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ORIGINAL ARTICLE

Algal diversity study in the western Algerian coast

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In order to identify species of seaweed on the algerian west coast, an exhaustive checklist was carried out. A total of 162 species was identified spread over three phyla: 77 species of Rhodophyceae, 48 species Pheophyceae and 37 species Chlorophyceae. Among the algae listed, six are considered invasive in the Mediterranean. The overall ratio of Rhodophyceae to Pheophyceae (*R/P*) is estimated at 2.19 for the entire study area.This is close to the national average estimated at 3 as well as other areas of the Mediterranean. The calculation of the Shannon-Weaver (*H'*) and Equitability (*E'*) diversity index identifies the ecological status of the sites which varies more or less moderately ($2.53 \le H' \le 3.09$; $1.38 \le E' \le 1.75$) for the Ben Abdelmalek ramdan, Petit port, Bahra and El-Geulta sites, to mediocre ($1.03 \le H' \le 1.24$; $0.55 \le E' \le 0.84$) for Saint-Michel, Mers El-Hadjadj, Stidia, Ouréah, Sablette, Salamander and El-Marsa. A Correspondence Analysis (CA) supported previous analysesin order to find the relation between the geographical position of the chosen sites and the algae inventoried. This analysis revealed that a floristic composition representative of healthy waters distinguishes the two sites Abdelmalek Ramdan and Bahara. This study could be a valuable tool in the field of biomonitoring and conservation biology.

Keywords: Macrophytes, Specific diversity, Inventory, Algerian west coast.

Introduction

In coastal marine ecosystems, the existence of a plant compartment plays a key role in maintaining ecological balance (primary production) and considered an indicator for the health status of marine ecosystems (Blanfuné et al., 2017; Orfanidis, 2011; Jégou, 2011; Ballesteros, et al., 2007). This compartment also plays an economic role, particularly in direct food consumption (Marfaing and Lerat, 2007; Falquet and Hurni, 2006; Conte and Payri, 2002).

Benthic macrophytes are excellent bio-indicators of the ecological status of an environment (Gibson, et al., 2000). They are involved in improving water clarity through sediment stabilization and act as ecosystem builders; they are a substrate for epiphyton, occupy a key position in the food chain and provide critical habitats for invertebrates and fish (Haury et al., 2008; Delmail, 2011).

They are also excellent indicators of water quality due to their sedentary lifestyle (Diez et al., 1999; Belsher, 1977), they incorporate the effects of long-term exposure to nutrients and/or other pollutants leading to a decrease or disappearance of the most sensitive species and their replacement by highly resistant species (Murray and Littler, 1978). Therefore, the study of macroalgal communities becomes interesting to assess changes in water quality (Fairweather, 1990).

Seaweed has scientifically proven nutritional interests since they contain many essential compounds such as dietary fiber, protein (50-70% of their dry weight in spirulina), polyunsaturated fatty acids, vitamins (F, B12, K1, B9, C, provitamin A, etc.), mineral elements (iodine, manganese, magnesium, calcium, iron, etc.) and antioxidants (polyphenols, carotenoids,...) (Marfaing and Lerat, 2007; Falquet and Hurni, 2006).

In North Africa, particularly in Algeria, knowledge of macrophytobenthos is limited to some inventory and ecology work carried out in the centre and west of the country. This concerns both algae (Ould Ahmed et al., 2013; Seridi, 2007; Seridi et al., 2007; Benhissoune, 2002; Ould Ahmed, 1994; Verlaque and Seridi, 1991; Seridi, 1990; Perret-Boudouresque and Seridi, 1989) and phanerogams (in particular *Posidonia oceanica*) (Mammeria, 2006; Bouhayene, 2002; Francour, 1990; Boudouresque and Meinesz, 1982).

