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**A contribution to the knowledge of epiphytic flora on the leaves of the seagrass *Cymodocea nodosa* Ucria (Ascherson) (*Najadales*, *Potamogetonaceae*) of the “Bay of Brucoli” (south-eastern Sicily) †**

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### Summary

The results of a study carried out on the epiphytic flora on the leaves of the seagrass *Cymodocea nodosa* occurring in the Bay of Brucoli (Syracuse, SE Sicily) are presented. Sampling was carried out in three stations and in two different seasons (summer and winter) in order to provide a contribution to the study of this epiphyte flora also considering the absence of data concerning these plant formations. From this study it resulted that the floristic richness of the macroalgal epiphytic flora on the leaves of *Cymodocea nodosa* is rather high, although the high number of species with wide ecological valence reflects some degree of environmental instability. Therefore, given the high landscape value as concerns the marine environment of this Bay, it can be concluded that environmental monitoring as well actions aiming at the protection and preservation of this important ecosystem are needed.

**Key words:** *Cymodocea nodosa*, *Brucoli*, *epiphytic flora*, *SE Sicily*

### Riassunto

Vengono presentati i risultati di uno studio condotto sulla flora epifita delle foglie di *Cymodocea nodosa* (Ucria) Ascherson, della baia di Brucoli, (SR, Sicilia sud-orientale). I campionamenti sono stati effettuati in tre stazioni e in due stagioni differenti (estate e inverno). Da questo studio è risultato che la ricchezza floristica della flora epifita è abbastanza elevata. Tuttavia l'elevato numero di specie ad ampia valenza ecologica denota una certa instabilità ambientale. Pertanto, dato l'elevato valore paesaggistico dell'ambiente marino di questa Baia, si può concludere che sono necessarie azioni di monitoraggio e intervento mirate alla tutela e salvaguardia di questo importante ecosistema.

**Parole chiave:** *Cymodocea nodosa*, *Brucoli*, *flora epifita*, *Sicilia sud-orientale*

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## 1 Introduction

*Cymodocea nodosa* Ucria (Ascherson) is the most widespread species of seagrasses in the Mediterranean Sea, after *Posidonia oceanica* (L.) Delile (Guiry M.D. & Guiry G.M. 2013 (1)). Outside of the Mediterranean it is distributed in warm temperate and subtropical seas, up to the Atlantic coast of Senegal and Mauritania (Den Hartog 1970 (2); Larkum & Den Hartog 1989 (3); Kuo & Mc Comb 1989 (4); Guiry M.D. & Guiry G.M. 2013 (1)). *C. nodosa* forms extended meadows which play a particular ecological function within marine ecosystems, in making the substrate suitable for the establishment of *P. oceanica*. *C. nodosa* develops between the coast and the outer front of *Posidonia* meadows (Buia et al. 2003 (5)); its underground apparatus stabilizes the bottom and facilitates the sedimentation of the material suspended in the water. Different studies (Terrados & Ros 1992 (6); Perez & Romero 1992 (7); Marbà et al. 1996 (8)) demonstrate that the *C. nodosa* shows a wide environmental tolerance being able to colonize different types of environments from coastal waters, up to lakes and coastal estuaries.

The Bay of Brucoli, located between Catania and Syracuse (eastern coast of Sicily), due to its historical and environmental importance is subject to environmental restrictions (G.U.R.S. Palermo – Friday, June 27, 2008 – n. 29 (9)). It extends from 37° 17'09, 35" N – 15° 11'12, 49" E, to 37° 17'32, 41" N – 15° 11'50, 08" E. It borders south west the ancient village of Brucoli, then follows the coastline with an interruption by the estuary of the channel "Porcaria" 25 – 30 m wide, no longer navigable due to the rise of the sea bottom. The coastline facing north is characterized by mobile substrate which hosts the "banquettes" of *Posidonia oceanica*, cleared in summer to favour bathing.

The east side of the bay is prevalently rocky with the exception of the first section which is characterised by pebbles. That area is involved, in summer, in intense recreational activities because of the presence of floating piers.

Submerged vegetation is characterized by the typical seagrass communities. There is a wide meadow of *P. oceanica* that rises to the surface forming a "récif barrier" formation. That creates a lagoon area towards the coastline colonized by *C. nodosa* and characterized by a low hydrodynamic regime.

