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Macroepiphytes and macroalgae (Phaeophyceae, rhodophyceae and chlorophyceae) in the nador lagoon (Morocco)

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Abstract

Many species of marine macroalgae support the development of attached communities on their external surfaces, studies on epiphytic algal communities are however rare in lagoonal environments. A major management plan was begun (2014) in the Nador Lagoon and this study was undertaken between 2012 and 2014 to investigate the diversity of the pre-impact epiphytic communities. As part a biodiversity assessment programme, 112 benthic algal macrophyte species were collected over the 3 year sampling period. 63 of macroepiphyte species were identified in this material. Similarities of epiphytic assemblages on different host algae and associations between epiphytes and thallus complexity were assessed. The aquatic algal macrophyte species list comprised 60 Rhodophyceae, 19 Phaeophyceae, 31 Chlorophyceae and, 2 Phanerogame species after the monitoring of 8 sampling stations. The species composition, phenology and ecological aspects of these algae indicated a dominance of macroalgae species with an Atlantic origin.

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Introduction

The Nador lagoon is the largest lagoon of Morocco. Spread over 114 km2 with a maximum depth of 6.5 m (figure 1) a nd it is currently connected to the Mediterranean Sea through the artificial inlet, the "Bokhana". This ecosystem has major socioeconomic, cultural and ecological significance. It is therefore essential to evaluate the impacts and consequences of anthropogenic activities in the lagoon. Organic waste water pollution is especially important and this affects the biota and notably the distribution of macrophytes in the rocky and soft sediment sectors of the lagoon. Surface water can be eutrophic as indicated by abundant green algae in shallow water areas during spring and summer periods. The distribution of the high abundances of organic carbon recorded in the lagoon is controlled by the hydrodynamic environment as well as by anthropogenic nutrient enrichment (Bloundi *et al.,* 2008; Oczkowski *et al.*, 2011; El Madani, 2012; Yachouti *et al.,* 2014) .

The fisheries potential lagoon has attracted the attention of scientific organizations for several decades (González Garcia et Condé, 1991, Benhissoune *et al.,* 2001, 2002a, 2002b; Bloundi *et al.,* 2008; Kada *et al.,* 2009; El Madani, 2012; Yachouti *et al.,* 2015). However, ecological qualities of the lagoon have been reduced, during the last decades, mainly by human activities, particularly the overfishing and waste water pollution from Nador city as well as the hydrocarbon waste from the boats (Bloundi *et al.*, 2008; Oczkowski *et al.*, 2011). Investment is needed for the Nador Lagoon because maintaining a rich diversity of biota and a high quality ecological environment is key to the sustainability of the lagoon ecosystem. As a foundation for this ecological work, base-line studies on the distributions of species are needed.

Many investigations on water quality, bathymetry, phytoplankton, fauna and fishing in the Nador lagoon have been carried out (Bloundi *et al.,* 2008; Kada *et al.,* 2009; El Madani, 2012; Ramdani *et al.,* 2015). However, studies on macroalgae are limited to the work of González Garcia and Conde (1991) where they listed for the first time the distribution of the seaweed species in the lagoon at 4 stations during 4 seasons of sampling. They cited 60 species of Rhodophyceae, 19 species of pheophyceae, 31 species of Chlorophyceae, and 2 phanerogams (*Zostera marina* and *Zostera noltii*). In 1994, González-García and Conde Poyales (1993, 1994) established a checklist of the seaweeds on the Moroccan Mediterranean costs and highlighted biogeography of these species. Riadi and Kazzaz (1998) published the bibliographic diagnostic of the seaweeds of the Atlantic and Mediterranean coasts. Benhissoune *et al.* (2001, 2002a, 2002b, 2003) included one site from Nador Lagoon when establishing a checklist of the Moroccan coastal seaweeds. Very little work has been carried out on the epiphytic algal diversity on aquatic macrophytes in lagoon environments (e.g. Taylor *et al.,* 1999; Johnson *et al.,* 2005; Mačić *et al.,* 2014). This study on seaweeds in the lagoon during 3 years monitoring has two main aims (1) to assess changes in the biodiversity of the macroepiphytes and macroalgae and to help assess future changes in the ecology state of the lagoon; (2) to assess the usefulness of also using the diversity of epiphytic algal species for contributing to ecological change assessments.

