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BIODIVERSITY
COMMUNITY STRUCTURE
EPIPHYTE ASSEMBLAGE
HALOPHILA STIPULACEA
INTRODUCED SPECIES
MEDITERRANEAN SEA

ABSTRACT. – Since the opening of the Suez Canal in 1869, a number of marine species have entered the Mediterranean Sea from the Red Sea. The seagrass *Halophila stipulacea* was among these introduced species. In the course of the past century, *H. stipulacea* developed extensive meadows in the eastern Mediterranean basin and is now extending its distribution into the western basin. As little is known of their vegetal assemblage, a temporal study of a meadow was carried out off the eastern coast of Sicily throughout a year cycle. The associated algal community was dominated by epiphytes followed by rhizophytic species. Species diversity showed significant variations over time with a maximum in October and a minimum in April. Changes in species diversity and community structure were positively correlated with the yearly cycle of seagrass' cover. The seagrass bed was also populated by the introduced rhizophytic green alga *Caulerpa racemosa*, representing the second dominant vegetal species after *H. stipulacea*. A comparison between the associated algal assemblages of this *H. stipulacea* meadow and two other contiguous ones of seagrass *Posidonia oceanica* and *Cymodocea nodosa*, respectively, showed significant differences in species composition.

INTRODUCTION

Seagrasses are known to play several ecologically important roles. For instance, they reduce the wave energy allowing sediment to settle out of the water column (Teeter *et al*. 2001), and partially prevent sediment resuspension (Gacia & Duarte 2001), represent an important substratum for epiphytic algae (Rindi *et al*. 1999), provide habitat, shelter, and nurseries for many ecologically important animal species (Cangemi *et al*. 1994), and play an important role in the regulation of nutrient fluxes (Pereg *et al*. 1994, Karez *et al*. 2004).

Halophila stipulacea (Forsskål) Ascherson is a marine seagrass with a wide ecological range and tropical to subtropical affinity (Lipkin 1975). The Indo-Pacific coastal areas represent its natural biogeographical region (Den Hartog 1970). However, after the opening of Suez Canal in 1869 this species was introduced in the Mediterranean Sea (Lipkin 1975), where its presence was first reported in 1895 off the Cyprus coast (Fritsch 1895). Thereafter, it successfully spread along the eastern Mediterranean basin coasts (Lipkin 1975, Kashta & Pizzuto 1995). It is unclear when *H. stipulacea* first arrived on the Italian coast, although at the end of the 1980's Villari (1988) first recorded its presence in the bay of Giardini Naxos (eastern coast of Sicily). In the following years this seagrass spread along the Sicilian coasts, and the small surrounding islands (Rindi *et al*. 1999). An extensive *H. stipulacea* seagrass bed was found in October 1997 in eastern Sicily in an area east of Cape Murro di Porco, south of Syracuse (Di Martino 2001). This seagrass meadow was also populated by the invasive species *Caulerpa racemosa*, a tropical green alga most likely introduced into the Mediterranean through the Suez Canal as well (Ceccherelli *et al*. 2000). A recent study reported its occurrence in the tropical west Atlantic (Ruiz & Ballantine 2004). It is an opportunistic species able to colonize both hard and soft substrata generally in shallow waters, although it also occurs in deep subtidal habitats. Since its introduction, it has rapidly spread from the southeastern to the northwestern part of the Mediterranean Sea (Ceccherelli *et al*. 2000), showing a more rapid spread than *H. stipulacea*.

Most of the studies carried out on *H. stipulacea* in the Mediterranean focused on the spreading of its spatial distribution (Villari 1988, Biliotti & Abdelahad 1990, Vandervelde & Den Hartog 1992, Kashta & Pizzuto 1995) as well as its morphological and genetical variability (Procaccini *et al.* 1999). Very few studies reported on its associated algal community (Alongi *et al.* 1993, Rindi *et al.* 1999), and none focused on the temporal variations of a *H. stipulacea* seagrass vegetal assemblage.