For over forty years the Bay of Brucoli has been subject to anthropogenic impact, especially in Summer, due to the high number of both summer residences and yachtsmen frequenting its coasts. This involves evident signs of an aggressive anthropogenic transformation absolutely careless towards the natural values of the place. Around the Bay there is a no swimming zone because of the presence of sewage that contributes to the deterioration of natural habitats.

For its safeguard, the Italian Department of Cultural and Environmental Heritage and Education, by the law of May 30<sup>th</sup> 2008, indicated as "Site of Public Interest" the area including the "coastal strip of Brucoli" falling in the town of Augusta and such an appointment was published in the Official Gazette of the Region Sicily of June 27<sup>th</sup> 2008, n. 29 (part one).

In addition, because of the presence of the *Posidonia oceanica* "récif barrier", the Bay was included in the Natura 2000 network as a "Site of Community Importance" called "SIC- ITA090026 – Depths of Brucoli – Agnone" identified by Directive 92/43/EC which aims at the preservation of natural habitats.

The existing data on marine benthic flora and vegetation of the Bay of Brucoli are rather scarce and fragmentary. Battiato & Ponte 1975 (10) carried out a study of the submerged flora of the channel Porcaria. They found 49 seaweeds (27 Rhodophyta, 11 Ochrophyta, 11 Chlorophyta) and *Cymodocea nodosa* recorded at about -0.50 cm in a muddy bottom.

A further study dealing with all the Bay was published by Battiato et al. 1978 (11) who collected from the surface to a depth of 10 m, a total of 96 taxa at specific and infraspecific level (63 Rhodophyta, 17 Ochrophyta, 14 Chlorophyta and 2 Angiospermae).

Serio & Pizzuto 1999 (12) published a work on a little meadow with *Caulerpa racemosa* (Forsskål) J. Agardh present in a bay near Brucoli, in which the expansion of this invasive species and possible interactions with the *Posidonia* prairies are pointed out.

Recently, Nisi 2012 a, b (13), (14) carried out the first specific studies on the *P. oceanica* meadow of the Bay providing the first quantitative and qualitative evaluation of the composition, phenology, macro-structural characteristics and epiphytic algal flora of leaves and rhizomes of *P. oceanica*.

Considering that no specific studies were made on the meadows of *Cymodocea* from this area, it seemed appropriate to conduct a study on epiphytic macroalgae on *Cymodocea nodosa* leaves.

## 2 Material and methods

The study was carried out on soft substrata at the following three stations: A (country side), B (central part of the Bay), C (wharf side) (Fig. 1), in two different seasons: winter (December 2010) and summer (June 2011, September 2012), by SCUBA diving. For each sample rhizomes

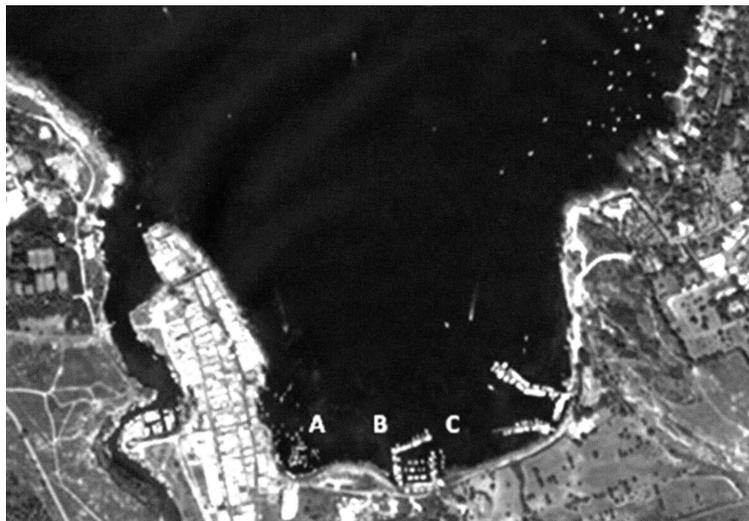


Figure 1: Map of Brucoli Bay showing sampling sites.

and leaves on a standard surface of 1600 cm<sup>2</sup> were collected.

The collected material was preserved in 5% formalin in seawater and stored in a refrigerated room to 5 – 8 °C and in the dark to retard the discoloration of specimens, for later study in laboratory. In the laboratory, the sorting of each sample and the identification of all epiphytic taxa on the leaves of *Cymodocea nodosa* using the optical microscope, were performed.