Material and methods

The fieldwork was carried out on 2 rocky shore sites (Atalayoune and Bni Nsar) and 6 stations on subaquatic mud-sandy soft substrates of the Nador lagoon (Figure 2). Two stations on the rocky shore of the adjacent Mediterranean Sea coast were sampled for comparison with the marine macrophyte diversity within the lagoon. Sampling was done by Scuba diving seasonally between autumn 2012 and spring 2014. Samples were obtained by removing all plant material from limestone substrate surfaces of 25cm x 25cm in area at three depths (0.5m, 3m and 5m when possible). Three replicate samples were always taken by diving using a quadrat to collect soft sediment and plants. Several hours after collection, samples were frozen and stored until processing in laboratory. For further analysis, each plant was examined for epiphytes; these were then separated from the host plant and , under the binocular, were identified to the lowest possible taxonomic level using manuals for identification and algaebase. All samples of host algae and of the epiphytes were preserved in 10% formalin and seawater and deposited in the collection at the Faculty of Sciences, University Mohamed 1st Oujda.

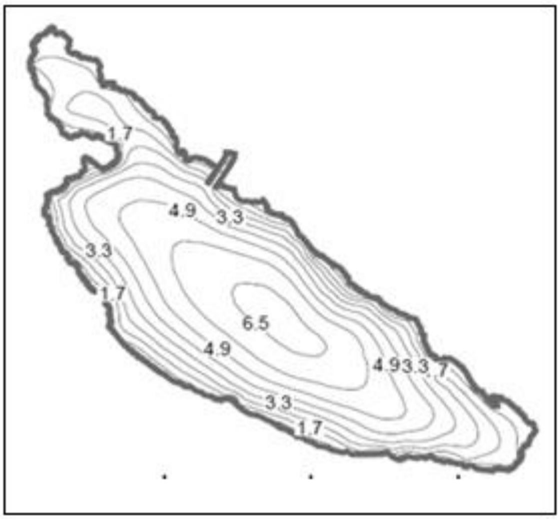

Fig. 1. Bathymetry of the Nador lagoon (Yachouti *et al.*, 2014). (Depth in meter).

Given the uniformity across the lagoon, we chose six sampling stations to provide a comprehensive representation of the whole of the lagoon ecosystem. Both stations (Atalayoun station1 and Bni Nsar station 2) are the only rocky sites in the lagoon. Other 6 stations corresponded to the closest shore transects (10 to 100m away) and are all soft sediments (figure 2). The floristic list was compiled using the nomenclature as followed by Gayral (1958), Boudouresque and Perret (1987), Gonzales Garcia and Pionel (1991), Furnari and Cormaci (1990), Athanasiadis (2003), and AlgaeBase (2015). Part of the samples was stored in seawater formalin at 10% for floristic study and another part was archived in the laboratory herbarium.

For each taxon, the distribution was examined and inventoried in detail. Reference was made to known native Mediterranean species to help assess the regional provenance of each species in the lagoon.

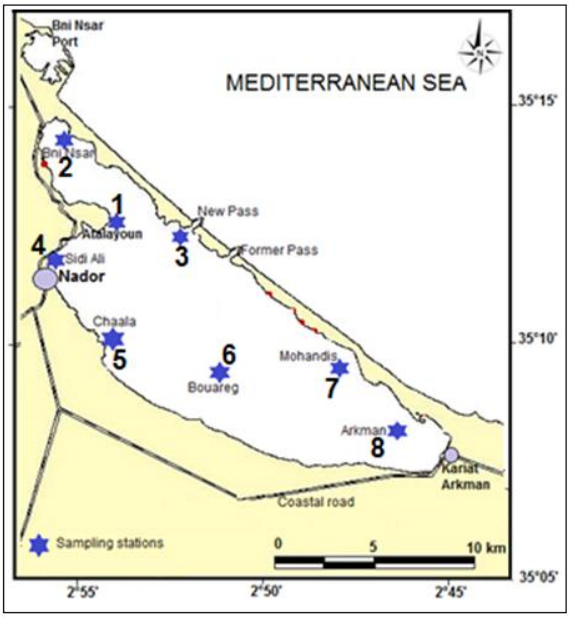

Fig. 2. Location of the 8 sampling stations in the Nador Lagoon during 2012-2014.