In order to fill this gap, the *H. stipulacea* seagrass bed located in the coastal area of Cape Murro di Porco (Di Martino 2001) was studied with four samplings throughout a year. Moreover, its algal assemblage was compared with the algal assemblages of adjacent *Posidonia oceani* -

ca (Linnaeus) Delile and *Cymodocea nodosa* (Ucria) Ascherson meadows. This comparison was done in order to study if and which species of the associated algal assemblage were to be considered as characteristic taxa of the *H. stipulacea* meadow.

Table I. – Some environmental factors at the sampling site and their average values in the four periods.

	October	January	April	July
Temperature (sea bottom °C)	17.4	13.9	15.5	20.0
Salinity	37.8	38.0	38.0	38.1
Dissolved O_2 saturation (%)	98.8	98.6	102.6	104.8
Average photoperiod (hours)	10.3	11.5	14.0	12.9
Secchi disk attenuation depth (m)	9-16	5-12	12-15	13-15

MATERIALS AND METHODS

Study area and sampling: The *H. stipulacea* seagrass bed was located in the infralittoral zone of a sheltered bay southeast of the Peninsula of Maddalena, eastern Sicily (Fig. 1). This meadow lies between two others running parallel to the coast. The landward one is a *C. nodosa* meadow, while the seaward one is a *P. oceanica* meadow. The *H. stipulacea* seagrass meadow is approximately 50 m wide and lies on a flat bottom at 21 m depth (± 0.5 m). Weak currents characterize this area with muddy sand covering a thick dead mat of *P. oceanica*. The sampling site was located in a homogenous area of the *H. stipulacea* seagrass bed at approximately 300 m southward from Capo Meli (37° 00.232 N; 15° 18.835 E). Four series of three samples each were collected in October 1998, January 1998, April 1999, and July 1999. Each sampling consisted in thoroughly harvesting vegetation from three quadrats of 900 cm^2 defined as the minimal area for macroalgal sampling in a *H. stipulacea* seagrass meadow (Di Martino *et al*. 2000). Quadrats were semi-haphazardly selected from the seagrass bed by the diver swimming along a predetermined transect and collecting a quadrat every ~15 meters. The algae found in all samples were identified at the species level. For rhizophytes and sediment-substratum species, cover was estimated and expressed as a percentage of the sampling area covered by the vertical projection of algae on the sediment surface. For *H. stipulacea* epiphytic species, cover was estimated by recording the area covered by the plants of each species as vertical projection on the surface of the seagrass leaves. The species composition and the structure of the algal community associated with *H. stipulacea* in April and October were compared with those of the adjacent *P. oceanica* and *C. nodosa* meadows at same periods. The *P. oceanica* and *C. nodosa* meadows were located at approximately the same water depth as the *H. stipulacea*'s (± 1 m). Water salinity, temperature and dissolved oxygen (expressed as % saturation) were sampled using a SBE C-T recorder (model: *16 plus SeaCat*), while photoperiod was derived from Tita (1994). Environmental variables results are reported in Table I.

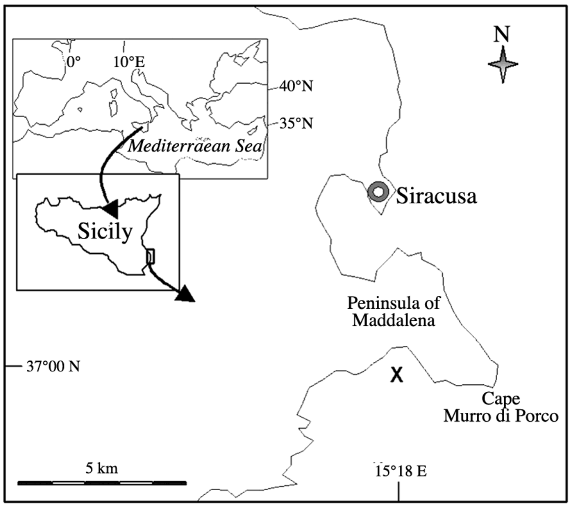

Fig. 1. – Study zone; an "X" symbol indicates the sampling site.

