

Reinstatement of species rank for *Cystoseira bosphorica* Sauvageau (Sargassaceae, Phaeophyceae)

Dimitar BEROV^{a*}, Enric BALLESTEROS^b, Marta SALES^c
& Marc VERLAQUE^d

^a Institute for Biodiversity and Ecosystem Research, Bulgarian Academy
of Sciences (IBER-BAS), 2 Juri Gagarin Street, 1113 Sofia, Bulgaria

^b Centre d'Estudis Avancats de Blanes (CEAB-CSIC), 17300 Blanes, Spain

^c Estació Jaume Ferrer, Centre Oceanogràfic de les Balears,
Instituto Español de Oceanografía, La Mola, Maó

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

Abstract – On the basis of literature data and new morphological and ecological studies, the reinstatement of species rank for the Black Sea endemic species *Cystoseira bosphorica* is proposed. Previously reduced to a simple form of the Mediterranean endemic species *C. crinita*, this member of the caespitose *Cystoseira* group without spinose-like appendages clearly differs from *C. crinita* by having the axes long with smooth and prominent apices, the branches with numerous and slightly prominent cryptostomates, the aerocysts frequent, large, oval to subconical-broader at the apex, with 2 or more apical outgrowths, and by the receptacles long, cylindrical-tuberculate, simple or bifid, with apices blunt bearing sometimes a short lateral sub-apical spine. The species that shares the greatest number of characters with *C. bosphorica* is not *C. crinita* but the Mediterranean endemic species *C. barbatula*; however, this latter species clearly differs from *C. bosphorica* by the constant absence of aerocysts, the filiform branches with prominent and spaced cryptostomates, and by the receptacles smaller, compact, simple, humpy and subulate with sometimes 1-2 long lateral spine-like appendages.

Cystoseira bosphorica / Sargassaceae / Ochrophyta / Black Sea / Bulgaria

Résumé – Sur la base des données de la littérature et de nouvelles études morphologiques et écologiques, le rétablissement de *Cystoseira bosphorica* dans son rang d'espèce est proposé. Précédemment réduit à une simple forme de l'espèce endémique méditerranéenne *C. crinita*, ce représentant du groupe des *Cystoseira* caespitueuses sans ramule épineux se distingue nettement de *C. crinita* par ses axes longs à apex saillants et lisses, ses rameaux avec des cryptostomates nombreux et légèrement saillants, ses aérocystes fréquents, grands, ovales à subconiques plus larges à l'apex et avec 2 proliférations apicales ou plus, et par ses réceptacles longs, cylindriques-tuberculés, simples ou bifides, à apex obtus portant parfois une épine subapicale courte. L'espèce qui partage le plus de caractères avec *C. bosphorica* n'est pas *C. crinita* mais l'espèce endémique méditerranéenne *C. barbatula*, cependant cette

* Corresponding author: dimitar.berov@gmail.com

dernière diffère clairement de *C. bosphorica* par l'absence constante d'aérocystes, par ses rameaux filiformes à cryptostomates saillants et très espacés et par ses réceptacles plus petits, compacts, simples ou ramifiés, bosselés et subulés, avec parfois 1 à 2 longues épines latérales.

***Cystoseira bosphorica* / Sargassaceae / Ochrophyta / Mer Noire / Bulgarie**

INTRODUCTION

The genus *Cystoseira* C. Agardh (1820) holds several species that form dominant stands in the photophilous subtidal zone in the Mediterranean and the Black Seas (Giaccone & Bruni, 1973; Kalugina-Gutnik, 1975; Ballesteros, 1992; Ballesteros, *et al.* 1998, Gómez Garreta *et al.*, 2000; Dimitrova-Konaklieva, 2000). *Cystoseira* spp. play an important role in the structure and functioning of rocky habitats providing shelter and food as well as nursery grounds for a wide array of organisms (Bulleri *et al.*, 2002; Ballesteros *et al.*, 2009; Verges *et al.*, 2009; Cheminée *et al.*, 2013; Gianni *et al.*, 2013). In spite of their importance as habitat formers, the systematics of the genus is still not well understood (Draisma *et al.*, 2010) and questions arise when species have to be delimited (Ballesteros 2002; Cormaci *et al.*, 2012). In fact, two thirds of the *Cystoseira* species that are present in the Mediterranean Sea are thought to have originated during the last six million years, after the Messinian salinity crisis (Draisma *et al.*, 2010) and thus, this genus is in a process of active speciation in the region (Roberts, 1978; Amico, 1995).

Cystoseira bosphorica Sauvageau takes up a singular place among the species of the genus *Cystoseira* whose taxonomic status is not clear. Its original description (Sauvageau 1912, pp. 413-415 and 529-530) was based on a single specimen collected by Gustave Thuret in the Buyuk-Déré Gulf (Bosphorus Strait, Turkey) on October 1840 and conserved in the Herbarium Thuret (PC0596565, Cryptogamy Herbarium, MNHN-Paris, PC, lectotype designated by Gómez Garreta & Ribera (2005). According to Sauvageau (1912), *C. bosphorica* is morphologically close to *C. barbata* (Stackhouse) C. Agardh because of its smooth axis, the occurrence of aerocysts and the slender receptacles, but it is also similar to *C. crinita* Duby in having a thallus caespitose and receptacles tuberculate and non-mucronate.

Since its description, *C. bosphorica* was widely reported throughout the Black Sea, along Bulgarian, Romanian, Turkish, Russian and Ukrainian coasts. Vouchers identified as *C. bosphorica* are present in important collections (e.g. J. Feldmann, M. Celan and A.D. Zinova Herbaria, among others).

In 1974, after the study of a large number of samples of *C. bosphorica* collected along the Russian and Ukrainian coasts of the Black Sea, Zinova & Kalugina (1974) reduced *C. bosphorica* to a simple form of *C. crinita* Duby as *C. crinita* f. *bosphorica* (Sauvageau) A.D. Zinova and Kalugina, and distinguished two forms of *C. crinita* in the Black Sea as follows (translated from Russian):

– “*C. crinita* f. *bosphorica*: axes thicker, 3-4 mm in diameter, adventitious branches well developed, terminal branches longer, 10-20 cm long and 550 µm in diameter, aerocysts numerous, 8 mm long and 4 mm in diameter, receptacles larger, 3.6 mm long and 1 mm in diameter; semi- and well-protected coasts; Black Sea (all around besides in the NW part) and Bosphorus Strait.”

