; scale bar = 1 cm.

Cormaci *et al*., 2012; Taşkin *et al.*, 2012). In Sicily (Italy), where *C. algeriensis* and *C. elegans* live together, some specimens bearing both spinose and verrucose-tuberculate tophules were regarded as putative hybrids of *C. algeriensis* × *C. elegans* (Amico *et al.,* 1988). Tunisian specimens with smooth-rugged tophules were attributed without any doubt to *C. algeriensis,* while those with slightly spinose tophules could be *C. algeriensis* × *C. elegans* hybrids since *C. elegans* was also present in the same localities.

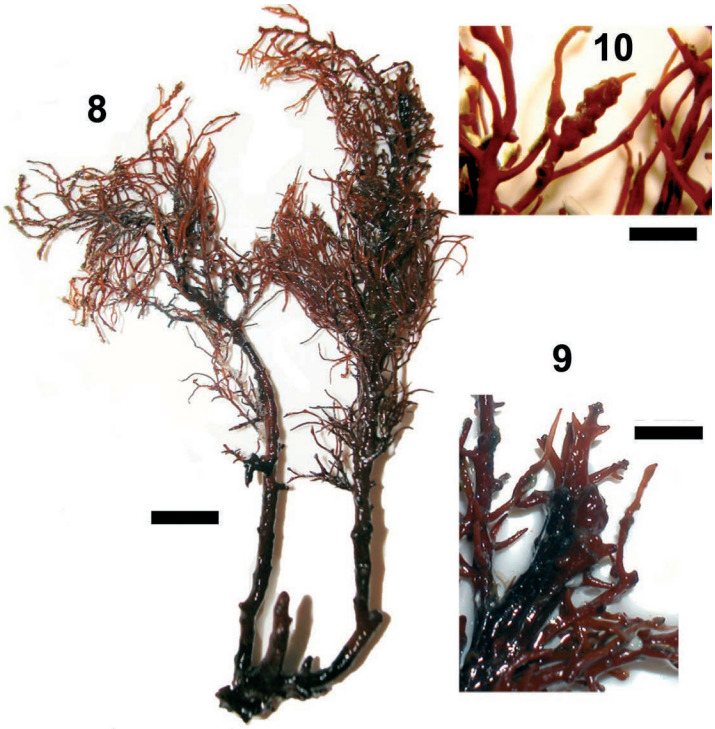
Ecology. *Cystoseira algeriensis* grew on semi-exposed to exposed rocky shores, in littoral pools, 0-1 m depth, frequently associated with *C. elegans*.

Distribution. Described from Bejaïa (Bougie) and reported from Cherchell, *C. algeriensis* has been reported as probably frequent in Algeria (Feldmann, 1945). It has been successively recorded from Algeria, Sicily, south of Italy, Spain and Balearic Islands (Gómez-Garreta *et al*., 2001; Furnari *et al*., 2003, 2010; Taşkin *et al*., 2012). Our observations extend its range of distribution to Tunisia where it was found close to the Algerian border (Melloula Bay) and along the northeastern coast near Sidi Daoud and Kelibia.

Cystoseira barbatula Kützing *emend.* Cormaci, G. Furnari & Giaccone Figs 8-10

Synonym: *Cystoseira graeca* Schiffner *ex* Gerloff & Nizamuddin

Material studied. Melloula Bay: July 2012, 1 m depth, rocky shores; Kelibia: May & July 2012, 1 m depth, rocky shores; Salakta: April 2012, 1m depth, rocky shores; Kuriat Islands: April 2012, 2.5 m depth, *Posidonia oceanica* shoots, exsiccata ref. A2393.

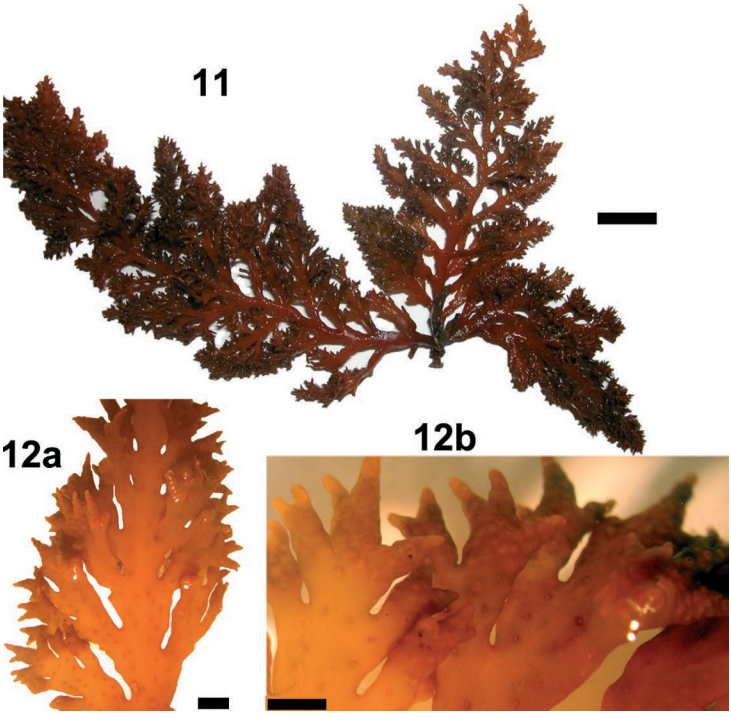


Figs 8-10. *Cystoseira barbatula* (Kuriat Islands, A2393, April 2012). **8.** Habit; scale bar = 2 cm. **9.** Detail of a smooth apex; scale bar = 2 mm. **10.** Terminal tuberculate-mucronate receptacle; scale bar = 2 mm.