Statistical analysis: Species diversity was estimated using three indices: (i) species richness, (ii) Shannon-Wiener's index (logarithmic base 2) (H'), and (iii) equitability (J'). Comparisons between data series were performed applying the one-way analysis of variance (ANOVA) followed by a Tukey test for post-hoc multiple pairwise comparisons. The Pearson's parametric correlation coefficient (r) was employed for testing the association strength between variables (e.g. number of epiphytic species *vs*. *H. stipulacea* cover). The community structure variations of the algal assemblage were analyzed using the PRIMER software. For this purpose, non-metric multidimensional scaling ordination (MDS) based on a Bray-Curtis similarity distance of untransformed data was used. The analysis of similarities (ANOSIM) followed the MDS to identify the differences between samplings collected at the different periods of the year. Contributions to assemblage dissimilarity of the different species were analyzed applying the SIMPER analysis of which a brief description of results is herein presented. The MDS plus ANOSIM approach was also used to compare the algal assemblages associated with *H. stipulacea*, *P. oceanica* and *C. nodosa* meadows, respectively; only the algal species data and not those from the seagrass were included in this analysis.

RESULTS

Species composition and community structure

A total of 118 plant and algal species were identified and belonged to Rhodophyta (80), Heterokontophyta (22), Chlorophyta (12), Cyanophyta (5), and Magnoliophyta (1) (Table II). Although Rhodophyta were always the most abundant taxon in terms of species number, angiosperms (*H. stipulacea*) dominated in terms of cover in all sampling periods excepted for April when chlorophytes dominated (Fig. 2). The increase of green algal cover in April reflected the significant increase of *Cauler* -

Table II. – List of species and their respective % covers; P = number of occurrences. An = Angiospermae, Ch = Cholorophyta, He = Heterokontophyta, Rh = Rhodophyta, Cy = Cyanophyta; e = epiphyte, s = substratum.

			October			January			April			July			P
			1	2	3	1	2	3	1	2	3	1	2	3	
Rhizophyte species															
Halophila stipulacea		An	80	65	80	70	55	70	40	25	40	60	55	40	12
Caulerpa racemosa		Ch	5	15	10		25	10	55	35	50	15	25	10	11
Caulerpa prolifera		Ch	1	3		4	10	3	3	8	5				12
Epiphyte (e) & substratum species (s)															
<u>High frequency species</u>															
Hydrolithon boreale	e	Rh	10	15	15	5	2	5	1	1	1	1	1	1	12
Womersleyella setacea	e s	Rh	2	2	2	2	2	2	2	3	2	3	2	1	12
Chaetomorpha linum	s	Ch	1	0.5	1	1	1	1	2		1	0.5	0.5	2	11
Antithamnion cruciatum v. *cruciatum*	e	Rh		1	1	1	1	1	1	1		1	1	1	10
Ulvella lens	e	Ch	1	1	1	1	1	1		1		1	1	1	10
Calothrix crustacea	e	Cy	1	1	1	1	1	1				1	1	1	9
Crouania attenuata f. *attenuata*	e	Rh	1	1	1				1	0.5	0.5	1	1	1	9
Myrionema liechtensternii	e	He	3	3	3	0.1	0.1		0.1	0.1	0.1			0.1	9
Spermorthamnion flabellatum	e	Rh	1	1	1	0.5	0.5	0.5	0.5	1	1				9
Chondria pygmaea	e	Rh	5	5	5	1	1	1	1				1		8
Dasya corymbifera	e	Rh	4	4	4	1	1	1		1	1				8
Microcoleus lyngbyaceus	e	Cy	0.1	0.1	0.1	0.1		0.1				0.1	0.1	0.1	8
Myrionema orbiculare	e	He	10	10	10	1		1		1		1		1	8
Padina pavonica	s	He	2	1		1	1	1			3	2	2		8
Champia parvula	e	Rh	1	1			1	1				1	1	1	7
Chroodactylon ornatum	e	Rh	1	1					1	1	1		1	1	7
Dictyota linearis	e	He	1	1	1	1	1	0.5					1		7
Lophocladia lallemandii	e	Rh	5	5	5		1		1	1	1				7
Pneophyllum fragile	e	Rh	1	1			1	0.5	1	1	1				7
Sphacelaria cirrosa	e	He	1	1		1	1	1.0					1	1	7
Spyridia filamentosa	e	Rh	1	1	1		1	1.0					1	1	7
Asparagopsis armata	e s	Rh	4	1	1	1	2	1.5							6
Ceramium codii	e	Rh	1	1	1							1	1	1	6
Ceramium tenerrimum v. *brevizonatum*	e	Rh	1	1	1	1						1	1		6
Giraudya sphacelarioides	e	He		1	1					1	1	1	1		6
Jania rubens v. *rubens*	e	Rh				1	1	1				1	1	1	6
Laurencia minuta ssp. *scammaccae*	e	Rh	1	1					1	1	0.5			0.5	6
Oscillatoria lutea	e	Cy	0.1	0.1	0.1	0.1	0.1	0.1							6
Polysiphonia scopulorum	e	Rh	1	1	1	1	1	1							6
Stylonema alsidii	e	Rh	1	1	1		0.5	0.5	1						6
Ceramium flaccidum	e	Rh	1	0.5	0.5							0.5	0.5		5
Ceramium siliquosum v. *lophophorum*	e	Rh	1	1	1		0.5	0.5							5
Cottoniela filamentosa v. *algeriensis*	e	Rh	1	1	1	1	1								5
Dasya baillouviana	e	Rh	1		1							1	1	1	5
Ectocarpus siliculosus	e	He	1	1	1	1		1							5
Halopteris filicina	e	He				1	1	1	1	1					5
Herposiphonia secunda	e	Rh	0.5	0.5	0.5							0.5	0.5		5
Hydrolithon farinosum v. *farinosum*	e	Rh							1	1	1	1	1		5
Myrionema strangulans	e	He		0.5	0.5	0.5	0.5	0.5							5
Pneophyllum confervicola	e	Rh	1	0.5		0.5	0.5				1				5
Spermorthamnion johannis	e	Rh	1	1	1	1		1							5