Results

Three temporary rivers (oueds) in southeastern part drain rainwater to the lagoon during winter and the lowest value of the salinity reach 33 ppm in December-January and 40 ppm in August 2014. The salinity of the lagoon is close to that of the Mediterranean Sea and is affected directly by metrological conditions, continental inputs, as well as by communications with the sea (a new enlarged opening was established in 2014). The pH is basic throughout the year (8.1 – 8.4). Water temperature can be 9.5°C in December but reaches 28.5°C in the shallow water during August.

The inventory of the flora of macro-algae and epiphyte macro-algae collected from the Nador lagoon during the period 2012-2014 is given in table 1. This table also indicates the geographical distribution of each species in the Mediterranean region and beyond, epiphytic character, and the host plant(s). Also included in table 1 are two higher plant species. The total number of taxa identified during the study period was 112 species, distributed in 62 Rhodophyceae, 19 Phaeophyceae and 31

Chlorophyceae) in addition to two species of flowering: *Cymodocea nodosa* and *Zostera noltii* in sandy-clay areas.

This results table shows the occurrence of each species according to location in the lagoon- this is particularly relevant for future base-line inventories and assessing species changes in relation to species that occurred outside the lagoon. The sample sites are therefore numbered for reference. The algal diversity is also indicated as the number of species at each location (for macroaglae and epiphytes). Note, that diversity estimates used 25 cm quadrats on rocks but was more difficult for soft bottom areas.

Table 1. Inventory of the epiphytes, macroalgae flora and seagrass collected from Nador lagoon during the period 2012-2014. (N_0: Species rank to precise the host of the epiphyte); Origine : origine of the species and its geographic distribution; Host: species number host of the epiphyte species; MOc: Mediterranean occidental origin; A: Atlantic origin; Ab: Atlantic boreal; C: cosmopolitan), x: epiphyte; Stations: sampling stations (1 to 8) : 1 = presence of the species

No	Species	Origine	Epiphyte	Host	Stations							
	RHODOPHYCEAE				1	2	3	4	5	6	7	8
	Acrochaetiales Acrochaetiaceae											
1	*Audouinella codii* (G.Hamel) G.Furnari	C	x	79	1							
2	*Audouinella daviesii* (Dillwyn) Woelkerling	C	x	6, 76, 77,78,79	1	1						
3	*Audouinella moniliformis* (Rosenvinge) Garbary	MOc	x	95		1						
4	*Audouinella parvula* (Kylin) P.S. Dixon	Ab	x	76,77,78	1	1						
5	*Audouinella saviana* (Meneghini) Woelkerling	C	x	76,77,78,93,95	1	1						
	Gelidiales Gelidiaceae											
6	*Gelidium latifolium* Bornet ex Hauck	C	x	20	1	1	1					
7	*Gelidium pusillum* (Stackhouse) Le Jolis	C			1	1						
	Gigartinales Cystocloniaceae											
8	*Hypnea musciformis* (Wulfen) J.V. Lamouroux	C			1	1						
	Caulacanthaceae											
9	*Caulacanthus ustulatus* (Mertens ex Turner) Kützing	C			1	1						
	Gracilariaceae											
10	*Gracilaria armata* (C.Agardh) Greville	At			1	1	1		1		1	1
11	*Gracilaria bursa-pastoris* (S.G.Gmelin) P.C.Silva	C			1	1						
12	*Gracilaria cervicornis* (Turner) J.Agardh	C			1							
13	*Gracilaria verrucosa* (Hudson) Papenfuss	C			1	1	1		1	1		1
	Phyllophoraceae											
14	*Gymnogongrus griffithsiae* (Turner) Martius	C rare			1							
15	*Phyllophora crispa* (Hudson) P.S.Dixon	Ab	x	20	1	1						
16	*Schottera nicaeensis* (J.V.Lamouroux ex Duby) Guiry & Holl	C			1	1						
	Gigartinaceae											
17	*Gigartina acicularis* (Roth) J.V.Lamouroux	C			1		1	1	1		1	1
	Corallinaceae											
18	*Amphiroa beauvoisii* J.V.Lamouroux	C	x	89	1	1						
19	*Fosliella farinosa* (J.V.Lamouroux) M.Howe	C	x	112	1	1						
20	*Jania rubens* (Linnaeus) J.V.Lamouroux	C	x	6, 8, 73, 112	1	1						
21	*Schmitziella endophloea* Bornet & Batters	C	x	99	1	1						
22	*Spongites fruticulosa* Kützing	Ab			1	1						
23	*Titanoderma pustulatum* (J.V.Lamouroux) Nägeli	C	x	6, 76,77,78,79	1	1						
	Halymeniales Halymeniaceae											
24	*Grateloupia filicina* (J.V.Lamouroux) C.Agardh	C			1	1						
	Peyssonneliales Peyssonneliaceae											
25	*Peyssonnelia bornetii* Boudouresque & Denizot	M			1	1						