Description. Plants caespitose, up to 30 cm high, dark brown to reddish brown, attached to the substrate by an irregular discoid holdfast; axes erect, up to 11, more or less stripped in their basal part with stumps of primary branches, bouquets of short adventitious branches arising from stumps; apices smooth and slightly prominent; tophules absent; branches filiform and cylindrical; spine-like appendages and aerocysts absent; cryptostomates scattered and prominent; receptacles compact small, 2-4 mm × 1 mm, tubercutate and subulate, arranged in terminal panicles.
Comment. Our specimens agree well with the original diagnosis of *C. barbatula* (Kützing, 1860, p. 17, Tab. 46, figs Ia-b), and with later descriptions (Gerloff & Nizamuddin, 1975, as *C. graeca*; Cormaci *et al.,* 2012; Taşkin *et al.*, 2012).
Ecology. *Cystoseira barbatula* grew on exposed rocky bottoms from 1 to 5 m depth.
Distribution. Originally described from the Western Mediterranean basin (Gulf of Naples; Kützing, 1860), *C. barbatula* has been reported from Sicily (Catania), Greece (Cyclades Islands) and Cyprus (Gerloff & Nizamuddin, 1975, as *C. graeca*). According to Cormaci *et al*. (1990, 1992, 1997) and Furnari *et al.* (2003, 2010), the species is also present at Lampedusa Island, Maltese Islands, and along the eastern coast of Libya. *Cystoseira barbatula* is new for the North-Western Africa coast (Maghreb). In Tunisia, it was only observed along the northern and the northeastern coasts.

***Cystoseira compressa* (Esper) Gerloff & Nizamuddin f. *plana* (Ercegovič) Cormaci, G. Furnari, Giaccone, Scammacca & D. Serio** **Figs 11-12**

Basionym: *Cystoseira abrotanifolia* subsp. *plana* Ercegovič



Figs 11-12. *Cystoseira compressa* f. *plana* (Ras Jebel, A2490, June 2012). **11.** Habit; scale bar = 2 cm. **12a-b.** Details of fertile branchlets with terminal receptacles; scale bars = 3 mm.

Material studied. Melloula Bay: July 2012, 1 m depth, rocky shores; Ras Jebel: June 2012, 30 cm depth, exposed rocky shores, exsiccata ref. A2490; Sidi Mechreg: July 2012, 30 cm depth, exposed rocky shores; Errimel: March & October 2012, 0.5 m depth, exposed rocky shores; Cap Zebib: March & October 2012, 30 cm depth, rocky-stony beach; Cani Island: March 2012, 0.5 m depth, exposed rocky shores; Sidi Rais: March 2012, 30 cm depth, rocky bottom, exsiccata ref. A2322; Dar Allouche: September 2012, 0.5 m depth, rocky shores.

Description. Plants caespitose, yellowish-brown to dark brown, non-iridescent, up to 20 cm high, pyramid-shaped, attached to the substrate by a compact basal disc; axes short, up to 1 cm high with smooth and not very prominent apices; tophules absent; primary and secondary branches flattened, up to 7 mm width, with pinnate ramification within a plane; branches of all orders crossed by an inconspicuous midrib; spine-like appendages and aerocysts absent; cryptostomates present in all branches in both sides and parallel to the midrib; receptacles terminal, lanceolate-fusiform, up to 5-6 mm long, simple to branched in one plane.

Comment. Our specimens agree well with the original diagnosis of *C. compressa* f. *plana* (Ercegovič, 1952, p. 113, fig. 19, as *C. abrotanifolia* subsp. *plana*), and with later descriptions (Gómez-Garreta *et al*., 2001; Cormaci *et al*., 2012; Taşkin *et al.*, 2012). The taxonomic value of this forma requires further investigations.

Ecology. Although *C. compressa* f. *plana* was described as a typical depth form (30-40 m depth) (Ercegovič, 1952; Cormaci *et al*., 1992; Gómez-Garreta *et al*., 2001), the species grew in the upper sublittoral zone (0-1 m depth) of moderately to highly exposed rocky shores.

Distribution. Originally described from the Adriatic Sea (Ercegovič, 1952, Munda, 1979), *C. compressa* f. *plana* has been successively reported from Sicily, Spain (Columbretes Islands), Greece and Cyprus (Ribera *et al.,* 1992; Gómez-Garreta *et al*., 2001; Taşkin *et al*., 2013; Tsiamis *et al*., 2013). *C. compressa* f. *plana* is new for the North Africa coast. In Tunisia, *C. compressa* f. *plana* was commonly observed along the whole of the northern coasts.