pa racemosa whose cover was negatively correlated with *H. stipulacea*'s over time (r = -0.729, $p < 0.01$).

Species diversity showed a yearly cycle with the highest values in October and the lowest in April (Fig. 3). The number of species per sample averaged 43 ± 10.4 but showed significant differences between periods (ANOVA: F = 13.36, $p < 0.01$). The Shannon-Wiener diversity index (H') showed a similar pattern (ANOVA: F = 5.24, $p < 0.05$). As for the equitability, no significant difference was found between periods (ANOVA: F = 2.0, $p = 0.192$). This suggested that temporal variations of H' were caused more by variations of species richness than by their equitability.

Replicate samples from the same sampling dates clustered together in MDS ordination plot (Fig. 4), suggesting temporal changes in the vegetal seagrass community structure, although ANOSIM did not show differences between periods below significance levels of 10 %. The low number of replicate sampling may probably explain this apparent contradiction.

Temporal variations of epiphyte species abundance were also observed (Fig. 4 bottom) together with a positive correlation between the cover of *H. stipulacea* and both the total number of epiphyte species (r = 0.736, $p < 0.01$), and their total cover (r = 0.755, $p < 0.01$). Epiphyte species

Table II – *(continued)*

			October			January			April			July			P
			1	2	3	1	2	3	1	2	3	1	2	3	
Low frequency species															
Aglaothamnion tenuissimum v. *tenuissimum*	e	Rh	2		1				1	1					4
Chondria capillaris	e	Rh		1								1	1	1	4
Dasya rigidula	e	Rh					1	1					1	0.5	4
Discosporangium mesarthocarpum	e	He		1	1		1	1							4
Jania adhaerens	e	Rh	1	1		1		1							4
Phaeophila dendroides	e	Ch	1								0.5	0.5	0.5		4
Aglaothamnion tenuissimum v. *mazoyerae*	e	Rh				0.5	0.5	0.5							3
Anotrichium furcellatum	e	Rh				3	3	5							3
Anotrichium tenue	e	Rh	1	1	1										3
Audouinella microscopica	e	Rh							0.5	0.5	0.5				3
Audouinella saviana	e	Rh	0.5	0.5	0.5										3
Audouinella subtilissima	e	Rh							0.5	0.5	0.5				3
Botryocladia boergesenii	e	Rh				1	0.5	0.5							3
Ceramium comptum	e	Rh	1		1			1							3
Ceramium siliquosum v. *siliquosum*	e	Rh	1	1			1								3
Chondria dasyphylla	e	Rh										1	1	1	3
Cladophora socialis	s	Ch	1	1	0.5										3
Elachista fucicola	e	He							1	1	1				3
Enteromorpha prolifera ssp. *prolifera*	e	Ch				1	1	1							3
Entocladia viridis	e	Ch	1		1	1									3
Halydictyon mirabile	e	Rh	1	1	1										3
Hincksia ovata	e	He	0.5	1	1										3
Laurencia epiphylla	e	Rh										1	1	1	3
Laurencia obtusa	e	Rh										0.5	0.5	1	3
Lejolisia mediterranea	e	Rh										1	1	1	3
Lomentaria chylocladiella	e	Rh	0.5	0.5	0.5										3
Microcoryne ocellata	e	He							0.5	0.5	0.5				3
Myriactula rivulariae	e	He	0.1	0.1	0.1										3
Myrionema sp.	e	He	0.5	0.5	0.5										3
Pneophyllum coronatum	e	Rh							1	1	1				3
Polysiphonia dichotoma	e	Rh	1	1									1		3