Taxa are included in a floristic list in alphabetical order within the division to which they belong. Also, for each taxon, the phytogeographical element, reproductive phenology and the indication of the collection season are reported

## 3 Results

The floristic analysis has allowed the identification of 32 Rhodophyta (51.61%), 14 Ochrophyta (22.58%) and 16 Chlorophyta (25.81%) for a total of 62 taxa at specific and infraspecific level (Fig. 2).

The index R/P (Rhodophyceae / Phaeophyceae) proposed by Feldmann 1937 (15) as an index for evaluating the phytogeographic characteristics of the flora of a given area, was 2.28. This index is also an indicator of environmental quality, because it increases with the increase in the degradation and decreases in conditions of environmental stability (Cormaci et al. 2003 (16)).

From a phytogeographic point of view the epiphytic flora on the leaves of *C. nodosa* is characterized by a higher incidence of cosmopolitan element (45%), followed by Atlantic (27%), Circumboreal (15%), Mediterranean (10%) and Indo Pacific (3%) elements (Fig. 3). Pantropical ele-

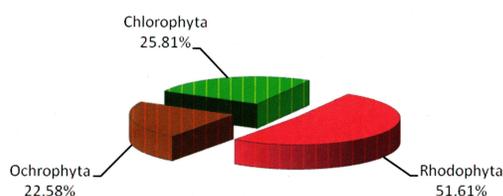


Figure 2: Floristic composition of epiphytic flora.

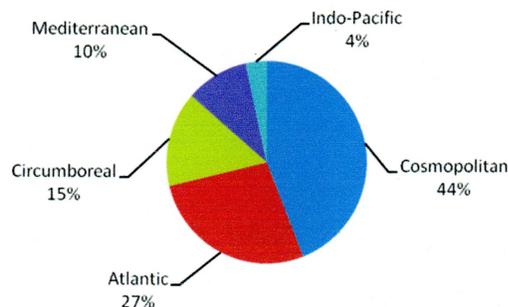


Figure 3: Chorological spectrum of epiphytic flora.

ment was not represented. The high percentage of Cosmopolitan species and the low incidence of Mediterranean species denotes a strong character of environmental instability that favours species with wide ecological valence.

Comparing the flora of the two seasons (summer and winter), a significant quantitative difference resulted. In fact, 58 and 23 taxa were found in summer and in winter, respectively. As regards the qualitative differences, the summer flora consists of 29 Rhodophyta, 14 Ochrophyta and 15 Chlorophyta, while the winter one is characterized by 15 Rhodophyta, 2 Ochrophyta and 6 Chlorophyta. Such differences are more evident if we consider the per cent values of each division. In fact Rhodophyta in summer represent the 50.0%, while in winter the 65.2%, Ochrophyta represent the 24.1% in summer and the 8.7% in winter, Chlorophyta have the smallest difference, representing the 25.9% in summer and the 26.1% in winter (Fig. 4).

The most obvious quantitative difference is that of Ochrophyta that have a much higher value in summer compared to what is found in winter. That is also highlighted by R/P index which results 2.28 in summer and 7.5 in winter. The strong seasonality of the flora is also demonstrated by the per cent incidence of the exclusive taxa (62.9% in summer and 6.5% in winter), while the 30.6% of the species is present in both seasons (Fig. 5).

From the above data it results that the floristic richness in the two seasons is almost identical but with a marked qualitative difference mainly due to the characteristics of the biological cycle of many species.

To date, only two other Mediterranean studies on epiphytic macroalgal flora on *C. nodosa* leaves were made. The one by Buia et al. 1996 (17) at Ischia island, the other by Reyes & Sanson 1996 (18) at El Medano (Tenerife Island). At Ischia island and at El Medano, a total of 34 species (22 Rhodophyta, 8 Ochrophyta and 4 Chlorophyta) and 46 species (26 Rhodophyta, 12 Ochrophyta and 8 Chlorophyta) were found respectively. In both the above localities the number of epiphytic species is lower than that found in the present study at Brucoli (a total of 62 species of which 32 Rhodophyta, 14 Ochrophyta and 16 Chlorophyta). But, due to such a low number of studies, comparison among the above floras doesn't allow to draw any significant conclusions on the characterization of Mediterranean macroalgal epiphytic community on *C. nodosa* leaves.