Cystoseira crinitophylla Ercegovič — Figs 13-17

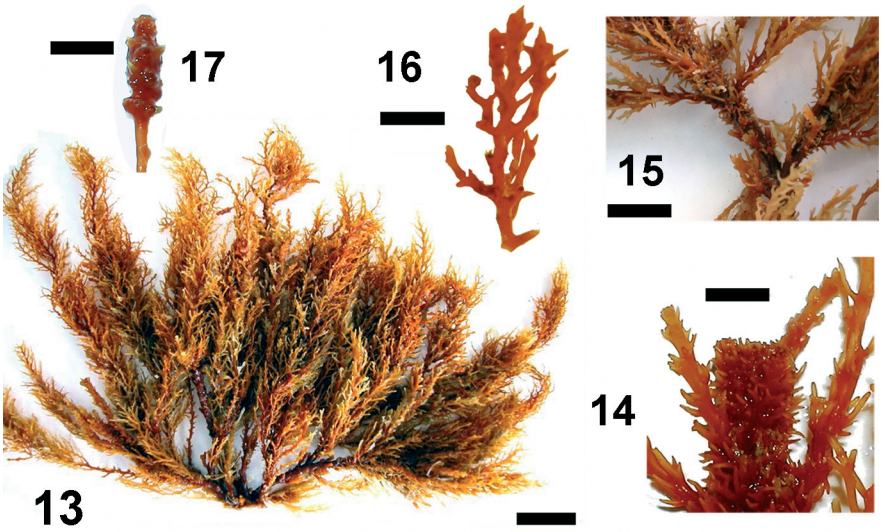
Material studied. Melloula Bay: July 2012, 1 m depth, rocky shores; Cap Zebib: June 2012, 1m depth, rocky shores, exsiccata ref. A2210, March & October 2012, 1 m depth, exposed rocky shores; Dar Allouche: May & July 2012, 0.5 m depth, rocky shores; Kelibia: May & July 2012, 1 m depth, rocky shores.

Description. Plants caespitose, up to 30 cm high, brownish yellow to dark brown with a green iridescence underwater in young individuals, attached to the substrate by an irregular basal holdfast; 2 to 15 erect axes, 1.5 to 17 cm long, cylindrical with slightly swollen basal part, branched, naked to spinose, bearing bouquets of adventitious branches; apices prominent and spinose; tophules absent; primary branches cylindrical with a swollen-spinose basal portion ; secondary branches cylindrical, 2 to 6 cm long; branches of higher order quite close, cylindrical; spine-like appendages frequent, cryptostomates prominent and scattered along branches; aerocysts absent; receptacles compact, terminal, club-shaped, tuberculate, not apiculate but with few short lateral spines.

Comment. Our specimens agree well with the original diagnosis of *C. crinitophylla* (Ercegovič, 1952, p. 112, pl. XXI and fig. 18), and with later descriptions (Cormaci *et al*., 2012; Taşkin *et al.*, 2012).

Ecology. *Cystoseira crinitophylla* grew on shallow rocky bottoms exposed to moderate to high hydrodynamism, down to 1 m depth.

Distribution. Originally described from the Adriatic Sea (Ercegovič, 1952), *C. crinitophylla* has been successively reported from Turkey, Italy, Greece,

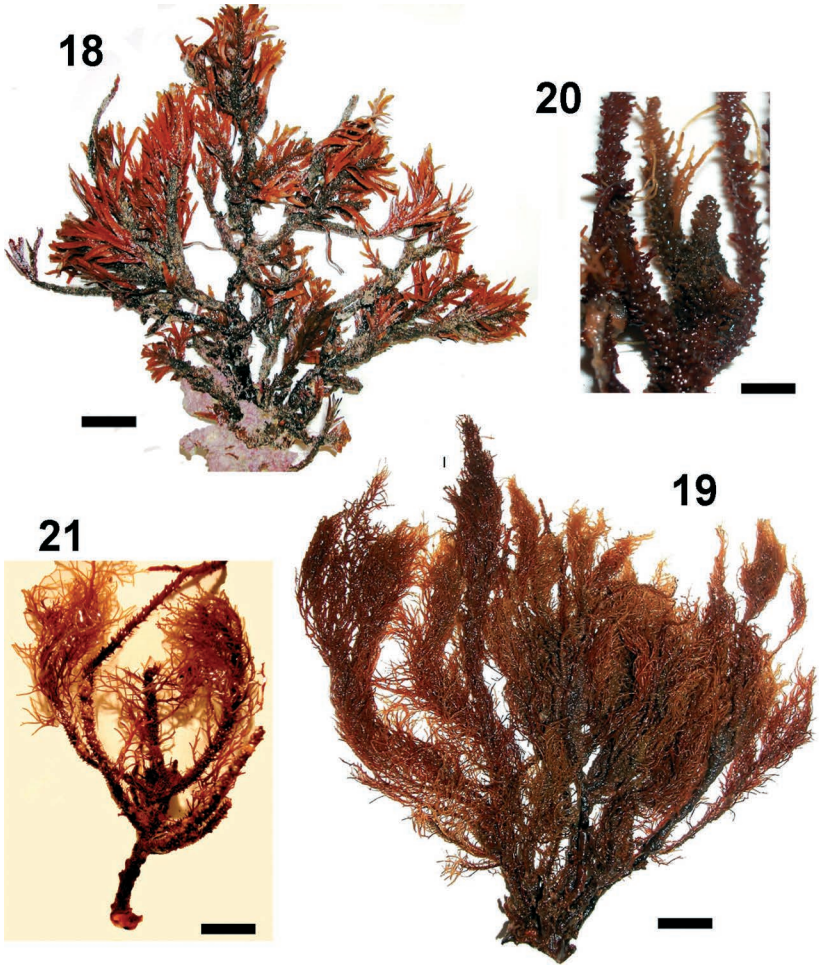


Figs 13-17. *Cystoseira crinitophylla* (Cap Zebib, A2210, June 2012). **13.** Habit; scale bar = 2 cm. **14.** Detail of a prominent spinose apex; scale bar = 2 mm. **15.** Detail of spinose axis with branches; scale bar = 2 cm. **16.** Fertile branchlet with young terminal receptacles; scale bar = 1 cm. **17.** Detail of a tuberculate-spinose receptacle; scale bar = 5 mm.