Polysiphonia stricta	e	Rh										1	1	1	3
Polysiphonia subulifera	e	Rh	1	1	1										3
Pringscheimiella scutata	e	Ch	0.5	0.5	0.5										3
Pterocladiella melanoidea	e	Rh							1	1	1				3
Pterothamnion plumula ssp. *plumula*	e	Rh				1							1	1	3
Ptilothamnion pluma	e	Rh							0.5	0.5	1.0				3
Schizothrix calcicola	e	Cy							0.1	0.1	0.1				3
Schizothrix mexicana	e	Cy							0.1	0.1	0.1				3
Seirospora apiculata	e	Rh				1	1	1							3
Sphacelaria fusca	e	He										1	1	1	3
Stypocaulon scoparium	e s	Fu										2	0.1	0.1	3
Antithamnion heterocladum	e	Rh				0.5	0.5								2
Audouinella daviesii	e	Rh								0.5	0.5				2
Callithamnion corymbosum	e	Rh								0.5	1.0				2
Ceramium bertholdii	e	Rh										1	1		2
Ceramium rubrum v. *rubrum*	e	Rh										1		1	2
Ceramium tenerrimum v. *tenerrimum*	e	Rh											1	1	2
Cladophora hutchinsiae	s	Ch				3		1							2
Cladophora liebertruthii	s	Ch					2	2							2
Cladosiphon cylindricus	s	Fu					1	1							2
Erythroglossum sandrianum	e	Rh								1	1				2

accounted for 90 % of the total number of identified species, while rhizophytes and other substratum-fixed species represented only 2.5 and 7.5 %, respectively.

Comparison with adjacent seagrass beds

The MDS plot showed samples clustering according to the seagrass and the period they belonged to (Fig. 4 middle). However, two-way ANOSIM (factors: seagrass species and period) revealed statistically significant differences between all pair of assemblages (statistic R = 1, $p < 0.01$), but not between periods. SIMPER showed that the *H. stipulacea* algal assemblage differed from the two others mainly for six epiphyte species that were not

Table II – *(continued)*

			October 1	October 2	October 3	January 1	January 2	January 3	April 1	April 2	April 3	July 1	July 2	July 3	P
Eupogodon planus	e	Rh				1	1								2
Feldmannia paradoxa	e	Fu										1	1		2
Hincksia dalmatica	e	Fu		1	1										2
Hypoglossum hypoglossoides	e	Rh				1		1							2
Lophosiphonia cristata	e	Rh										1	2		2
Monosporus pedicellatus	e	Rh	2	1											2
Polysiphonia adriatica	e	Rh	2	2											2
Polysiphonia furcellata	e	Rh	1	1											2
Polysiphonia sertularioides	e	Rh					2	0.5							2
Stylonema cornu-cervi	e	Rh							1	1					2
Wrangelia penicillata	e	Rh			2		2								2
Acrochaetium lenormandii	e	Rh											1		1
Apoglossum ruscifolium	e	Rh							1						1
Asperococcus compressus	e	Fu										1			1
Audouinella leptonema	e	Rh							1						1
Chondria mairei	e	Rh				1									1
Erythrotrichia carnea	e	Rh					1								1
Feldmannophycus rayssiae	e	Rh					2								1
Heterosiphonia crispella	e	Rh					2								1
Laurencia chondroides	e	Rh	2												1
Microdictyon tenuius	e	Ch											2		1
Nithophyllum punctatum	e	Rh											2		1
Radicilingua reptans	e	Rh											1		1

Table III. – Comparison of dominant epiphyte species of *H. stipulacea* found in different Mediterranean areas; "+" indicates if the species was present but not abundant and/or frequent.