## 4 Conclusions

At present, the Bay of Brucoli doesn't enjoy a state of optimal environmental health because of the presence of sewage and the supply of muddy material from the channel Porcaria. These factors alter the normal rate of sedimentation of the Bay with the resulting increase in water turbidity and siltation of seagrasses, thus causing the alteration of the density of the prairies and their regression. The substrate that is released is generally colonized by species belonging to the genus *Caulerpa*, in particular *Caulerpa racemosa* v. *cylindracea* (Sonder) Verlaque et al., an invasive species which

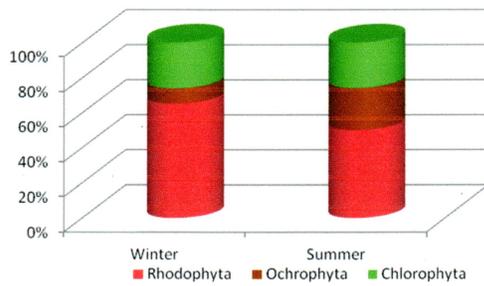


Figure 4: Comparison between floristic composition of epiphytic flora in winter and summer.

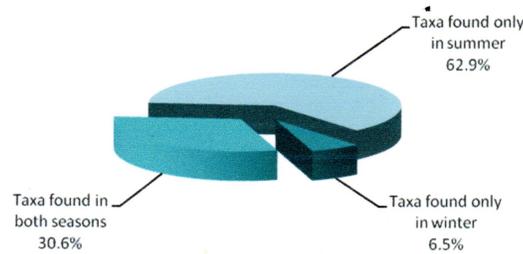


Figure 5: Cyclogram showing seasonal distribution of species.

has a high rate of growth and vegetative propagation and forms meadows very close to *Posidonia oceanica* (Serio & Pizzuto 1999 (12)).

The observations carried out have also detected a significant deterioration in the south-west side of the Bay, where the meadow of *Cymodocea nodosa* presents a per cent coverage value of 40% and the plants have rather small leaves. The condition of the meadow improves towards the east where *C. nodosa* reaches a per cent coverage value of 90% and shows longer leaves. That demonstrates the major signs of distress occur in the side which is most affected by human activity (urban settlement, sewage, channel Porcaria). On the whole, the macroalgal epiphytic flora on *Cymodocea nodosa* leaves resulted rather rich (62 taxa of which 32 Rhodophyta, 14 Ochrophyta and 16 Chlorophyta). However, the large number of species with wide ecological valence denotes a certain environmental instability. Given signs of environmental degradation and instability recorded by the study of *P. oceanica* meadow (Nisi 2012 a, b (13), (14)) from the Bay of Brucoli, a site of high landscape value as concerns the marine environment, it can be concluded that environmental monitoring as well actions aiming at the protection and preservation of this important ecosystem are needed.

## Acknowledgements

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## Appendix: floristic list

Species are listed alphabetically within the three divisions Rhodophyta, Ochrophyta and Chlorophyta. Each species is preceded by the phytogeographic element. Phytogeographic elements are named according to Cormaci et al. 1982 (19). Captions to abbreviations are: **A** = Atlantic; **Ab** = boreo-Atlantic; **Abt** = boreo-tropical Atlantic; **AP** = Atlanto-Pacific; **APt** = Atlanto-Pacific tropical; **APtf** = Atlanto-Pacific cold temperate; **At** = Atlantic tropical; **C** = Cosmopolitan; **CA** = Circumastral; **CB** = Circumboreal; **CBA** = Circumboreo-Austral; **IA** = Indo-Atlantic; **IAt** = Indo-Atlantic tropical; **IAtf** = Indo-Atlantic cold temperate; **IP** = Indo-Pacific; **M** = Mediterranean; **P** = Pantropical; **SC** = Sub-Cosmopolitan. In round brackets the season of collection: W = winter; S = summer; in square brackets the reproductive phenology: f = female gametophyte including carposporophyte; m = male gametophyte; t = tetrasporophyte; p = plurilocular cysts.