– *C. crinita* f. *crinita*: axes 2-3 mm in diameter, adventitious branches few developed, terminal branches 8-12 cm long and 400-450 µm in diameter, aerocysts

usually absent except during warm springs (1-5 aerocysts per thallus, 5 mm long and 3 mm in diameter), receptacles small, 2.3 mm long and 0.9 mm in diameter; form widely distributed in shallow waters on open and exposed coasts; Black Sea (all around besides in the NW part) and Mediterranean Sea.

Zinova & Kalugina (1974) checked neither the type specimen of *C. crinita*, nor any specimens of *C. crinita* from the syntype localities (Corsica and French Riviera; Duby, 1830) or from other Mediterranean areas, where the species is frequent, like the western Mediterranean basin and the Adriatic Sea. Nevertheless, the taxonomical change they proposed was widely accepted (Table 1). In the meantime, phycologists did not find any conclusive element to justify or reject the Zinova and Kalugina's taxonomic treatment (Giaccone & Bruni, 1973; Amico *et al.*, 1985). Guiry & Guiry (2014) treat *C. crinita* f. *bosphorica* as an accepted taxon, while Cormaci *et al.* (2012), Takin *et al.* (2012) and Takin & Öztürk (2013) consider further investigation was necessary to precise its taxonomic status. According to Cormaci *et al.* (2012), *C. bosphorica* could be a later heterotypic synonym of *C. barbatula* Kützinger (1860), a species described from Naples (Italy) and successively reported from Sicily, Greece (Cyclades Islands), Cyprus (Gerloff and Nizamuddin 1975, as *C. graeca*), Lampedusa Island, Maltese Islands, the eastern coast of Libya (Cormaci *et al.*, 1990, 1992, 1997; Furnari *et al.*, 2003, 2010), and from Tunisia (Bouafif *et al.*, 2014).

Here, we reconsider the taxonomic status of *C. bosphorica* Sauvageau by comparing specimens of *Cystoseira* spp. recently collected in Bulgaria with data from the literature, the lectotype of *C. bosphorica*, old collections of *Cystoseira* spp. from the Black Sea and several large collections of *Cystoseira* species from the Mediterranean Sea.

MATERIAL AND METHODS

Specimens of *Cystoseira* spp. were sampled by one of us (D.B.) along the Bulgarian coast, in May 2011, in shallow benthic assemblages (0-3 m depth) (Fig. 1). Fresh material was transported to the laboratory in plastic bags with seawater. *Cystoseira* species were cleaned and thoroughly rinsed with freshwater to remove epiphytes. Some specimens were preserved in 4% buffered formalin/seawater, while the rest was pressed, air dried and prepared as herbarium specimens.

Voucher specimens were deposited in the Verlaque Herbarium (HCOM), Marseille, France with following references:

- *Cystoseira barbata* (Stackhouse) C. Agardh: **H8269** and **H8270** - Sozopol, Bulgaria, Black Sea, coll. D. Berov, 10-11/05/2011, 1-3 m depth, fertile;
- *C. bosphorica* Sauvageau: **H8268** - Varvara, Bulgaria, Black Sea, coll. D. Berov, 12/05/2011, 1 m depth, fertile; **H8267** and **H8271** - Sozopol, Bulgaria, Black Sea, coll. D. Berov, 11/05/2011, 1 m depth, fertile.

The material was compared with the almost exhaustive collection of Mediterranean *Cystoseira* species deposited in the Herbaria of HCOM, in particular:

- *C. barbatula* Kützinger: **H5102** to **H5106** - Dhekelia, south Cyprus, coll. C.F. Boudouresque, 29/01/1992, fertile; **H7216** to **H7218** - Gyrne, north Cyprus, coll. M. Verlaque, 18/11/1998, 4 m depth, fertile;



Fig. 1. Map of the study sites.

– *C. crinita* Duby: **H5169** - Le Pradet, France, coll. *P. Francour*, 16/01/1997, 0-1 m depth; **H8212** - Toulon, France, coll. *M. Verlaque*, 01/11/1990, 0.5 m depth; **H8220**, Giens, France, coll. *T. Thibaut*, 21/11/2012, 0-1 m depth.

The following exsiccate deposited in the Cryptogamy Herbarium of the Muséum National d'Histoire Naturelle, Paris (PC) were also examined (Sonnerat Database <http://coldb.mnhn.fr/colweb/form.do?model=SONNERAT>. [wwwsonnerat.org](http://www.sonnerat.org)):

– *C. barbata* (Stackhouse) C. Agardh: **PC0519104** and **PC0519105**, Banyuls-sur-Mer, France, coll. *C. Sauvageau*, 13/11/1909, fertile.

– *C. bosphorica* Sauvageau: **PC0596565** - Lectotype, Buyuk-Déré Gulf (Istanbul), Turkey, coll. *G. Thuret*, October 1840; **PC0483343** and **PC0501372** - Constana, Romania, coll. *M. Celan*, 6/10/1931, fertile; **PC0483339** and **PC0501373** - Constana, Romania, coll. *M. Celan*, 20/08/1933, fertile; **PC0483340** - Constana, Romania, coll. *M. Celan*, 30/05/1933, fertile, drawings; **PC0483341** - Constana, Romania, coll. *M. Celan*, 14-20/11/1946, fertile.

– *C. crinita* Duby: **PC0519941** - Banyuls-sur-Mer, France, coll. *C. Sauvageau*, 28/03/1910, fertile; **PC0501301** - Castiglione, Algeria, coll. *J. Feldmann*, 6/06/1935, fertile.

All this material was compared to the *Cystoseira* collection deposited in the E. Ballesteros i Sagarra Herbarium of the CEAB-CSIC. Herbarium abbreviations follow Thiers (2014).

RESULTS AND DISCUSSION

The material collected along the Bulgarian coasts belongs to two species of *Cystoseira*: *C. barbata* and the species identified as *C. bosphorica* Sauvageau or *C. crinita* f. *bosphorica* (Sauvageau) A.D. Zinova and Kalugina. The specimens of *C. barbata* agree well with the previous descriptions and illustrations of large Black Sea individuals of *C. barbata* (Table 1).