Corsica, Sardinia and Sicily (Ribera *et al*., 1992, Taşkin *et al*., 2008; Furnari *et al.,* 2010). *C. crinitophylla* is new for the North Africa coasts. In Tunisia, *C. crinitophylla* was only observed along the northern coasts.

***Cystoseira foeniculacea* (Linnaeus) Greville f. *latiramosa* (Ercegovič)**
A. Gómez-Garreta, M.C. Barceló, M.A. Ribera & J. Rull Lluch **Fig. 18**

Basionym: *Cystoseira discors* subsp. *latiramosa* Ercegovič
Synonyms: *Cystoseira ercegovicii* f. *latiramosa* (Ercegovič) Giaccone; *Cystoseira schiffneri* f. *latiramosa* (Ercegovič) Giaccone
Material studied. Sidi Rais: March & May 2012, 0.5 m depth, rocky shores, exsiccata ref. A2325; Dar Allouche: May & July 2012, 0.5 m depth, rocky shores; October 2012, 0.5 m depth, exsiccata ref. A2652; Kelibia: May & July 2012, 1 m depth, rocky shores.
Description. Plants caespitose, up to 50 cm high, light to dark brown, non-iridescent, attached to the substrate by an irregular holdfast; erect axes, up to 12, cylindrical and spinose; apices prominent and spinose; tophules absent; branching distichous in one plane; all branches flattened with a toothed margin and a prominent midrib; cryptostomates abundant; aerocysts and receptacles not observed.
Comment. Despite the lack of reproductive organs and aerocysts, our specimens agree well with the original diagnosis of *C. foeniculacea* f. *latiramosa* (Ercegovič, 1952, p. 113, pl. XXVIIa, as *C. discors* subsp. *latiramosa*), and with later descriptions (Gómez-Garreta *et al*., 2001; Cormaci *et al*., 2012; Taşkin *et al.*, 2012).
Ecology. Although *C. foeniculacea* f. *latiramosa* is usually known as a typical deep form (down to 50 m depth) (Ercegovič, 1952; Gómez-Garreta *et al.,* 2001; A. Meinesz and M. Verlaque, unpublished data), the species was commonly found in the upper sublittoral zone (0.5-3 m depth) on moderately to highly exposed rocky shores.
Distribution. Originally described from the Adriatic Sea (Ercegovič, 1952), *C. foeniculacea* f. *latiramosa* has been successively reported from the Balearic



Figs 18-21. **18.** *Cystoseira foeniculacea* f. *latiramosa* (Dar Allouche, A2652, October 2012), Habit; scale bar = 2 cm. Figs 19-21. *Cystoseira foeniculacea* f. *tenuiramosa* (Kelibia, A2575, July 2012). **19.** Habit; scale bar = 2 cm. **20.** Detail of a spinose apex; scale bar = 5 mm. **21.** Detail of a branched axis; scale bar = 3 cm.

Islands, Corsica, Greece, Italy, Malta, Sardinia, Sicily and Turkey (Ribera *et al.*, 1992; Cormaci *et al*., 1997; Gómez-Garreta *et al*., 2001; Taşkin *et al.,* 2008, 2012; Furnari *et al.,* 2010). *Cystoseira foeniculacea* f. *latiramosa* is new for the North Africa coast. In Tunisia, *C. foeniculacea* f. *latiramosa* was only observed along the coasts of Cap Bon Peninsula.

***Cystoseira foeniculacea* (Linnaeus) Greville f. *tenuiramosa* (Ercegovič)**
A. Gómez-Garreta, M.C. Barceló, M.A. Ribera & J. Rull Lluch **Figs 19-21**

Basionym: *Cystoseira discors* f. *tenuiramosa* Ercegovič

Synonyms: *Cystoseira ercegovicii* f. *tenuiramosa* (Ercegovič) Giaccone ; *Cystoseira schiffneri* f. *tenuiramosa* (Ercegovič) Giaccone

Material studied. La Marsa: April, June & October 2012, 0.5 m depth, rocky-stony beaches; Sidi Rais: March & May 2012, 1 m depth, rocky shores; Dar Allouche: May & July 2012, 1 m depth, rocky shores; Kelibia: May & July 2012, 1 m depth, rocky shores, exsiccata ref. A2575.

Description. Taxon with general characters of *C. foeniculacea* (*i.e.* Plants caespitose; wide and irregular holdfast; several thorny cylindrical axes; apices prominent and spinose; tophules absent), but that differs from other forms in having no flattened branches, primary branches cylindrical and covered with spines and secondary and higher order branches filiform; receptacles not observed.