Referring to the inventory of benthic seaweed of the Algerian coast, a total of 497 species have been identified which are divided into three systematic groups including 315 Rhodophyceae (red algae), 99 Phaeophyceae (brown algae) and 83 Chlorophyceae (green algae) (Perret-Boudouresque and Seridi, 1989). Over the past two decades, many species of exotic algae have appeared in the Mediterranean basin via maritime traffic and especially across the Suez Canal. (Verlaque and Fritayre, 1994). We can mention the expansion of invasive *Caulerpa* (*Caulerpa taxifolia* and *Caulerpa racemosa* var. *cylindracea*) in many regions of the Mediterranean including along the North African coasts. On the Algerian coasts, *C. racemosa* was reported for the first time in the centre by Ould Ahmed and Meinesz (2007) then in eight other localities in the same region (Lamouti et al., 2011; Seridi and Kabrane, 2010; Ould Ahmed et Meinesz, 2007) and the Algerian west coast: Mostaganem (Bachir-Bouiadjra et al., 2010) and Oran (Bentaallah and Kerfouf, 2017).
The aim of this work is to establish an inventory of macrophyte algae species and to classify the Algerian west coast in relation to all Algerian and Mediterranean coast in terms of algal biodiversity.

Materials and Methods

Sampling stations

A sampling extending over eleven stations on the Algerian west coast was carried out (Fig. 1, Table 1).

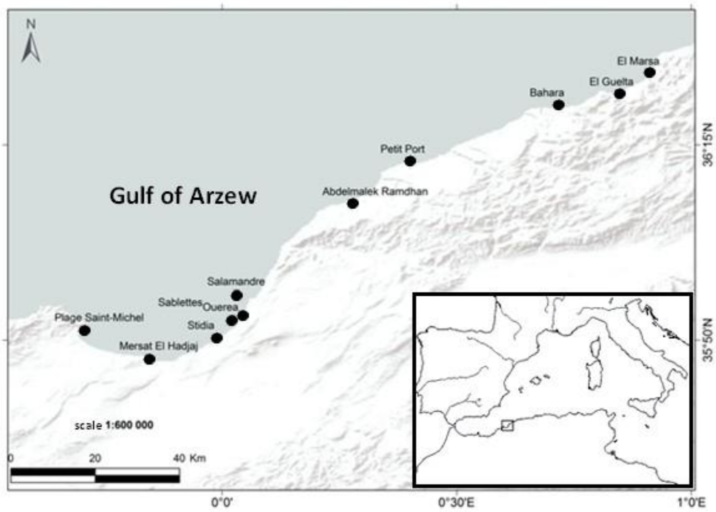

Fig. 1. Geographical location of study stations.

Table 1. Sampling stations.

Stations	Abbreviations	Geographic Coordinates
Saint-Michel	SM	35°51′5″N; 0°17‘40″W
Mers El Hadjadj	MH	35°47′27″N; 0°09′22″W
Stidia	ST	35°50′05″N; 0°00′39″W
Ouréah	OR	35°52′26″N; 0°01′17″E
Sablette	SB	35°53′02″N; 0°02′34″E
Salamandre	SL	35°55′42″N; 0°01′52″E
Abdmalek Ramdan	AR	36°07′14″N; 0°16′35″E
Petit port	PP	36°12′40″N; 0°24′01″E
Bahara	BA	36°19′53″N; 0°43′06″E
El-Guelta	EG	36°21′17″N; 0°50′44″E
El-Marsa	EM	36°23′56″N; 0°54′41″E

Collection and identification of seaweed

The stations were visited monthly over a period of two years between December 2018 and December 2020. The inventory established was carried out on the basis of samples taken in diving with autonomous diving suit between 0 and 40 m deep using a PVC quadrat of (20 × 50 cm). For each station we prospected a coastal linear of 25 to 50 m in length and 5 to 10 m wide taking care to recover the entire thallus and the most varieties Possible.Individuals have been carefully taken with their base, which is often a fundamental character of recognition and identification. Species identification was carried out using identification keys.

Analytical parameters

Quantitative and qualitative analyses of vegetation were carried out using terrestrial phytosociological methods adapted to the marine environment such as Shannon Diversity Index (*H'*) (Shannon, 1948) and equitability (*E'*) (Scammacca et al*.,* 1993; Ribera et al., 1992).

Multivariate analysis

In order to assess a possible relationship between sampling stations' geographical position and the algae inventoried in each region, a Correspondence Analysis (CA) was carried out on the specific diversity of sampling sites using the R Studio program.