The characteristics of the second species are as follows: thalli, 30-50 cm high, caespitose, with 8-17 axes, up to 20 cm high and 3-4 mm in diameter; apex of axes prominent and smooth; primary branches not spinose, 15-23 cm long and 1 mm in diameter, with bases broadened and persistent; adventitious branches on the base of dropped primary branches; ultimate branches cylindrical; cryptostomates numerous and slightly prominent; aerocysts frequent, oval to subconical broader at the apex, 9-10 mm × 3-4 mm, with 2 or more outgrowths that can produce other aerocysts; receptacles cylindrical tuberculate, simple to bifid, 5-12 mm × 1.5-2 mm, with apices blunt and sometimes a short sub-apical lateral spine-like appendage; conceptacles slightly prominent (Figs 2-9). This material agrees well with the diagnosis (Sauvageau, 1912), the lectotype (Fig. 10), other specimens from the Black Sea (Figs 11-12), and the published descriptions and illustrations of *C. bosphorica*, *C. crinita* f. *bosphorica* and *C. crinita* f. *crinita* from the Black Sea (Table 1). The analysis of literature data and the examination of large Mediterranean collections showed that, except for the caespitose character and the absence of spine-like appendages on branches, no other determinant character could justify the taxonomical reduction of *C. bosphorica* to a form of *C. crinita* proposed by Zinova & Kalugina (1974). *Cystoseira crinita* differs significantly from *C. bosphorica*, especially by a smaller size, the presence of spinose parts (apex of axes and receptacles), the constant absence of distinctive aerocysts, and by the location close to the surface: 0-0.5 m depth versus 0.5-10 m depth for *C. bosphorica* (Table 1).

The Black Sea specimens attributed to *C. crinita* f. *crinita* by Zinova & Kalugina (1974) possess apex of axes smooth and distinctive aerocysts, consequently they cannot be a form of *C. crinita*. We consider they constitute a reduced form from open and exposed coasts of *C. bosphorica*.

Table I. Comparison of diagnostic characters of *Cystoseira bosporica* and closest *Cystoseira* species

Species	<i>C. bosporica</i> Sauvageau	<i>C. barbatula</i> Kützing	<i>C. crinita</i> Duby	<i>C. barbata</i> (Stackhouse) C. Agardh
Synonyms	<i>C. crinita</i> f. <i>bosporica</i> (Sauvageau) A.D.Zinova & Kalugina	<i>C. graeca</i> Schiffner ex Gerloff & Nizamuddin	<i>Fucus crinitus</i> Desfontaines	<i>Abrotanifolia barbata</i> Stackhouse 1809 <i>C. hoppei</i> C.Agardh <i>C. barbata</i> var. <i>hoppei</i> (C.Agardh) J.Agardh
Type localities	Buyuk-Déré Gulf, Bosphorus, Turkey	Naples, Italy	Corsica & French Riviera (Nice)	Unknown
References (Illustrations)	Sauvageau, 1912; Voronikhin, 1908, 1925; Petkoff, 1919, 1929, 1932; Celan, 1935, 1936 (Fig. 9), 1948; Celan and Bavaru, 1968 (Fig. 1); Celan <i>et al.</i> , 1969; Bavaru, 1972 (Fig. 2), 1973; Zinova, 1967. As <i>C. crinita</i> f. <i>bosporica</i> : Zinova and Kalugina, 1974 (Fig. 1); Kalugina-Gutnik, 1975 (Figs 37b); Zinova and Dimitrova-Konaklieva, 1975; Bavaru, 1980; Bavaru <i>et al.</i> , 1991; Mimicheva, 1998; Dimitrova-Konaklieva, 2000; Milchakova, 2002; Milchakova and Petrov, 2003; Aysel <i>et al.</i> , 2004, 2005a,b, 2006, 2008; Vasilev <i>et al.</i> , 2005; Bologa and Sava, 2006; Takin <i>et al.</i> , 2008; Biserkov <i>et al.</i> , 2011; Berov <i>et al.</i> , 2012; Berov, 2013; Marin <i>et al.</i> , 2013; Takin and Öztürk, 2013, Bologa <i>et al.</i> , 2014. As <i>C. crinita</i> : Kalugna-Gutnik, 1973 (Figs 2, 3b, 4b, 5b, 6, 8, 9 right), 1975 (Figs 37a, 38b, 39b, 44, 52); Dencheva, 2008; Simakova, 2009; Milchakova, 2011 (p. 63 right); Bologa <i>et al.</i> , 2014. As <i>C. crinita</i> f. <i>crinita</i> : Zinova and Kalugina, 1974; Aysel <i>et al.</i> , 2004, 2005a,b, 2006, 2008.	Kützing, 1860 (Pl. 46; fig. 1.); Cormaci <i>et al.</i> , 1990, 1992 (Figs 1-3, holotype : MEL, Folio 694721 : figs 4-6); 2012 (Pl. 94, figs 1-4); Tsirika and Haritonidis, 2005; Takin <i>et al.</i> , 2012 (pp. 24-25); Bouafif <i>et al.</i> , 2014 (Figs 8-10); Tsiamis <i>et al.</i> , 2014. As <i>C. graeca</i> : Gerloff and Nizamuddin, 1975 (pls 1-2, holotype , and 3-4). Misidentified as <i>C. cf. bosporica</i> : Campos-Villaca <i>et al.</i> , 1985 (Fig. 1).	Sauvageau, 1912; Hamel, 1931-1939 (Pl. VIII); Ercegovci, 1952 (Pl. XX); Amicoet <i>al.</i> , 1985 (Fig. 24); Gómez Garreta <i>et al.</i> , 2000 (Fig. 35a-c); Mannino and Mancuso, 2009; Cormaci <i>et al.</i> , 2012 (Pl. 100, figs 1-4); Sales Villalonga, 2010; Sales and Ballesteros, 2009; Sales <i>et al.</i> , 2012; Takin <i>et al.</i> , 2012 (pp. 34-35).	Sauvageau, 1912; Hamel, 1931-1939 (Pl. II); Celan, 1935, 1936*, 1948*; Ercegovci, 1952 (Pls XXII-XXIVa-d); Guern, 1962 (Fig.) ; Zinova, 1967* (Fig. 104); Celan and Bavaru, 1968* (Fig. 2); Bavaru, 1972* (Fig. 1), 1973*, 1991*; Zinova and Kalugina, 1974* (Fig. 2); Kalugina-Gutnik, 1973* (Figs 1, 3a, 4a, 5a, 7, 9 left), 1975* (Figs 37c-d, 38a, 39a-41, 51, 58, 60b); Amico <i>et al.</i> , 1985 (Fig. 28); Dimitrova-Konaklieva, 2000*; Gómez Garreta <i>et al.</i> , 2000 (Fig. 29); Aysel <i>et al.</i> , 2004*, 2006*; Sava, 2006* (Figs 2, 55); Milchakova, 2011* (p. 63 left); Cormaci <i>et al.</i> , 2012 (Pl. 92, figs 1-4); Takin <i>et al.</i> , 2012 (pp. 22-23); Berov, 2013; Marin <i>et al.</i> , 2013*; Takin and Öztürk, 2013 (Fig. 139); Bologa and Bavaru, 2014*.