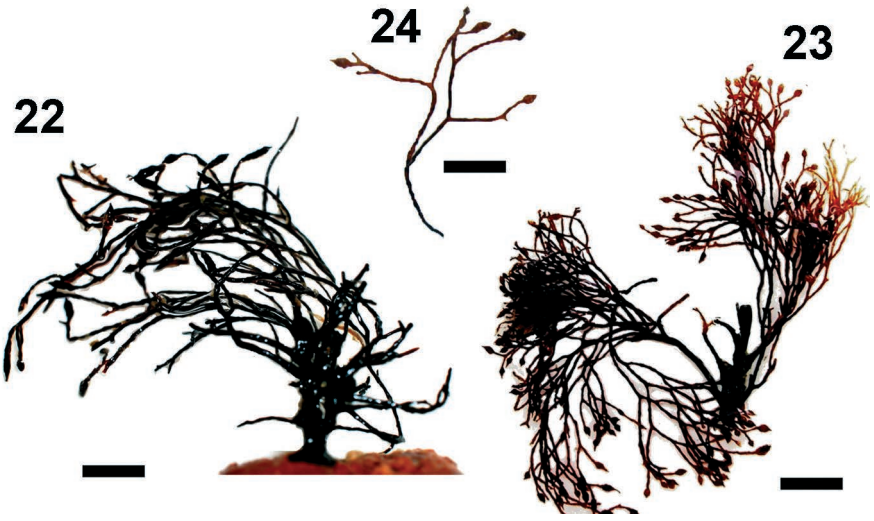
Comment. Our specimens agree well with the original diagnosis of *C. foeniculacea* f. *tenuiramosa* (Ercegovič, 1952, p. 113, pl. XXVI, as *C. discors* f. *tenuiramosa*), and with later descriptions (Gómez-Garreta *et al*., 2001; Cormaci *et al*., 2012; Taşkin *et al.*, 2012).

Ecology. *C. foeniculacea* f. *tenuiramosa* grew on semi-exposed to sheltered rocky shores, down to 1 m depth, in association with *C. foeniculacea* f. *latiramosa*.

Distribution. Originally described from the Adriatic Sea, *C. foeniculacea* f. *tenuiramosa* has been successively reported from the Balearic Islands, Corsica, Cyprus, Greece, Italy, Sardinia, Sicily, Spain and Turkey (Gómez-Garreta *et al*., 2001; Pérez-Ruzafa *et al.,* 2008; Furnari *et al.,* 2010; Taşkin *et al.,* 2012, 2013). *C. foeniculacea* f. *tenuiramosa* is new for the North African coast. In Tunisia, *C. foeniculacea* f. *tenuiramosa* was only observed along the northeastern coasts and the Cap Bon Peninsula.

Cystoseira susanensis Nizamuddin **Figs 22-24**

Material studied. Melloulèche: April 2012, 0.5 m depth, lagoon area, sandy littoral pools; Kerkennah Islands: March 2012, 30 cm depth, muddy bottoms, fastened to a clam shell; El Ketef: June 2012, 30 cm depth, sandstone pebbles, exsiccata ref. A2475.



Figs 22-24. *Cystoseira susanensis* (El Ketef, A2475, June 2012). **22.** Habit; scale bar = 2 cm. **23.** Detail of a smooth apex; scale bar = 2 cm. **24.** Fertile branch with small terminal receptacles; scale bar = 2 cm.

Description. Plants caespitose, up to 16 cm high, dark brown to black, non-iridescent, fixed to the substrate by a small circular holdfast (0.3-1.5 cm in diameter); axes trunk shaped, short, 0.5 to 4 cm long, cylindrical, 1 to 5 mm in diameter, early branched; apex prominent, truncate and smooth; tophules absent; primary branches deciduous, arranged radially on the axis, 10 to 15 cm long, up to 1 mm in diameter with a persistent swollen basal part; secondary branches thin, cylindrical, up to 0.5 mm in diameter, leaving a conspicuous stumps along the lower part of old primary branches once fallen; tertiary branches very slender (maximum 0.40 mm diameter) with dichotomous branching; aerocysts absent; cryptostomates scattered on branches; receptacles terminal, compact, 2-4 mm long, spindle-shaped, apiculate.

Comment. Contrary to Alongi *et al*. (1999) and Cormaci *et al*. (2012) who consider *C. susanensis* as a pseudocaespitose plant with a single stout axis bearing long secondary and sometimes tertiary similar axes, the slender Tunisian specimens display a clearly caespitose base and long, thin primary branches in good agreement with the original diagnosis (Nizamuddin, 1985), and with later descriptions (Tsiamis *et al.*, 2010; Taşkin *et al.*, 2012).

Ecology. In Tunisia, *C. susanensis* was found in similar habitats to the type locality in Libya. It grew on sandstone pebbles and other various substrates (*e.g*., clam shells) in sandy littoral pools and exposed sandy shores, down to 1 m depth.

Distribution. *Cystoseira susanensis* is a rare species originally described from Susa, Libya (Nizamuddin, 1985) and successively reported from Sicily and Greece (Alongi *et al*., 1999; Tsiamis *et al.*, 2010; Taşkin *et al.,* 2012). However, the Sicilian record might belong to another taxon (possibly *C. barbata*) since the specimens differed from the original diagnosis in having a single stout axis, up to 8 cm long and 4.0-5.0 mm in diameter, usually bearing long secondary and sometimes tertiary similar axes, up to 30 cm long (Alongi *et al*., 1999). *Cystoseira susanensis* was found along the southeastern shores of Tunisia and close to the Libyan border.

CONCLUSION

Cystoseira species are known for their great morphological plasticity and seasonal variability (Ercegovič, 1952; Roberts, 1967, 1978; Amico, 1995), which may cause some troubles in identification. The case of *C. barbatula*, here described, is an example since it can be easily confused with *C. crinita* when sterile, although the latter has darker main axes with spinose apices and larger denuded zones than *C. barbatula*.

In Tunisia, the *Cystoseira* genus was poorly investigated, probably because of the lack of experts in algal taxonomy. Our extensive prospection of shallow marine benthic assemblages along the whole of the coasts resulted in the discovery of seven *Cystoseira* taxa new for this country. The putative hybrids of *C. algeriensis* × *C. elegans* here described deserve further attention. Further research and genetic studies are needed to refine its taxonomy. Our next step will be the study of taxa inhabiting deep water benthic assemblages.