### • Rhodophyta

*Acrochaetium* sp. (W-S)

**SC** *Acrosorium ciliolatum* (Harvey) Kylin (S)

- Aglaothamnion* sp.(W-S)
- CT** *Anotrachium tenue* (C. Agardh) Nägeli (S)
- C** *Asparagopsis armata* Harvey (S) [t]
- Abt** *Callithamnion corymbosum* (J. E. Smith) Lyngbye (W)
- IA** *Ceramium comptum* Børgesen (S)
- SC** *Ceramium diaphanum* (Lightfoot) Roth (S)
- SC** *Ceramium siliquosum* (Kützing) Maggs & Hommersand (S) [m, t]
- SC** *Ceramium tenerrimum* (G. Martens) Okamura (S) [m, f, t]
- M** *Chondria mairei* Feldmann-Mazoyer (S) [m, f, t]
- C** *Chroodactylon ornatum* (C. Agardh) Basson (S)
- At** *Chylocladia verticillata* (Lightfoot) Bliding (W-S)
- Abt** *Dasya rigidula* (Kützing) Ardissonne (W)
- C** *Erythrotrichia carnea* (Dillwyn) J. Agardh (W-S)
- M** *Erythrotrichia rosea* P. J. L. Dangeard (W-S)
- M** *Gayliella mazoyerae* T.O. Cho, Fredericq & Hommersand (W-S)
- CT** *Herposiphonia secunda* (C. Agardh) Ambronn (W-S)
- CT** *Heterosiphonia crispella* (C. Agardh) M. J. Wynne (S)
- C** *Hydrolithon boreale* (Foslie) Y. M. Chamberlain (W-S)
- IA** *Hydrolithon cruciatum* (Bressan) Y. M. Chamberlain (W-S)
- CT** *Hypnea spinella* (C. Agardh) Kützing (S)
- C** *Jania rubens* (Linnaeus) J.V. Lamouroux (W-S)
- IA** *Lithophyllum pustulatum* (J.V. Lamouroux) Foslie (S)
- CT** *Lophosiphonia cristata* Falkenberg (S)
- SC** *Lophosiphonia obscura* (C. Agardh) Falkenberg (S)
- SC** *Pneophyllum coronatum* (Rosanoff) Penrose (W-S)
- Ab** *Polysiphonia fibrillosa* (Dillwyn) Sprengel (S)
- Ab** *Polysiphonia sanguinea* (C. Agardh) Zanardini (S)
- IA** *Polysiphonia sertularioides* (Grateloup) J. Agardh (S) [m]
- M** *Spermothamnion flabellatum* Bornet (W)
- C** *Stylonema alsidii* (Zanardini) K. M. Drew (W-S)

- **Ochrophyta**

- Abt** *Acinetospora crinita* (Carmichael) Sauvageau (S)
- M** *Cladosiphon irregularis* (Sauvageau) Kylin (S) [p]
- C** *Dictyota dichotoma* (Hudson) J. V. Lamouroux (S)
- IP** *Discosporangium mesarthrocarpum* (Meneghini) Hauck (S)
- Abt** *Ectocarpus siliculosus* (Dillwyn) Lyngbye v. *dasycarpus* (Kuckuck) Gallardo (S)
- CB** *Ectocarpus siliculosus* (Dillwyn) Lyngbye v. *pigmaeus* (Areschoug) Gallardo (S)
- IAtf** *Giraudia sphacelarioides* Derbès & Solier (S)
- SC** *Halopteris scoparia* (Linnaeus) Sauvageau (W-S)
- Ab** *Kuckuckia spinosa* (Kützing) Kornmann (S) [p]
- M** *Myrionema orbiculare* J. Agardh (W-S)

*Sphacelaria* sp. (S)

C *Sphacelaria rigidula* Kützing (S)

C *Sphacelaria tribuloides* Meneghini (S)

SC *Stypocaulon scoparium* (Linnaeus) Kützing (S)

• **Chlorophyta**

CT *Bryopsis corymbosa* J. Agardh (S)

CT *Bryopsis muscosa* J. V. Lamouroux (S)

C *Chaetomorpha linum* (O.F. Müller) Kützing (W-S)

SC *Cladophora albida* (Nees) Kützing (S)

SC *Cladophora dalmatica* Kützing (W-S)

IA *Cladophora echinus* (Biasoletto) Kützing (S)

SC *Cladophora glomerata* (Linnaeus) Kützing (S)

SC *Cladophora laetevirens* (Dillwyn) Kützing (W-S)

IA *Cladophora pellucida* (Hudson) Kützing (S)

SC *Cladophora prolifera* (Roth) Kützing (W-S)

AP *Cladophora rupestris* (Linnaeus) Kützing (W)

SC *Cladophora sericea* (Hudson) Kützing (W-S)

SC *Phaeophila dendroides* (P. et H. Crouan) Batters (S)

SC *Pseudochlorodesmis furcellata* (Zanardini) Børgesen (S)

IP *Ulva multiramosa* Taskin (S)

C *Ulva prolifera* O.F. Müller (S)

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