* Black Sea references for *C. barbata*. ** Black Sea populations; Mediterranean populations are usually smaller (to 1 m high). ***. Records from the Canary Islands are misidentifications.

Table I. Comparison of diagnostic characters of *Cystoseira bosphorica* and closest *Cystoseira* species (continued)

Species	<i>C. bosphorica</i> Sauvageau	<i>C. barbatula</i> Kützting	<i>C. crinita</i> Duby	<i>C. barbata</i> (Stackhouse) <i>C. Agardh</i>
Figures	Figs 2-12 (Fig. 10: lectotype, PC0596565)	Figs 13-17		
Height	30-100 (-120) cm	30-40 cm	25-30 cm	20-130 (-170) cm**
Plants	Caespitose	Caespitose	Caespitose	Single axis
Axes	Up to 20, 2-4 mm in diameter, 5-90 cm long	3-7 (-11), 2-3 mm in diameter, 3-30 cm long	Up to 20, 2-5 mm in diameter, 10-30 cm long	Single, 4-12 mm in diameter, 10-60 cm long**
Apex of axes	Smooth and prominent	Smooth and prominent	Spinose and prominent	Smooth and prominent
Primary branches	Not spinose	Not spinose	Lower part spinose	Not spinose
Bases of primary branches	Broadened and persistent	Broadened and persistent, not spinose,	Leaving a small stump on the axis	Broadened and persistent
Adventitious branches	Few, on the base of dropped primary branches	On the base of dropped primary branches	In short tufts on stumps of primary branches	On the bases of dropped primary branches
Ultimate branchlets	Cylindrical	Cylindrico-filiform	Cylindrical	Cylindrico-filiform
Cryptostomates	Numerous and slightly prominent	Spaced and prominent	Numerous and prominent	Numerous
Aerocysts	Very abundant in plants growing in sheltered locations, less frequent and smaller in size in plants from open shores; oval to subconical, broader at the apex, inflated, with 2 or more outgrowths, which might bear other aerocysts, 4-8 mm × 2-5 mm; most abundant in spring and decrease in number in summer	Absent	Usually absent, but, if present, occur isolated near or included in the receptacles, 4-5 mm x 2-3 mm	Frequent, simple, oval to spindle-shaped without outgrowths, arranged in chains, 4-7 mm x 1-3 mm
Receptacles	Compact, cylindrical, simple to bifid, tuberculate with an apex blunt, 2-10 mm × 1 mm, sometimes with one short lateral sub-apical spine-like appendage	Compact, simple, humpy and subulate, 2-4 mm × 1 mm, sometimes with 1-2 long lateral spine-like appendages	Compact, usually simple, rarely bifid, cylindrical-oval, 2-15 mm × 1-2 mm, tuberculate, non mucronate, with few to no short spine-like appendages	Compact, simple, cylindrical to spindle-shaped, often bent like sickles, 5-30 mm × 1-1.2 mm, smooth to slightly rough, pedicellate and mucronate

* Black Sea references for *C. barbata*. ** Black Sea populations; Mediterranean populations are usually smaller (to 1 m high). ***. Records from the Canary Islands are misidentifications.

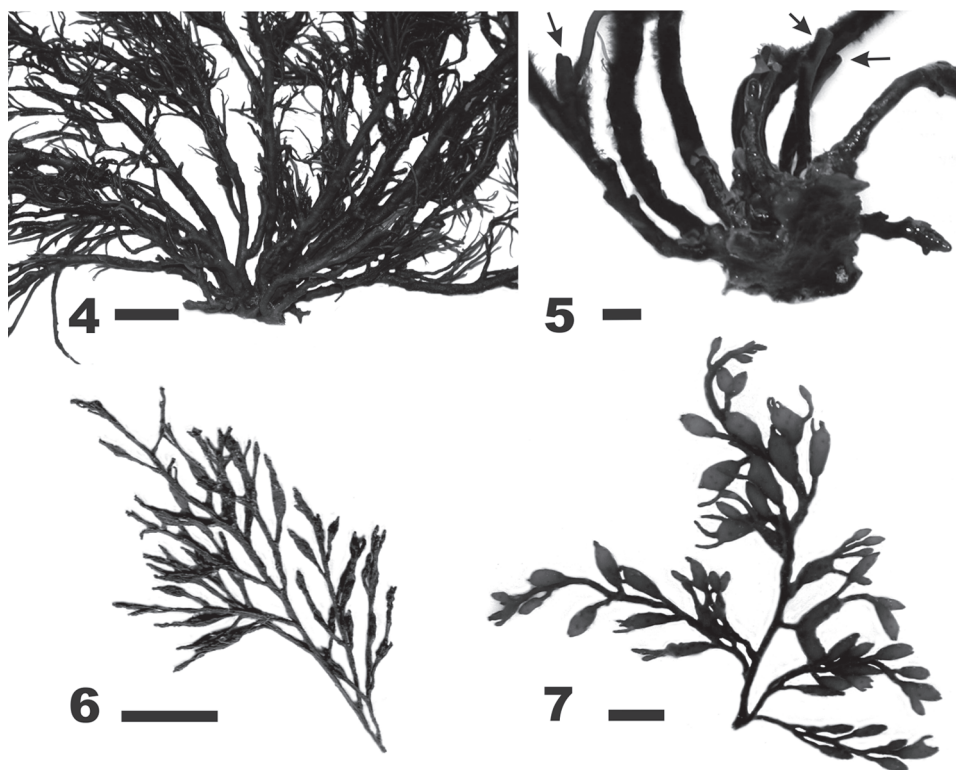
Table I. Comparison of diagnostic characters of *Cystoseira bosphorica* and closest *Cystoseira* species (*continued*)