Results

Identification of seaweed

The analysis of the harvests carried out over the entire study area allowed us to determine a total of 162 species divided into six classes (Bangiophyceae, Floridaophyceae, Phaeophyceae, Chlorophyceae, Bryopsidophyceae, Compsogonophyceae) (Fig. 2; Table 2).

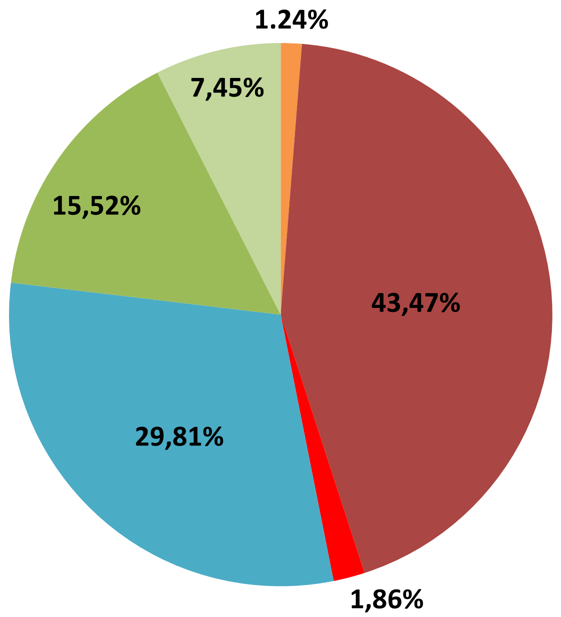

Fig. 2. Distribution of different classes of the seaweed sampled. ■ **,**Bangiophyceae; ■ ,Bryopsidophyceae; ■ ,Florideophyceae; ■ ,Compsopogonophyceae**;** ■ **,**Phaeophyceae; ■ ,Chlorophyceae.

Table 2. Inventory of algae species sampled. (+) presence/(-) absence.

Rhodophyceae (n=77)											
Species	**Stations**										
	SM	**MH**	**ST**	**OR**	**BA**	**SL**	**AR**	**PP**	**BA**	**EG**	**EM**
Acrothamnion preissii	+	-	+	+	-	+	+	+	-	-	+
Acrochaetium hamelii	-	-	+	-	-	+	+	+	+	-	-
Acrochaetium caesareae	-	-	+	-	-	-	-	-	-	-	-
Acrochaetium cheminii	+	+	-	-	-	-	-	+	-	-	-
Acrochaetium crassipes	+	-	-	-	-	+	-	+	+	-	-
Amphiroa beauvoisii	+	+	-	-	-	+	-	+	-	+	+
Amphiroa rigida	-	-	-	+	+	-	+	+	+	-	-
Anotrichium secundum	-	-	-	-	+	-	+	-	+	-	-
Antithamnion amphigeneum	-	+	-	+	+	-	-	+	+	-	-
Aparagpsis armata	+	+	+	+	+	+	+	+	+	+	+
Asparagpsis taxiformis	-	+	+	+	+	+	+	+	+	+	+
Bliding Chylocladiaverticillata	-	-	-	-	-	-	+	-	+	+	+
Bonnemaisonia asparagoides	+	-	-	-	+	-	-	+	-	+	+
Bonnemaisonia hamifera	+	-	-	-	-	-	-	+	-	-	+
Centroceras clavulatum	-	-	-	+	+	-	-	+	+	+	-
Ceramium codii	+	+	-	-	-	+	-	-	+	+	-
Ceramium diaphanum	-	-	-	-	-	+	+	+	+	+	-
Chondracanthus acicularis	+	-	+	+	-	-	-	+	-	+	-
Chondracanthus teedei	+	-	-	-	-	-	-	+	-	-	-
Chondria capillaris	-	+	-	-	+	-	+	+	-	-	-
Chondria coerulescens	-	-	-	-	+	+	+	+	-	+	-
Chondria dasyphylla	+	-	+	-	-	+	-	+	-	+	-
Chondria mairei	+	-	+	-	-	+	-	+	-	-	+