Acknowledgements. The authors thank Dr T. Thibaut and Ms. A. Blanfune and all the staff of the ECOMERS (Coastal Marine Ecosystems and Response to Stress) Laboratory-University of Nice Sophia Antipolis for accepting one of them (C. B.) for training on *Cystoseira* taxonomy. Special thanks are addressed to Prof. G. Pergent for

providing support and requested documents, to Prof. C.F. Boudouresque for providing the library space for necessary documentation, and to the anonymous reviewers for their useful comments and the correction of the manuscript. Mrs. Feriel Sellem is warmly thanked for her support. We are grateful to the Regional Activity Center for Specially Protected Areas (RAC/SPA) for their financial support. This study is part of the PhD research of Ms. Cyrine Bouafif.

REFERENCES

ALONGI G., CATRA M. & CORMACI M., 1999 — Observations sur *Cystoseira susanensis* (Cystoseiraceae, Phaeophyta): une espèce méditerranéenne rare et peu connue. *Cryptogamie, Algologie* 20: 25-33.

AMICO V., 1995 — Marine brown algae of family Cystoseiraceae: chemistry and chemotaxonomy. *Phytochemistry* 39: 1257-1279.

AMICO V., GIACCONE G., PIATTELLI M. & RUBERTO G., 1988 — Inheritance of chemical constituents in algae: tetraprenyltoluquinols of *Cystoseira elegans* × *Cystoseira algeriensis*. *Phytochemistry* 27: 1069-1071.

ANTONIOLI F., ZENETOS A., KARAKASSIS I. & KAMIZOULIS G., 1999 — Ecosystem sensitivity and impacts. *In*: Papathanassiou E. & Gabrielides G.P. (eds.), *State and Pressure of the Marine and Coastal Mediterranean Environment*. Copenhagen, European Environment Agency Publ., pp. 105-123.

BÁEZ J.C., OLIVERO J., REAL R., VARGAS J.M. & FLORES-MOYA A., 2005 — Analysis of geographical variation in species richness within the genera *Audouinella* (Rhodophyta), *Cystoseira* (Phaeophyceae) and *Cladophora* (Chlorophyta) in the western Mediterranean Sea. *Botanica marina* 48: 30-37.

BALLESTEROS E., SALA E., GARRABOU J. & ZABALA M., 1998 — Community structure and frond size distribution of a deep water strand of *Cystoseira spinosa* (Phaeophyta) in the north-western Mediterranean. *European journal of phycology* 33: 121-128.

BALLESTEROS E., GARRABOU J., HEREU B., ZABALA M., CEBRIAN E. & SALA E., 2009 — Community structure and growth of a deep water stand of *Cystoseira zosteroides* (Phaeophyta) in the Northwestern Mediterranean. *Estuarine coastal and shelf science* 82: 477-484.

BELLAN-SANTINI D., 1968 — Influence de la pollution sur les peuplements benthiques. *Revue internationale d'océanographie médicale* 10: 27-53.

BEN MAIZ N., BOUDOURESQUE C.F. & OUAHCHI F., 1987 — Inventaire des algues et phanérogames marines benthiques de la Tunisie. *Giornale botanico Italiano* 121 (5-6): 259-304.

BENEDETTI-CECCHI L., PANNACCIULLI F., BULLERI F., MOSCHELLA P.S., AIROLDI L., RELINI G. & CINELLI F., 2001 — Predicting the consequences of anthropogenic disturbance: large scale effects of loss of canopy algae on rock shores. *Marine ecology, Progress series* 214: 137-150.

BOUDOURESQUE C.F., 1971 — Recherches de bionomie analytique structurale et expérimentale sur les peuplements benthiques sciaphiles de Méditerranée Occidentale (fraction algale): la sous-strate sciaphile des peuplements des grandes *Cystoseira* de mode battu. *Bulletin du musée d'histoire naturelle de Marseille* 31: 79-104.

BULLERI F., BENEDETTI-CECCHI L., ACUNTO S., CINELLI F. & HAWKINS S.J., 2002 — The influence of canopy algae on vertical patterns of distribution of low-shore assemblages on rocky coasts in the northwest Mediterranean. *Journal of experimental marine biology and ecology* 267: 89-106.

CHEMINÉE A., SALA E., PASTOR J., MANGIALAJO L., COTTALORDA J.M., BODILIS P., BIANCHIMANI O., ARCEO H. & FRANCOUR P., 2010 — Algal forests and the replenishment of Mediterranean rocky fishes. Consequences of the decline of *Cystoseira* forests on Mediterranean juvenile fish populations. ICES Conference, Nantes, France, September 2010, ASC Edition, p Q17.

CHEMINÉE A., SALA E., PASTOR J., BODILIS P., THIRIET T., MANGIALAJO L., COTTALORDA J.M. & FRANCOUR P., 2013 — Nursery value of *Cystoseira* forests for Mediterranean rocky reef fishes. *Journal of experimental marine biology and ecology* 442: 70-79.

CORMACI M., FURNARI G., GIACCONE G. & SERIO D., 1990 — Taxonomic and biogeographic observations on some species of the genus *Cystoseira*: *C. sauvageauana*, *C. barbatula* and *C. pelagosae*. *Rapport P.V. Commission Internationale pour l'Exploration Scientifique de la Mer Méditerranée* 32 (1): 314.