<i>Species</i>	<i>C. bosphorica Sauvageau</i>	<i>C. barbatula Kützting</i>	<i>C. crinita Duby</i>	<i>C. barbata (Stackhouse) C. Agardh</i>
Conceptacles	Slightly prominent	Prominent	Slightly protruding from the surface	Slightly protruding from the surface
Habitat	Upper sublittoral zone, 0.5-10 m depth, on open and exposed rocky shores and in semi-sheltered inlets	Upper sublittoral zone, 1-1.5 m depth, on open and exposed rocky shores	Upper sublittoral zone, near the surface, 0-0.5 m depth, on open and sheltered to semi-exposed rocky shores and in littoral pools	Upper sublittoral zone, 0-2 m depth, on open and sheltered rocky shores, in semi-closed areas and coastal lagoons
Distribution	Black Sea	Mediterranean Sea: Italy, Sicily, Lampedusa, Malta, Ionian Sea (Greece), Tunisia, Libya, Egypt, Cyclades Islands, Cyprus	Mediterranean Sea ^{***}	Mediterranean Sea, Black Sea, Atlantic coasts close to the Gibraltar Straits ^{***}

* Black Sea references for *C. barbata*. ** Black Sea populations; Mediterranean populations are usually smaller (to 1 m high). ***. Records from the Canary Islands are misidentifications.



Figs 2-3. *Cystoseira bosporica*, Bulgaria, H8268 and H8271, habit of fertile thalli. Scales = 1 cm.

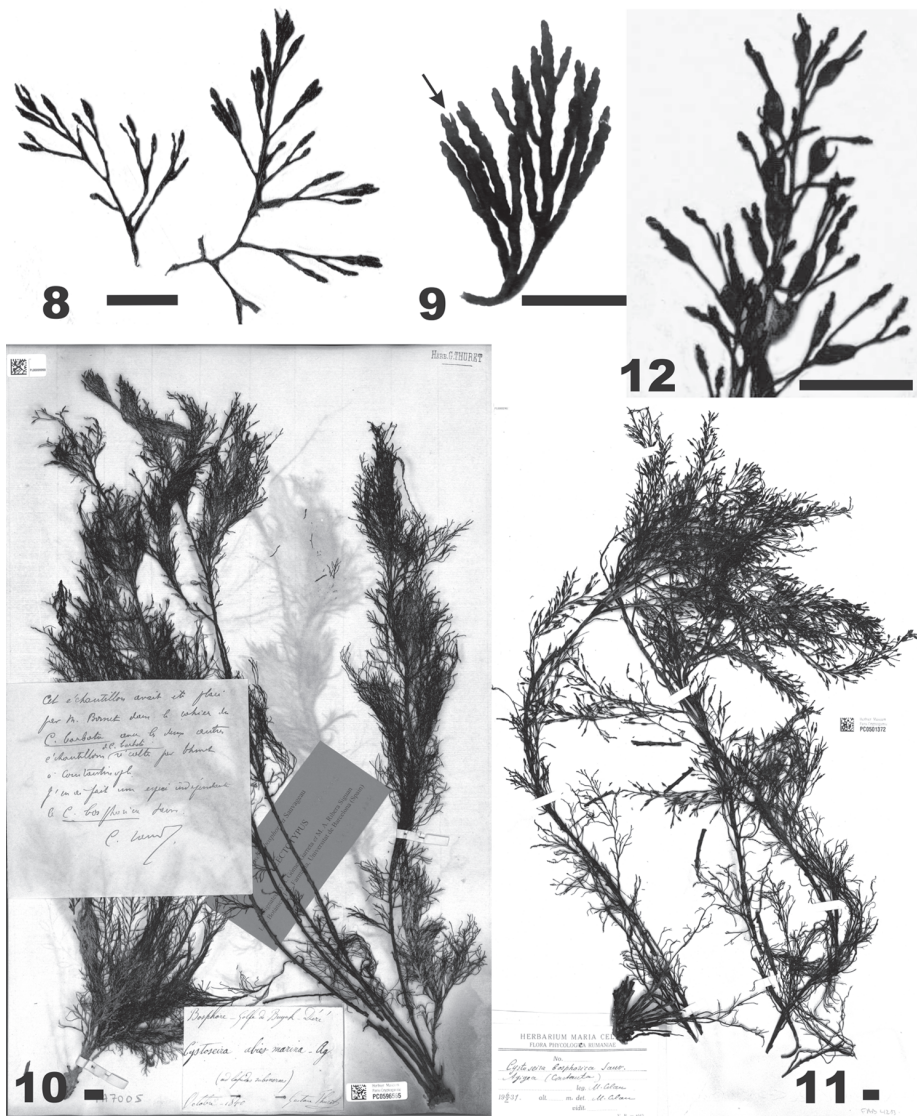


Figs 4-7. *Cystoseira bosphorica*, Bulgaria. **4.** H8268, detail of the basis. **5.** H8267, basis with young axes; arrows: prominent and smooth apices. **6-7.** H8271 and H8268, young and well-developed aerocysts. Scales = 1 cm.

By its morphological characters, *C. bosphorica* is closer to a *C. barbata* than to *C. crinita* (Table 1). Finally we agree with Cormaci *et al.* (2012), *C. barbatula* Kützinger is the species that shares the greatest number of characters with *C. bosphorica* (Table 1). However, the descriptions of *C. barbatula* and the study of extensive populations from Cyprus (Table 1, Figs 13-17), allow us to claim that both species are distinct. *Cystoseira barbatula* clearly differs from *C. bosphorica* by the constant absence of aerocysts, the filiform branches with prominent and spaced cryptostomates, and by the receptacles smaller, compact, simple, humpy and subulate with sometimes 1-2 long lateral spine-like appendages.