Colaconema daviesii	-	-	+	+	-	-	-	+	-	+	-
Colaconema leptonema	-	-	+	+	-	-	-	+	-	+	+
Corallina officinalis	-	+	+	+	-	+	+	+	-	+	+
Corallophilacinnabarina	-	+	+	+	-	-	+	-	-	+	-
Dasya rigidula	-	-	+	-	-	-	-	+	-	+	-
Digenea simplex	-	-	+	+	-	-	-	+	+	-	+
Ellisolandia elongata	+	+	+	-	-	+	+	+	+	+	+
Erythrotrichiabertholdii	-	+	-	-	-	-	+	+	-	-	+
Erythrotrichiacarnea	-	+	-	+	-	+	-	+	-	-	-
Gastroclonium clavatum	+	-	-	-	-	+	-	+	-	+	+
Gelidium corneum	+	+	+	-	-	+	-	+	-	-	-
Gelidium crinale	-	-	+	-	-	+	-	+	-	-	-
Gelidium lubrica	-	+	-	-	-	-	-	+	-	-	-
Gelidium spinosum	+	-	+	-	-	+	-	-	-	+	+
Gracilaria bursa-pastoris	-	+	-	-	-	-	+	+	-	-	-
Gracilariopsislongissima	-	+	-	-	-	-	+	+	-	-	-
Grateloupiafilicina	-	+	-	-	-	-	+	+	-	-	-
Halopithys incurva	+	-	-	-	-	-	-	-	+	+	-
Herposiphonia seconda	-	-	-	-	-	+	-	+	+	-	-
Heterosiphonia crispella	-	-	-	-	-	+	-	+	-	-	-
Huismaniella ramellosa	-	+	-	-	-	+	-	+	+	-	-
Hypnea musciformis	-	+	-	-	-	-	+	+	+	+	-
Jania longifurca	+	-	-	-	-	+	-	+	-	-	+
Jania rubens	+	+	+	-	-	+	+	+	+	+	+
Laurencia microcladia	-	-	+	-	-	-	-	+	+	-	-
Laurencia obtusa	-	-	+	-	-	-	-	+	+	-	-
Leptosiphonia fibrillosa	-	-	+	-	-	-	+	+	+	+	-
Liagora viscida	-	-	-	-	-	-	+	+	-	-	-
Lithophyllum incrustans	+	-	+	-	-	+	-	+	-	+	+
Lithothamnio nvalens	+	-	-	-	-	-	-	+	+	-	-
Lomentaria articulata	+	-	-	-	-	-	+	+	-	-	+
Mesophyllum alternans	+	-	+	-	-	-	-	-	-	+	-
Mesophyllum lichenoides	+	+	+	-	-	+	+	+	-	+	+
Nemalionelm inthoides	+	-	+	-	-	-	-	-	-	-	-
Neosiphonia sertularioides	-	-	+	-	+	-	-	+	-	-	-
Palisada perforata	-	-	-	-	-	-	+	+	-	-	-
Peyssonnelia heteromorpha	-	-	-	-	-	-	+	-	-	-	-
Peyssonnelia rosa-marina	-	-	+	-	-	-	+	+	-	-	-
Peyssonnelia rubra	-	-	-	-	-	-	+	+	-	-	-
Peyssonnelia squamaria	-	-	+	-	-	-	-	+	-	-	-
Plocamium cartilagineum	-	-	+	-	-	+	-	+	-	+	-
Polysiphonia deusta	-	-	+	-	-	-	-	+	-	-	-
Porphyra umbilicalis	-	-	+	-	+	-	-	+	-	-	-
Pterocladiella capillacea	+	+	+	-	-	-	-	+	-	+	-
Pyropia leucosticta	+	-	+	-	-	-	-	+	+	+	-
Rissoella verruculosa	-	-	+	-	-	-	-	+	-	-	-
Sahlingia subintegra	-	-	-	-	-	-	+	-	-	-	-
Schotteranicaeensis	-	-	-	-	-	-	-	+	-	+	-
Sphaerococcus coronopifolius	+	-	+	-	-	-	+	+	-	-	-
Spyridia filamentosa	-	-	-	-	-	-	-	+	-	-	-
Taeniom ananum	-	-	+	-	-	-	-	+	-	-	-
Titanodermapustulatum	-	-	-	-	-	-	-	+	-	+	-
Vertebratafruticulosa	-	+	+	-	-	-	+	+	-	-	-
Vertebratafurcellata	-	-	+	-	-	-	-	+	-	-	-