26	*Peyssonnelia dubyi* P.L.Crouan & H.M.Crouan	C			1	1						
27	*Peyssonnelia squamaria* (S.G.Gmelin) Decaisne	M			1	1						
	Rhodymeniales Champiaceae											
28	*Gastroclonium clavatum* (Roth) Ardissone	M			1	1						
	Ceramiales Ceramiaceae											
29	*Antithamnion cruciatum* (C.Agardh) Nägeli	Ab	x	6,7	1							
30	*Antithamnionella elegans* (Berthold) J.H.Price & D.M. John	M	x	18	1	1						
31	*Callithamnion neglectum* (Feldmann-Mazoyer) M.J. Wynne	At	x	6,7	1	1						
32	*Centroceras clavulatum* (C.Agardh) Montagne	C	x	18	1	1						
33	*Ceramium cingulatum* Weber-van Bosse	C	x	76,77,78, 79	1	1	1	1	1		1	1
34	*Ceramium diaphanum* (Lightfoot) Roth	C	x	6, 13, 49, 50, 112	1	1						
35	*Ceramium flaccidum* (Harvey ex Kützing) Ardissone	C	x	8, 76,77,78,79	1	1						
36	*Ceramium rubrum* C.Agardh	C	x	73, 112	1	1						
37	*Ceramium tenerrimum* (G.Martens) Okamura	C	x	44	1	1						
38	*Griffithsia tenuis* C.Agardh	M	x	8	1	1						
39	Monosporus pedicellatus var. tenuis (Feld-Maz) Huis & Kraft	M	x		1	1						
40	Spyridia filamentosa (Wulfen) Harvey	C	x	76,77,78,79	1	1						
	Dasyaceae											
	Dasya baillouviana (S.G.Gmelin) Montagne	C	x	7	1	1						
42	*Heterosiphonia crispella* (C.Agardh) M.J.Wynne	C			1	1						
	Delesseriaceae											
43	*Acrosorium uncinatum* (Turner) Kylin	C	x	43, 106,	1	1						
	Rhodomelaceae											
44	*Alsidium corallinum* C. Agardh	M					1	1	1	1	1	1
45	*Chondria dasyphylla* (Woodward) C.Agardh	C	x	112	1							
46	*Chondria mairei* G.Feldmann	M	x	112	1							
47	*Chondria tenuissima* (Withering) C.Agardh	Ab	x	112	1	1						
48	*Herposiphonia secunda* (C.Agardh) Ambronn	C	x	7, 20, 93, 95, 97	1							
49	*Herposiphonia secunda* f. *tenella* (C.Agardh) M.J.Wynne	C	x		1	1			1	1	1	1
50	*Laurencia obtusa* (Hudson) J.V.Lamouroux	C			1	1						
51	*Polysiphonia elongata* (Hudson) Sprengel	Ab	x	110	1	1						
52	*Polysiphonia fruticulosa* (Wulfen) Sprengel	Ab			1	1						
53	*Polysiphonia violacea* (Roth) Sprengel	Ab			1	1						
	Stylonematales Stylonemataceae											
54	*Stylonema alsidii* (Zanardini) K.M.Drew	C	x	7, 79, 98, 100	1		1					1
55	*Stylonema cornu-cervi* Reinsch	C	x	96, 98, 100	1	1						
	Erythropeltidales Erythrotrichiaceae											
56	*Erythropeltis subintegra* (Rosenvinge) Kornmann & Sahling	C	x	7	1	1						
57	*Erythrotrichia carnea* (Dillwyn) J.Agardh	C	x	96, 97, 98, 99, 110	1	1						
58	*Erythrotrichia investiens* (Zanardini) Bornet	Ab	x	6, 96, 97, 98, 99	1	1						
59	*Erythrotrichia reflexa* (Crouan & Crouan) Thuret ex De Toni	Ab	x	96, 97, 98, 99, 110	1	1						
	Bangiales Bangiaceae											
60	*Bangia atropurpurea* (Mertens ex Roth) C.Agardh	C	x	112	1	1						
	PHAEOPHYCEAE											
	Ectocarpales Acinetosporaceae											
61	*Giffordia mitchelliae* (Harvey) G.Hamel	C	x	76,78	1	1						
	Chordariaceae											
62	*Asperococcus turneri* (Dillwyn ex Smith) W.J.Hooker	C			1							