CONCLUSION

On the basis of literature data and new morphological and ecological studies, the reinstatement of species rank for the Black Sea endemic species *Cystoseira bosphorica* Sauvageau (homotypic synonym *C. crinita* f. *bosphorica*) is proposed. The Black Sea records of *C. crinita* f. *crinita* are considered misidentifications of *C. bosphorica*. Thus, *C. crinita* is a strictly Mediterranean



Figs 8-12. *Cystoseira bosporica*. **8-9.** Bulgaria, H8267, receptacles; arrow: spine-like appendage. **10.** Turkey, PC0596565, Lectotype collected by Gustave Thuret © MNHN-Paris (The plant in the lower left corner of the sheet is a *C. barbata*). **11-12.** Romania, PC0501372, collected by Maria Celan © MNHN-Paris. **11.** Habit. **12.** Detail of aerocysts. Scales = 1 cm (Figs 10-12, by courtesy of the MNHN-Paris).

endemic species that is absent from the Black Sea. In our opinion, the status of *C. bosporica* should be ratified through genetically based comparisons, which at the moment are in their early stages of development for the genus *Cystoseira* (Draisma *et al.*, 2010). The implications of this taxonomical reinstatement are important in terms of biological conservation. The habitat dominated by *C. bosporica* becomes



Figs 13-17. *Cystoseira barbatula*, Cyprus. **13.** H.7217, habit. **14.** H.7217, basis with a young axis; arrow: prominent and smooth apex. **15.** H.7217, apex of a developed axis. **16-17.** H.7217 and H.7218, fertile branches with receptacles. Scales: Figs 13-14. = 1 cm; Figs 15-17 = 5 mm.

a major feature of the Black Sea region and its conservation constitutes a new challenge in the current efforts in setting up marine habitat classification schemes in the framework of the EU Habitats Directive, the Marine Strategy Framework Directive and the creation of networks of marine protected areas ensuring the conservation of European marine environments.

Acknowledgements. The authors thank Michèle Perret-Boudouresque for documentation assistance, the Muséum National d'Histoire Naturelle de Paris for the permission to reproduce photos of herbarium specimens, Stefka Dimitrova-Konaklieva for her guidance in the history of studies of macroalgae in the Black Sea region, Georgi Hiebaum for his continuous support of our work, and Diana Deyanova, Borislava Gyosheva and Luybomir Kenderov for their help during the field mission. This study has been funded by the EU FP7 Wetlanet project, Bulgarian National Science Fund project 218/2008 to D.B., and a Marina Bueno fellowship from CSIC to M.S.

REFERENCES

- AGARDH C.A., 1820 — *Species algarum rite cognitae, cum synonymis, differentiis specificis et descriptionibus succinctis*. Volumen primum. Pars prima. pp. [i-iv], [1]-168. Lundae [Lund]: ex officina Berlingiana.
- AMICO V., 1995 — Marine brown algae of family Cystoseiraceae: chemistry and chemotaxonomy. *Phytochemistry* 38: 1257-1279.
- AMICO V., GIACCONE G., COLOMBO P., MANNINO A.M. & RANDAZZO R., 1985 — Un nuovo approccio allo studio della sistematica del genere *Cystoseira* C. Agardh (Phaeophyta, Fucales). *Bollettino delle accademia Gioenia di scienze naturali di Catania* 18: 887-985.
- AYSEL V., ERDGAN H., DURAL-TARAKÇI B., OKUDAN E.S., ENKARDELER A. & AYSEL F., 2004 — Marine Flora of Sinop (Black Sea, Turkey). *E.U. journal of fisheries & aquatic sciences* 21 (1-2): 59-68.
- AYSEL V., ERDUGAN H. A. & DURAL-TARAKCI B., 2005a — Marine Flora of Kastamonu (Black Sea, Turkey). *Journal of Black Sea/Mediterranean environment* 11: 179-194.
- AYSEL V., ERDGAN H., DURAL B. & OKUDAN E.S., 2006 — Marine algae and seagrasses of Tekirdag (Black Sea, Turkey). *Journal of Black Sea / Mediterranean environment* 12: 251-267.
- AYSEL V., ERDUGAN H., DURAL-TARAKÇI B. & OKUDAN E., 2005b — Marine algae and Seagrasses of Giresun Shores (Black Sea, Turkey). *Journal of Black Sea/Mediterranean environment* 11: 241-255.
- AYSEL, V., ERDUGAN, H., DURAL B. & OKUDAN E., 2008 — A survey of Marine Algae and Seagrasses of stanbul (Turkey). *Journal of Black Sea/Mediterranean Environment* 14: 129-144.
- BALLESTEROS E., 1992 — *Els vegetals i la zonació litoral: espècies, comunitats i factors que influeixen en la seva distribució*. Arxius Secció Ciències IEC 101, 656 pp.
- BALLESTEROS E., SAL E., GARRABOU J. & ZABALA M., 1998 — Community structure and frond size distribution of a deep water stand of *Cystoseira spinosa* Sauvageau in the Northwestern Mediterranean. *European journal of phycology* 33: 121-128.
- BALLESTEROS E., 2000 — Book review: Flora Phycologica Iberica. Vol. 1. Fucales. Gómez-Garreta, A. (ed.). *Scientia marina* 66: 187-188.
- BALLESTEROS E., GARRABOU J., HEREU B., ZABALA M., CEBRIAN E. & SALA E., 2009 — Deep-water stands of *Cystoseira zosteroides* (Fucales, Phaeophyta) in the Northwestern Mediterranean: insights into assemblage structure and population dynamics. *Estuarine, Coastal and shelf science*, 82: 477-484.
- BAVARU A., 1972 — Evaluari cantitative in populatiile de *Cystoseira* la tarmul romanesc al Marii Negre- *Studii si cercetri de biologie, Seria botanica* 24 (2): 95-101.
- BAVARU A., 1973 — Les associations algales de la ceinture des Cystoseires sur la côte roumaine de la Mer Noire *Rapport P.V. Commission internationale pour l'exploration scientifique de la Mer Méditerranée* 22(4) : 125-126.
- BAVARU A., 1980 — Endémiques et reliques ponto-caspiennes de la flore algale de la Mer Noire *Journées Études Systématiques et Biogéographies Méditerranée, Commission internationale pour l'exploration scientifique de la Mer Méditerranée* : 93-94.
- BAVARU A., BOLOGA A. S. & SKOLKA H. V., 1991 — A checklist of the benthic marine algae (except the diatoms) along the Romanian shore of the Black Sea. *Revue Roumaine de biologie, Série de Biologie végétale* 36(1-2): 7-22.