CORMACI M., FURNARI G., GIACCONE G., SCAMMACCA B. & SERIO D., 1992 — Observations taxonomiques et biogéographiques sur quelques espèces du genre *Cystoseira* C. Agardh. *Bulletin de l'institut océanographique de Monaco* 9 (n° spécial): 21-35.

CORMACI, M., LANFRANCO, E., BORG, J.A., BUTTGIEG, J.A., FURNARI, G., MICALLEF S.A., MIFSUD C., PIZZUTO F., SCAMMACCA B. & SERIO D., 1997 — Contributions to the knowledge of benthic marine algae on rocky substrata of the Maltese Islands (Mediterranean Sea). *Botanica marina* 40: 203-215.

CORMACI M., FURNARI G., CATRA M., ALONGI G. & GIACCONE G., 2012 — Flora marina bentonica del Mediterraneo: Phaeophyceae. *Bollettino dell'accademia Gioenia di scienze naturali di Catania* 45: 1-508.

DRAISMA S.G.A., BALLESTEROS E., ROUSSEAU F. & THIBAUT T., 2010 — DNA sequence data demonstrate the polyphyly of the genus *Cystoseira* and other Sargassaceae genera (Phaeophyceae). *Journal of phycology* 46: 1329-1345.

ERCEGOVIC A., 1952 — *Fauna i Flora Jadrana. Jadranske cistozire. Njihova morfologija, ekologija i razvitak/Fauna et Flora Adriatica. Sur les* Cystoseira *adriatiques. Leur morphologie, écologie et évolution*. Vol. 2. Split, Institut za Oceanografiju i Ribarstvo Split/Institut d'Océanograpie et de Pêche, pp. 1-172 (Croatian), 173-210 (French), 211-212 (references), Map.

FELDMANN J., 1937 — Recherches sur la végétation marine de la Méditerranée. La Côte des Albères. *Revue algologique* 10: 73-254.

FELDMANN J., 1945 (1944) — Une nouvelle espèce de *Cystoseira* (Fucales, Sargassacées) des côtes d'Algérie. *Bulletin de la société d'histoire naturelle de l'Afrique du Nord* 35: 7-10.

FURNARI G., GIACCONE G., CORMACI M., ALONGI G., SERIO D., 2003 — Biodiversità marina delle coste italiane: catalogo del macrofitobenthos. *Biologia marina Mediterranea* 10: 3-483.

FURNARI G., GIACCONE G., CORMACI M., ALONGI G., CATRA M., NISI A., SERIO D., 2010 — Macrophytobenthos. *Biologia marina Mediterranea* 17(Suppl. 1): 801-828.

GERLOFF J. & NIZAMUDDIN M., 1975 — Three new species of the genus *Cystoseira* C. Ag. *Willdenowia* 7: 565-582.

GIACCONE G., 1973 — Écologie et chorologie des *Cystoseira* de Méditerranée. *Rapport P.V. Commission Internationale pour l'Exploration Scientifique de la Mer Méditerranée* 22: 49-50.

GIACCONE G. & BRUNI A., 1973 — Le Cistoseire e la vegetazione sommersa del Mediterraneo. *Atti del reale istituto Veneto di scienze, lettere ed arti* 131: 59-103.

GOMEZ GARRETA A., BARCELO I MARTÍ M.C., RIBERA SIGUÁN M.A. & RULL LLUCH J., 2001 — *Cystoseira* C. Agardh. *In*: Gómez Garreta, A. (eds) *Flora Phycologica Iberica Vol. 1 Fucales.* Murcia: Universidad de Murcia, pp. 99-166.

GUIRY M.D. & GUIRY G.M., 2014 — AlgaeBase. World-wide electronic publication, National University of Ireland, Galway. http://www.algaebase.org. (Assessed June 2014).

HAMEL G., 1931-1939 — *Phéophycées de France*. Paris, 432 p. + 10 Plates.

HAMZA A., 1987 — Étude des *Cystoseira* du Golfe de Gabès: notes préliminaires. *Bulletin de l'institut national scientifique et technique d'océanographie et de pêche de Salammbô* 14 : 59-70.

HOFFMANN L., CLARISSE S., DETIENNE X., GOFFART A., RENARD R. & DEMOULIN V., 1988 — Evolution of the populations of *Cystoseira balearica* (Phaeophyceae) and epiphytic Bangiophyceae in the Bay of Calvi (Corsica) in the last eight years. *Bulletin de la société royale de Liège* 4-5: 263-273.

HOFFMANN L., RENARD R. & DEMOULIN V., 1992 — Phenology, growth and biomass of *Cystoseira balearica* in Calvi (Corsica). *Marine ecology, Progress series* 80: 249-254.

JEGOU C., CULIOLI G., KERVAREC N., SIMON G. & STIGER-POUVREAU V., 2010 — LC/ESI-MS*n* and ^{1}H HR-MAS NMR analytical methods as useful taxonomical tools within the genus *Cystoseira* C. Agardh (Fucales; Phaeophyceae). *Talanta* 83(2): 613-622.

JONES C.G., LAWTON J.H. & SHACHAK M., 1994 — Organisms as ecosystem engineers. *Oikos* 69: 373-386.

KÜTZING F.T., 1860 — *Tabulae phycologicae; oder, Abbildungen der Tange.* Vol. X. Nordhausen, Gedruckt auf kosten des Verfassers, iv, 39 p., 100 pls.

MANGIALAJO L., CHIANTORE M. & CATTANEO-VIETTI R., 2008 — Loss of fucoid algae along a gradient of urbanisation and relationships with the structure of benthic assemblages. *Marine ecology, Progress series* 358: 63-74.