	Scytosiphonaceae											
63	Colpomenia sinuosa (Mertens ex Roth) Derbès & Solier	C			1	1		1		1	1	1
64	*Scytosiphon lomentaria* (Lyngbye) Link	C			1							
	Ectocarpaceae											
65	*Ectocarpus siliculosus* (Dillwyn) Lyngbye	C	x	76,78	1	1						
	Acinetosporaceae											
66	Feldmannia globifera (Kützing) G.Hamel	C	x	76, 78	1	1						
67	*Feldmannia irregularis* (Kützing) G.Hamel	C	x	112	1	1						
	Sphacelariales Sphacelariaceae											
68	*Sphacelaria fusca* (Hudson) S.F.Gray	C			1							
69	*Sphacelaria rigidula* Kützing	C	x	25	1	1						
	Stypocaulaceae											
70	*Halopteris filicina* (Grateloup) Kützing	C			1	1						
71	*Stypocaulon solarium* (Linnaeus) Kützing	C			1	1						
	Dictyotales Dictyotaceae											
72	*Dictyota dichotoma* (Hudson) J.V.Lamouroux	C			1	1						
73	*Padina pavonica* (Linnaeus) Thivy	C			1	1						
74	*Taonia atomaria* (Woodward) J. Agardh	M rare	x	23, 104	1	1						
75	*Zonaria tournefortii* (J.V.Lamouroux) Montagne	Ab rare			1	1						
	Fucales Sargassaceae											
76	*Cystoseira compressa* (Esper) Gerloff & Nizamuddin	Ab			1	1						
77	*Cystoseira barbata* (Stackhouse) C.Agardh	M			1	1	1	1	1	1	1	1
78	*Cystoseira crinita* Duby	M			1	1						
79	*Sargassum vulgare* C.Agardh	C			1	1						
	CHLOROPHYCEAE											
	Ulvales Kornmanniaceae											
80	*Blidingia marginata* (J.Agardh) P.J.L.Dangeard ex Bliding	Ab	x	50	1	1	1		1	1		1
	Ulvaceae											
81	*Enteromorpha clathrata* (Roth) Greville	C										
82	*Enteromorpha compressa* (Linnaeus) Nees	C					1		1		1	1
83	*Enteromorpha flexuosa* (Wulfen) J.Agardh	C	x	44			1	1	1		1	1
84	*Enteromorpha intestinalis* (Linnaeus) Nees	C										
85	*Enteromorpha linza* (Linnaeus) J.Agardh	C					1	1	1	1	1	1
86	*Enteromorpha multiramosa* Bliding	M	x	8, 40, 50, 74			1		1	1	1	1
87	*Enteromorpha prolifera* (O.F.Müller) J.Agardh	Ab	x	8, 40, 50, 74, 112	1	1	1					1
88	*Enteromorpha torta* (Mertens) Reinbold	C	x	44, 76	1	1	1	1	1	1	1	1
89	*Ulva olivascens* P.J.L .Dangeard	Ab	x	34, 76	1	1				1		
90	*Ulva lactuca* var. *rigida* (C.Agardh) Le Jolis	C	x	20, 34	1	1	1	1	1	1	1	1
	Cladophorales_Cladophoraceae											
91	*Chaetomorpha aerea* (Dillwyn) Kützing	C	x	6, 7, 40, 76, 77, 78	1							
92	*Chaetomorpha linum* (O.F.Müller) Kützing	C	x	6, 7, 40			1	1	1		1	1
93	*Cladophora coelothrix* Kützing	C	x	6, 7,			1	1	1	1	1	1
94	*Cladophora dalmatica* Kützing	C	x	6, 7, 40, 44			1	1	1	1	1	1
95	*Cladophora echinus* (Biasoletto) Kützing	C	x	6, 7, 96, 97, 98		1	1					
96	Cladophora globulina (Kützing) Kützing	M	x	6, 7		1						1
97	*Cladophora lehmanniana* (Lindenberg) Kützing	Ab										
98	*Cladophora pellucida* (Hudson) Kützing	Ab					1		1	1	1	1
99	*Cladophora prolifera* (Roth) Kützing	C	x	21		1	1	1	1	1	1	1
100	*Cladophora vadorum* (Areschoug) Kützing	C						1	1	1	1	1
101	*Cladophora vagabunda* (Linnaeus) Hoek	C						1	1	1	1	1
102	*Rhizoclonium tortuosum* (Dillwyn) Kützing	C					1		1	1	1	1