- BEROV D., 2013 — Structure of *Cystoseira* spp. macroalgal communities and the influence of anthropogenic factors on their distribution. Macroalgae as an indicator of the ecological state of coastal marine ecosystems in the Black Sea. PhD Thesis. Institute of Biodiversity and Ecosystem Research, Bulgarian Academy of Sciences (IBER-BAS), Sozopol, 306 p. [In Bulgarian].
- BEROV D., DEYANOVA D., GEORGIEVA I., GYOSHEVA B. & HIEBAUM G., 2012 — *Cystoseira* sp.-dominated macroalgal communities in the SW Black Sea (Burgas Bay, Bulgaria). Current state and possible long-term effects of eutrophication. *Comptes rendus de l'académie Bulgare des sciences* 65 (6): 821-830.
- BISERKOV V., GUSSEV C., POPOV V., HIBAUM G., ROUSSAKOVA V., PANDURSKI I., UZUNOV Y., DIMITROV M., TZONEV R. & TSONEVA S. (Eds.), 2011 — *Red Data Book of the Republic of Bulgaria. Volume 3. Natural habitats*. Sofia, IBER- BAS & MOEW.
- BOLOGA A.S. & SAVA D., 2006 — Progressive decline and present trend of Romanian Black Sea macroalgal flora. *Cercetari marine* 36: 31-60.
- BOLOGA A.S. & BAVARU A., 2014 — *Cystoseira barbata* (Good. et Wood. Ag., 1821). In: *Black Sea Red data Book website*. Black Sea Environmental Internet Node – Marine Hydrophysical Institute, Sevastopol. <http://www.grid.unep.ch/bsein/redbook/txt/cystos-c.htm> (accessed on June 2014).
- BOLOGA A.S., BAVARU A. & DENCHEVA K., 2014 — *Cystoseira crinita* (Desf. Bory, 1832). In: *Black Sea Red data Book website*. Black Sea Environmental Internet Node – Marine Hydrophysical Institute, Sevastopol. <http://www.grid.unep.ch/bsein/redbook/txt/cystos-c.htm> (accessed on June 2014).
- BOUAFIF C., VERLAQUE M. & LANGAR H., 2014 — *Cystoseira* taxa new for the marine flora of Tunisia. *Cryptogamie, Algologie* 25: 269-283.
- 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.
- CAMPOS-VILLACA R., BERGIN F., BOUDOURESQUE C.F. & THELIN I., 1985 — Le benthos littoral d'El Dabaa (Méditerranée, Egypte). III. Les peuplements algaux photophiles de substrat dur. *Rapports P.V. Réunion de la Commission Internationale pour l'exploration scientifique de la Mer Méditerranée* 29 (5): 249-252.
- CELAN M., 1935 — Notes sur la flore algologique du littoral roumain de la Mer Noire. I. *Bulletin de la section scientifique de l'académie Roumaine* 17: 55-70.
- CELAN M., 1936 — Notes sur la flore algologique du littoral roumain de la Mer Noire. III. *Memoriile sesiunii stiintifice*, Ser. 3, 12: 39-70, pls i-vi.
- CELAN M., 1948 — Sur la végétation algale à Agiea (Mer Noire) pendant les mois Septembre-Novembre 1946. *Bulletin de l'institut polytechnique de Jassy* 4: 340-351.
- CELAN M. & BAVARU A., 1968 — Quelques observations sur l'embryologie des espèces de *Cystoseira* de la Mer Noire. *Lucrile Sesiunii stiintifice statiunii cercetri marine "Prof. Ioan Borcea"*. Universitatea "Alexandru Ioan Cuza". Iasi, Special vol.: 96-100.
- CELAN M., BAVARU A. & ELEFTERIU R., 1969 — Sur la végétation algale à Agiea pendant le mois d'octobre 1968. *Lucrile sesiunii stiintifice statiunii cercetri marine "Prof. Ioan Borcea"*. Universitatea "Alexandru Ioan Cuza". Iasi 3: 59-65.
- CHEMINÉE A., SALA E., PASTOR J., THIRIET P., 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 (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 delle accademia gioenia di scienze naturali di Catania* 45: 1-508.

- DENCHEVA K. H., 2008 — Influence of the anthropogenic stress on macrophytobenthic communities. *Phytologia balcanica* 14 (3): 315-321.
- DIMITROVA-KONAKLIEVA S., 2000 — *Flora of the Marine Algae of Bulgaria (Rhodophyta, Phaeophyta, Chlorophyta)*. Pensoft, Sofia-Moscow, 302 p. [In Bulgarian].
- 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.
- DUBY J.É., 1830 — *Aug. Pyrami de Candolle Botanicon gallicum* sen synopsis plantarum in flora gallica descriptarum. Editio secunda. Ex herbariis et schedis Candollianis propriisque digestum a J. É. Duby V.D.M. Pars secunda plantas cellulares continens. Paris: Ve Desray, pp. [i-vi], [545]-1068, [i]-lviii.
- ERCEGOVI 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'Océanographie et de Pêche, pp. 1-172 (Croatian), 173-210 (French), 211-212 (references), Map.
- 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. & BRUNI A., 1973 — Le Cistoseire e la vegetazione sommersa del Mediterraneo. *Atti delle Istituto Veneto di Scienze Lettere ed Arti Venezia* 131: 59-103.
- GIANNI F., BARTOLINI F., AIROLDI L., BALLESTEROS E., FRANCOUR P., MEINESZ A., THIBAUT T. & MANGIALAJÓ L., 2013 — Conservation and restoration of marine forests in the Mediterranean Sea and the potential role of Marine Protected Areas. *Advances in oceanography and limnology* 4 (2): 83-101.
- GÓMEZ GARRETA A., BARCELÓ MARTÍ M.C., RIBERA SIGUAN M.A. & RULL LLUCH J., 2000 — Cystoseiraceae Kützinger. In: Gómez Garreta, A. (ed.), *Flora phycologica Iberica, 1. Fucales*, Universidad de Murcia, pp. 89-166.
- GÓMEZ GARRETA A. & RIBERA M. A., 2005 — Lectotypification of several taxa of *Cystoseira* (Cystoseiraceae, Fucales) described by Sauvageau. *Cryptogamie, Algologie* 26: 135-147.
- GUERN M., 1962 — Embryologie de quelques espèces du genre *Cystoseira* Agardh, 1821. *Vie & milieu* 13 (4): 649-679.
- GUIRY M.D. & GUIRY G.M., 2014 — *AlgaeBase*. World-wide electronic publication, National University of Ireland, Galway. <http://www.algaebase.org/> (searched on 10 September 2014).
- HAMEL G., 1931-1939 — *Phéophycées de France*. Paris, Rouen, Imprimerie Wolf, XLVII + 431 p., 9 plates.
- KALUGINA-GUTNIK A., 1973 — Some characteristics of the development of the Black Sea *Cystoseira* (*Cystoseira barbata* and *C. crinita*). *Botanical journal* 58: 20-32 [In Russian].
- KALUGINA-GUTNIK A., 1975 — *Phytobenthos of the Black Sea*. Kiev, Naukova Dumka, 247 p. [In Russian].
- KÜTZING F.T., 1860 — *Tabulae phycologicae; oder, Abbildungen der Tange*. Vol. X pp. i-iv, 1-39, 100 pls. Nordhausen: Gedruckt auf kosten des Verfassers.
- MANNINO A.M. & MANCUSO F.P., 2009 — *Guida all'identificazione delle Cistoseire*. Palermo, Tipografia Alba, 79 p.
- MARIN O., ABAZA V. & SAVA D., 2013 — Phytobenthos – Key biological element in shallow marine waters. *Cercetri marine* 43: 197-218.
- MILCHAKOVA N.A., 2002 — Brown macroalgae of the Black Sea: systematic composition and occurrence. *Algologia* 12: 324-337.
- MILCHAKOVA N.A. & PETROV A., 2003 — Morphofunctional analysis of long-term changes in the structure of *Cystoseira* phytocoenosis (Lapsi Bay, Black Sea). *Algologia* 13: 355-370.
- MILCHAKOVA N.A., 2011 — *Marine plants of the Black Sea. An illustrated field guide*. Sevastopol, Digit Print Press, 144 p.
- MINICHEVA G. G., 1998 — Morphofunctional fundamentals of formation of marine phytobenthos. *Abstract of dissertation for doctor of biological sciences* 3: 17 [In Russian].
- PETKOFF S., 1919 — Materials about the macroalgal flora of the Bulgarian Black Sea coast. *Journal of the Bulgarian academy of sciences* 17: 25-134 [In Bulgarian].
- PETKOFF S., 1929 — *The Basics of Botany. Part II. Special Botany*. Sofia, University of Sofia Library, 73 p. [In Bulgarian].
- PETKOFF S., 1932 — Sur la flore algologique des côtes bulgares de la mer Noire. *Excerpts of the Bulgarian botanical society* 5: 117-127.