	Eastern Sicily (Capo Meli) (Present study)	Eastern Sicily (Harbor of Catania) (Alongi *et al.* 1993)	Southern Albania (Kashta & Pizzuto. 1995)	Vulcano Island (Hydrothermal vents) (Rindi *et al.* 1999)
Antithamnion cruciatum	X		X	
Ceramium flaccidum	+		X	
Ceramium siliquosum	+		X	
Chondria pygmaea	X	X	X	X
Ceramium tenerrimum	+			X
Dasya corymbifera	X			
Ectocarpus siliculosus	+	X		
Entocladia viridis	+	X		
Fosliella cruciata		X		
Hincksia secunda		X		
Hydrolithon boreale	X			
Hydrolithon farinosum v. *farinosum*	+		X	
Laurencia sp.				X
Myrionema orbiculare	X			
Pneophyllum fragile	+	X		
Polysiphonia cfr. *tenerrima*				X
Polysiphonia dichotoma	+		X	
Spyridia filamentosa	+			X
Ulvella lens	X			
Womersleyella setacea	X			

recorded in the two other meadows: *Antithamnion cruciatum v. cruciatum, Chondria pygmaea, Crouania attenuata, Dasya corymbifera, Hydrolithon boreale, Lophocladia lallemandii*. It is worth mentioning that five other species were also associated exclusively with *H. stipulacea*, although they were found only at specific periods: *Halydictyon mirabile* (October), *Lomentaria chylocladiella* (October), *Pterocladiella melanoidea* (April), *Ptilothamnion pluma* (April), and *Schizothrix calcicola* (April).

DISCUSSION

In terms of number of species, the seagrass meadow studied here was always dominated by Rhodophyta, accounting for 60-65 % of the total number of species. However, in terms of cover, which gives a closer idea of the vegetal biomass, *H. stipulacea* dominated in all periods except for April, when Chlorophytes took over mainly because of *C. racemosa* cover increase.

The canopy cover values of *C. racemosa* and *H. stipulacea* were negatively correlated over time, with *C. racemosa* dominating in April. Ceccherelli *et al.* (2000) reported a similar behaviour in a *P. oceanica* meadow, where they observed a negative correlation of *C. racemosa*'s growth with the seagrass density. Another study (Davis & Fourqurean 2001) focused on a similar interaction between the seagrass *Thalassia testudinum* and the rhizophytic green alga *Halimeda incrassata*.

Species diversity showed temporal variations with minimums in April, and maximums in October, suggesting seasonal biodiversity differences between seasons.

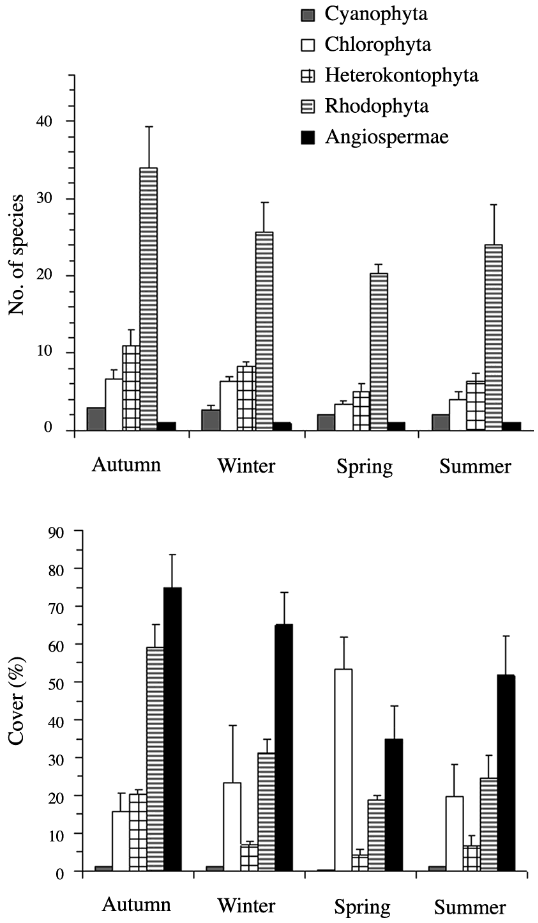

Fig. 2. – Average number of species (top) and total cover (bottom) for the different taxonomic vegetal groups (error bars = standard deviation).