103	*Rhizoclonium riparium* (Roth) Harvey	C	x	76	1			1	1	1		1
	Valoniaceae											
104	*Valonia utricularis* (Roth) C.Agardh	C	x	44	1	1						
	Dasycladales Polyphysaceae											
105	*Acetabularia acetabulum* (Linnaeus) P.C.Silva	M			1	1						
	Bryopsidales Bryopsidaceae											
106	*Bryopsis plumosa* (Hudson) C.Agardh	C			1		1	1	1	1		1
107	*Derbesia tenuissima* (Moris & De Notaris) Crouan & Crouan	Ab	x	76, 77, 78, 79	1	1						
108	*Pedobesia lamourouxii* (J.Agardh) Feldmann, Loreau, Codomier & Couté	Ab	x	7								
	Codiaceae											
109	*Codium effusum* (Rafinesque) Delle Chiaje	C			1							
	Caulerpaceae											
110	*Caulerpa prolifera* (Forsskål) J.V.Lamouroux	C			1	1	1	1	1		1	1
	PHANEROGAMES Alismatales Zosteraceae											
111	*Cymodocea nodosa* (Ucria) Ascherson	C					1	1	1	1	1	1
112	*Zostera noltei* Hornemann	C			1	1	1	1	1	1	1	1

Discussion

The benthic algae of the Nador Lagoon and the surrounding coastal area is a simplified representation of the Mediterranean Sea, as happens with other gaps where morphological and climate are similar. It appears from this study that the maximum of species is closely linked to the rocky areas of the lagoon (Atalayoune and Bni Nsar, while muddy and sandy areas, which dominate the surface of the lagoon, are particularly rich in Chlorophyceae (*Chaetomorpha* spp. and *Cladophora* spp.) and angiosperms. Rhodophyceae and Phaeophyceae are less represented in the whole of the muddy part of the lagoon. Therefore, the maximum diversity is reduced only in the rocky areas.

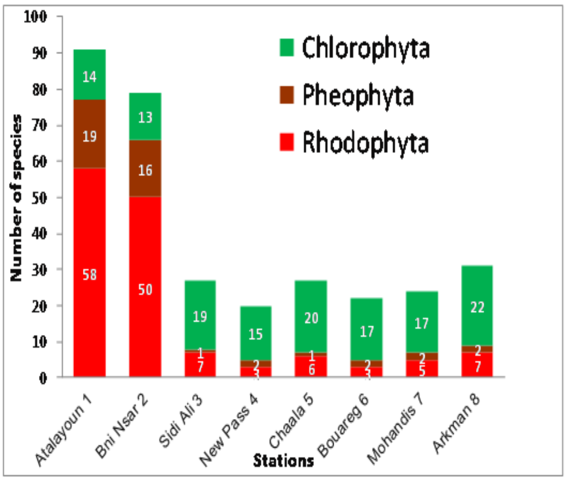

Fig. 3. Number of species of Rhodophyta, Pheophyta and Chlorophyta in the studied stations of Nador Lagoon.

Compared to other lagoons around the Mediterranean Sea, algal biodiversity is very close to that noted in lagoons of the western Mediterranean Sea (Ben Maiz *et al.*, 1987; Pérez Ruzafa, 1989; Furmari *et al.*, 2003).