- ROBERTS M., 1978 — Active speciation in the taxonomy of the genus *Cystoseira* C. Ag. In: D.E.G. Irvine and J.H. Price (eds) *Modern Approaches to the taxonomy of red and brown algae*, London, Academic Press, pp. 399-422.
- 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., 2010 — *Cystoseira*-dominated assemblages from sheltered areas in the Mediterranean Sea: diversity, distribution and effects of pollution. PhD Universitat de Girona, Spain, 203 p. + Appendices.
- SALES M., BALLESTEROS E., ANDERSON M.J., IVESA L. & CARDONA E., 2012 — Biogeographical patterns of algal communities in the Mediterranean Sea: *Cystoseira crinita*-dominated assemblages as a case study. *Journal of biogeography* 39: 140-152.
- SAUVAGEAU C., 1912 — A propos des *Cystoseira* de Banyuls et de Guéthary. *Bulletin de la station biologique d'Arcachon* 14: 133-556.
- SAVA D., 2006 — *Algele macrofite de la litoralul românesc al Mrii Negre*. Constana, Ovidius University Press, 147 p.
- SIMAKOVA U. V., 2009 — Influence of the sea bottom relief on the *Cystoseira* communities of the North Caucasian coast of the Black Sea. *Oceanology* 49(5), 672-680.
- TAKIN E., ÖZTÜRK M., KURT O. & ÖZTÜRK M., 2008 — *The check-list of the marine flora of Turkey*. Manisa, Turkey, 87 p.
- TAKIN E., JAHN R., ÖZTÜRK M., FURNARI G. & CORMACI M., 2012 — *The Mediterranean Cystoseira (with photographs)*. Manisa, Turkey: Celal Bayar University, pp. [2] 1-75, photographs.
- TAKIN E. & ÖZTÜRK M., 2013 — *Türkiye deniz algleri. I. Phaeophyceae*. Matbaasi, Manisa, Turkey, Celal Bayar University, ii + 229 p.
- THIERS B., 2014 — Index Herbariorum: A global directory of public herbaria and associated staff. New York Botanical Garden's Virtual Herbarium. <http://sweetgum.nybg.org/ih/> (searched on 10 September 2014).
- TSIAMIS K., TAKIN E., ORFANIDIS S., STAVROU P., ARGYROU M., PANAYOTIDIS P., TSIOLI T., CICEK B.A., MARCOU M. & KÜPPER F.C., 2014 — Checklist of seaweeds of Cyprus (Mediterranean Sea). *Botanica marina* 57: 153-166.
- TSIRIKA A. & HARITONIDIS S., 2005 — A survey of the benthic flora in the National Marine Park of Zakynthos (Greece). *Botanica marina* 48: 38-45.
- VASILEV V., KARAMFILOV V., DENCHEVA K. & HIEBAUM G., 2005 — Distribution of benthic macrophytes and their communities in the area of Sozopol and Cape Maslen. Results from a pilot study carried out within the Natura-2000 program. In: Chihev V., N.B. (eds), *Biodiversity, Ecosystems, Global Changes*. Proceedings of the First National Ecology Conference, Petekston, Sofia, pp. 295-302 [In Bulgarian].
- VERGES 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.
- VORONIKHIN N.N., 1925 — Algological results from the expedition of prof. S.A Zernov in the Black Sea onboard "Meotida" in 1909-10 and "Gaimak" in 1911. *Journal of the Russian botanical society* 10. [In Russian].
- ZINOVA A.D., 1967 — *Classification guide of green, brown and red algae of the Southern seas of USSR*. Moscow, Leningrad, Nauka, 398 p. [In Russian].
- ZINOVA A.D. & DIMITROVA-KONAKLIEVA S., 1975 — Macroalgae in the Ahtopol Bay (South-West Bulgaria). II. *News on the systematics of lower plants* 12: 119-123 [In Russian].
- ZINOVA A.D. & KALUGINA A., 1974 — On the systematics of the genus *Cystoseira* AG. in the Black Sea. *News on the systematics of lower plants* 11: 116-125 [In Russian].