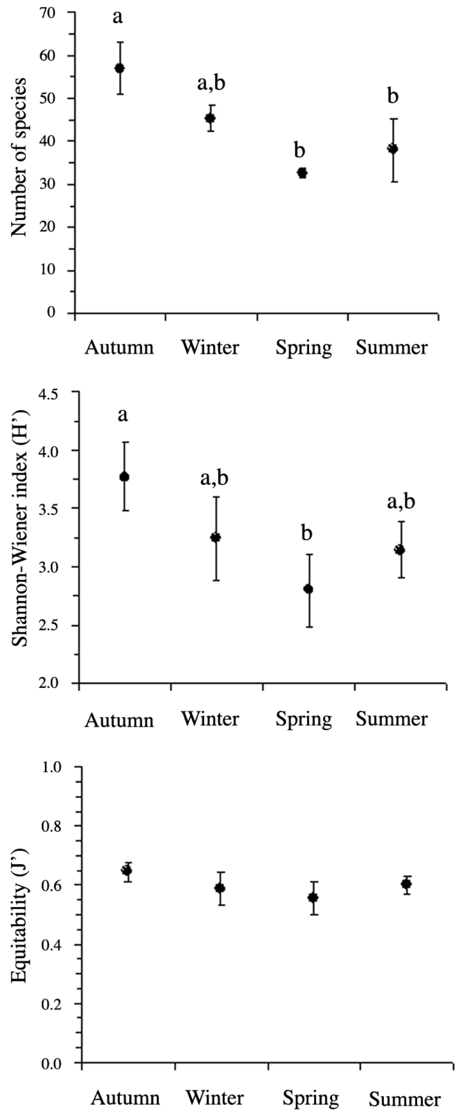

Fig. 3. – Diversity indices for the whole vegetal assemblage in the four periods (error bars = standard deviation). Equal letters above means express no significant difference (Tukey test, $p < 0.05$); no significant differences were found between periods for equitability.

Species richness was positively correlated with the annual cycle of *H. stipulacea* cover, reflecting the substratum role played by the seagrass. Indeed, temporal variations in seagrass foliage are characterized by cyclic losses and gains of leaf-substratum for epiphyte colonization. In this regard it is worth mentioning that seagrass leaf life span is critical for epiphytic assemblage development, i.e. high leaf turnover rates make epiphytic loads low (Sand-Jensen 1975). Compared to other seagrasses, fast turnovers were generally reported for most of *Halophila* species (*H. hawaiiana* = 14.7 d; *H. decipiens* = 10-30 d; *H. ovalis* = 11-24 d; Rindi *et al.* 1999 and references therein reported). As for *H. stipulacea*, Wahbeh (1984) estimated a longer life span (74 d), which is comparable to values reported for most of other seagrass genera and promotes a more abundant epiflora (Borowitzka & Lethbridge 1989).

The present study showed floristic differences between the epiphytic assemblages present in the three seagrass meadows that were compared. However, such observation should not be generalized before comparing equivalent seagrass meadows in other areas.