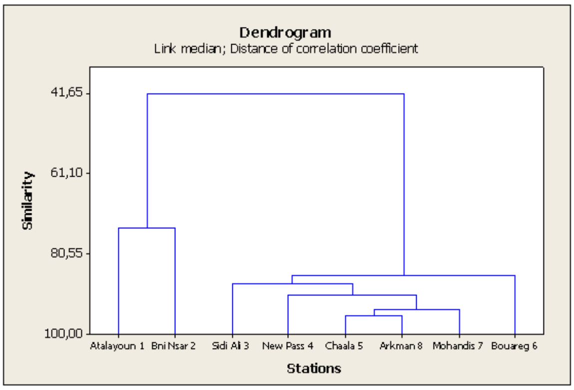

Fig. 4. Automatic hierarchic classification of the studied stations and similarity between them.

It appears from this study that high algal diversity is closely linked to rocky areas of the lagoon (Atalayoune 1 and Bni Nsar 2), while muddy and sandy habitats, dominant in the lagoon (~ 90%), are particularly rich in Chlorophyceae (*Chaetomorpha* spp., *Cladophora* spp., AND *Caulerpa prolifera*). THE seagrass (*Zostera noltii*) takeS advantage of soft sediment to establish their root systems (Fig. 3 and 4). The Rhodophyceae and Phaeophyceae are qualitatively less represented in all muddy habitats of the lagoon except that the red alga *Gracilaria* and *Cystoseira barbata* develop massively in sandy-muddy habitats deep (2 to 6.5 m).

Considering the broad geographical distributions of species, cosmopolitan species comprised 44% of the assemblages, followed by those of Atlantic and Pacific origins with ca. 40%, while Mediterranean origin algae did not exceed 16% (Table 1). Invasive species from the eastern Mediterranean areas were not found in the lagoon.

Concerning the environmental groups, statistics showed that 49% are sciaphilous and 22% photophilous. Thermophilic species represented 10%. Many species also highlighted adaption to calm habitats (41%). All the dominant species in the lagoon (*Cladophora, Ulva lactuca rigida, Enteromprpha* spp and *Caulerpa prolifera*) indicated an ecological eutrophication pathway in accordance with the physico-chemical conditions caused by enriched nitrogen and phosphate nutrients across lagoon (El Madani, 2012). This is further evidence for the increase in the degree of eutrophication recognized in previous studies (Bloundi, 2008). The frequencies of Cladophoraceae and Ulvaceae, especially in the geographical extremes of the lagoon and near centers of human activity, have increased significantly over the past three decades. According to phenology, the period between May shows high diversity, such as increased vegetative growth with a greater presence of reproductive organs, whereas autumn and winter show the low diversity over the entire lagoon.

The presence of 63 of epi-flora species on different algae hosts is shown In Table 1. For epi-floral species demonstrate a dominance of the Rhodophyta group it is also characteristic that the highest number of epiphytes has a *Cystoseira* species*, C. barbata, C. compressa C. crinita and Sargassum vulgare*. The Ceramiaceae group is mainly represented as epiphyte species on various hosts. Mačić and Svirčev (2014) showed 46 epiphytes on 9 species of *Cystoseira* in the coastal area of Montenegro and also noted the importance of crustacean and molluscs species associated with algal communities of Pheophyceae species. The Ceramiales group was strictly epiphytic whereas other epiphytes were observed on different substrates i.e *Ulva lactuca rigida*, *Gelidium latifolium* and *G. pusillum*. Furthermore, we observed the genera *Cystoseira* and *Sargassum* with complex thalli generally support particularly abundant epiphytic assemblages. Fraschetti *et al.* (2002) consider that the composition of epiphytes is more dependent on external environmental factors than on host species and can provide a better indication of pollution than do the macro-algal species alone. Especially for epifaunistic species (Isopoda, Polychaeta), the macroalgae hosts insure the availability of food and shelter from predators that is doubtless enhanced by epiphyte cover.

Conclusion

The algal floral composition has undergone a major change in the organization and the spatial distribution since the earlier study of Gonzalez Garcia and Conde (1991). Indeed, the species *Cystoseira barbata* had not been reported by these authors for the lagoon; it was however observed here in abundance in deeper areas of the lagoon and the rocky parts. This species is competitive with *Alcidium corallinum* and *Gracilaria* spp. *Caulerpa prolifera* has invaded the entire lagoon and has prevented resettlement of *Posidonia oceanica*. The latter has completely disappeared from the lagoon since the 1960s (Gonzalez Garcia and Conde, 1991). *Zostera marina* reported by these authors in the lagoon was not observed during this investigation but *Cymodocea nodosa*, unreported by these authors, now appears to be present in the north western part of the lagoon.

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