MUNDA I., 1979 — Some Fucacean Associations from the vicinity of Rovinj, Istrian Coast, Northern Adriatic. *Nova Hedwigia* 31: 607-666.

MYERS N., 1988 — Threatened biotas: `hotspots' in tropical forests. *The environmentalist* 8 (3): 187-208.

MYERS N., 1990 — The biodiversity challenge: expanded hotspots analysis. *The environmentalist* 10 (4): 243-256.

NIZAMUDDIN M. 1985 — A new species of *Cystoseira* C. Ag. (Phaeophyta) from the Eastern part of Libya. *Nova Hedwigia* 42: 119-122.

OLIVERAS M.A. & GÓMEZ, A., 1989 — Corologia del género *Cystoseira* C. Agardh (Phaeophyceae, Fucales). *Anales del jardín botánico de Madrid* 46: 89-97.

PAINE R.T., 1969 — A note on trophic complexity and community stability. *American naturalist* 103: 91.

PÉREZ-RUZAFA A., HEGAZI M.I., PÉREZ-RUZAFA I.M. & MARCOS C., 2008 — Differences in spatial and seasonal patterns of macrophyte assemblages between a coastal lagoon and the open sea. *Marine environmental research* 65: 291-314.

RIBERA M.A., GÓMEZ-GARRETA A., GALLARDO T., CORMACI M., FURNARI G. & GIACCONE G., 1992 — Check-list of Mediterranean Seaweeds. I. Fucophyceae (Warming 1884). *Botanica marina* 35: 109-130.

ROBERTS M., 1967 — Studies on marine algae of the British Isles 3. The genus *Cystoseira*. *British phycological bulletin* 3: 345-366.

ROBERTS M., 1978 — Active speciation in the taxonomy of the genus *Cystoseira* C. Ag.. *In*: Irvine D.E.G. & Price J.H. (Eds) *Modern approaches to the taxomy of Red and Brown Algae*. Systematics Association Special Vol. 10, London, New York, Academic Press, pp. 399-422.

RODRÍGUEZ-PRIETO C. & POLO L., 1996 — Effects of sewage pollution in the structure and dynamics of the community of *Cystoseira mediterranea* (Fucales, Phaeophyceae*). Scientia marina* 60: 253-263.

RUITTON S., FRANCOUR P. & BOUDOURESQUE C.F., 2000 — Relationships between algae, benthic herbivorous invertebrates and fishes in rocky sublittoral communities of a temperate sea (Mediterranean). *Estuarine, coastal and shelf science* 50: 217-230.

SALES M. & BALLESTEROS E., 2009 — Shallow *Cystoseira* (Fucales: Ochrophyta) assemblages thriving in sheltered areas from Menorca (NW Mediterranean): relationships with environmental factors and anthropogenic pressures. *Estuarine, coastal and shelf science* 84: 476-482.

SALES M. & BALLESTEROS E., 2012 — Seasonal dynamics and annual production of *Cystoseira crinita* (Fucales: Ochrophyta) dominated assemblages from the northwestern Mediterranean. *Scientia marina* 76: 391-401.

SAUVAGEAU C., 1912 — À propos des *Cystoseira* de Banyuls et Guéthary. *Bulletin de la station biologique d'Arcachon, France* 14: 133-556.

SAUVAGEAU C., 1920 — À propos des *Cystoseira* de Banyuls et Guéthary. Supplément (1). *Bulletin de la station biologique d'Arcachon*, *France* 17: 5-56.

SERIO D., ALONGI G., CATRA M., CORMACI M. & FURNARI G., 2006 — Changes in the benthic algal flora of Linosa Island (Straits of Sicily, Mediterranean Sea). *Botanica marina* 49: 135-144.

TAŞKIN E., ÖZTÜRK M., KURT O. & ÖZTÜRK M., 2008 — The *check-list of the marine algae of Turkey.* Manisa, Turkey, Ecem Kirtasiye, [i-ii] + 87 p.

TAŞKIN E., ÖZTÜRK M., KURT O. & ULCAY S., 2013 — Benthic marine algae in Northern Cyprus (Eastern Mediterranean Sea). *Journal of Black Sea/Mediterranean environment* 19(2): 143-16.

THIBAUT T., PINEDO S., TORRAS X. & BALLESTEROS E., 2005 — Long-term decline of the populations of Fucales (*Cystoseira* spp. and *Sargassum* spp.) in the Albères coast (France, North-western Mediterranean). *Marine pollution Bulletin* 50: 1472-1489.

TSIAMIS K., VERLAQUE M., PANAYOTIDIS P. & MONTESANTO B., 2010 — New macroalgal records for the Aegean Sea (Greece, eastern Mediterranean Sea). *Botanica marina* 53: 319-331.

TSIAMIS K., PANAYOTIDIS P., ECONOMOU-AMILLI A. & KATSAROS C., 2013 — Seaweeds of the Greek coasts. I. Phaeophyceae. *Mediterranean marine science* 14/1: 141-157.

UNEP-PAM-RAC/SPA, 2012 — Protocol concerning specially protected areas and biological diversity in the Mediterranean. Annex II. List of endangered or threatened species. Paris, France, 8-10 February 2012, 7 p.

VERGÉS A., ALCOVERRO T. & BALLESTEROS E., 2009 — Role of fish herbivory in structuring the vertical distribution of canopy algae *Cystoseira* spp. in the Mediterranean Sea. *Marine ecology, Progress series* 375: 1-11.