Over the last few decades, *H. stipulacea* seagrass beds have been spreading in the western Mediterranean basin (Rindi *et al.* 1999), thus becoming a more and more common vegetal assemblage around the whole Mediterranean Sea. Previous studies of *H. stipulacea* meadows in the Mediterranean (Alongi *et al.* 1993, Kashta & Pizzuto 1995, Rindi *et al.* 1999) reported substantially different dominant epiphyte species (Table III). The only constant species between these three previous studies and the present one was *Chondria pygmaea*. Garbary & Vandermeulen (1990) first described this species as an epiphyte of *H. stipulacea* in the Red Sea, and it is considered to have entered the Mediterranean together with its host (Alongi *et al.* 1993). Differences in species composition between the present study and the previous ones may be due to the different environmental conditions of their respective study areas and possibly to the different sampling periods. Alongi *et al.*

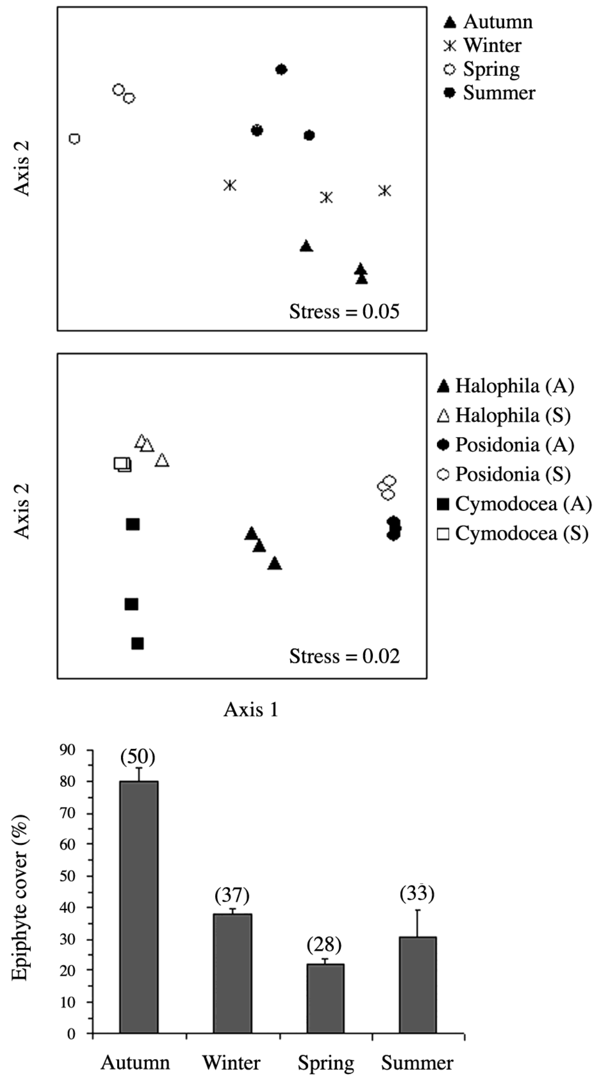

Fig. 4. – Top, Multidimensional scaling (MDS) ordination of the *H. stipulacea* meadow periodical samplings. Middle, MDS ordination of the data relative to the epiphytic assemblages in the three adjacent seagrass meadows in April (S) and October (A) periods. Bottom, Epiphyte average cover in the different periods (error bars = standard deviation); between parenthesis are reported the corresponding number of species.

(1993) (winter sampling), studied a meadow in a disturbed area (i.e. polluted harbor environment). Rindi *et al.* (1999) (July sampling) studied a meadow close to hydrothermal vents, which have been shown to influence diversity and species composition of phytobenthic assemblages (Acunto & Rindi 1997). Finally, Kashta & Pizzuto (1995) (period of sampling not reported) studied *H. stipulacea* meadows at relatively shallow depths (2-15 m) in different areas of the southern Adriatic Sea, which probably represent the northern front edge of *H. stipulacea*'s distribution.

The areas colonized by this species may have been previously occupied either by "bare" sediment or by other seagrass, as in the case of the studied area where *H. stipulacea* lies over a *P. oceanica* dead mat. In this regard, it would be interesting to investigate if the colonizing behaviour of *H. stipulacea* may be associated to an opportunistic strategy (i.e. occupation of "available" space) or if its geographical spread in the Mediterranean follows a competition strategy with other seagrass. Moreover, its increasing presence in the different Mediterranean subregions may result in local alterations of biodiversity and ecological interactions between faunal and floral species. For instance, De Troch *et al.* (2001) found that *H. stipulacea*'s root system favoured meiobenthic copepod diversity. Therefore, future investigations should focus on the ecological implications of the extending geographical distribution of *H. stipulacea* in the Mediterranean Sea.

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