Pheophyceae (n=48)

Species	**Stations**										
	SM	**MH**	**ST**	**OR**	**SB**	**SL**	**AR**	**PP**	**BA**	**EG**	**EM**
Arthrocladiavillosa	+	+	+	-	+	+	+	+	+	+	+
Asperococcusbullosus	+	+	+	-	-	-	+	+	+	+	-
Cladosiphon mediterranéen	-	-	-	+	-	-	-	+	-	-	-

Cladostephusspongiosus f. verticillatus	-	-	-	-	-	-	-	+	-	-	-
Colpomeniaperegrina	-	+	+	-	-	-	+	+	+	+	-
Colpomeniasinuosa	-	-	-	-	-	+	+	+	+	-	-
Cutleriaadspersa	-	-	-	+	-	-	+	+	+	-	-
Cutleriachilosa	-	-	-	-	-	-	-	+	-	-	-
Cystoseiraamentacea var. stricta	-	+	+	-	+	-	+	+	+	+	-
Cystoseirabrachycarpa	-	-	-	-	-	+	+	+	+	-	-
Cystoseira compressa	-	-	-	-	-	-	+	+	+	+	+
Cystoseiracrinita	-	-	-	-	-	-	+	+	+	+	-
Cystoseirafoeniculacea	-	-	-	-	-	-	+	+	-	-	-
Cystoseiramediterranea	-	-	-	-	-	-	+	+	+	-	-
Cystoseirasedoides	-	-	-	-	-	-	-	-	+	-	-
Cystoseiratamariscifolia	-	-	-	-	-	-	+	+	+	+	-
Cystoseirazosteroides	-	-	-	+	-	-	-	+	-	-	-
Dictyopterisdivaricata	-	-	-	-	-	-	-	+	-	-	-
Dictyopterispolypodioides	-	+	-	-	-	-	-	+	-	-	-
Dictyotadichotomaf.dichotoma	-	-	-	-	+	-	+	+	-	-	-
Dictyotafasciola	-	-	+	-	-	-	-	-	+	+	-
Dictyotaspiralis	-	+	-	-	+	-	+	+	+	+	-
Ectocarpuscommensalis	+	-	-	-	-	-	-	+	-	-	-
Ectocarpusfasciculatus	+	-	-	-	-	-	-	-	-	-	-
Ectocarpussiliculosus	-	-	-	-	-	-	+	+	-	+	+
Feldmanniaglobifera	-	-	-	-	-	-	-	+	+	-	-
Feldmanniamitchelliae	-	-	-	-	-	-	+	-	+	-	-
Feldmannia simplex	-	-	-	-	-	-	-	+	+	+	-
Halopterisfilicina	-	-	-	-	-	-	+	+	-	-	-
Halopterisscoparia	-	-	-	-	-	-	-	-	-	-	+
Hincksiasandriana	+	-	-	-	-	-	-	-	-	-	+
Hydroclathrusclathratus	-	-	-	+	-	-	-	+	-	-	+
Laminariaochroleuca	-	-	-	+	-	-	+	+	+	+	-
Laminariarodriguezii	-	-	-	-	-	-	-	+	-	-	-
Leathesia marina	-	-	-	-	-	-	-	+	-	-	-
Myriactulagracilariae	+	-	-	-	-	+	-	-	-	-	-
Myriactularigida	+	-	-	-	-	+	-	-	-	-	-
Myriactularivulariae	+	-	-	-	-	+	-	-	-	-	-
Padinapavonica	+	+	+	-	+	-	+	+	+	+	-
Phacelariacirrosa	-	-	-	+	-	-	-	+	-	-	-
Ralfsiaverrucosa	-	-	-	-	-	+	+	+	+	+	+
Sargassumacinarium	-	-	-	-	+	-	-	+	-	-	-
Sargassumvulgare	-	+	+	-	+	-	-	-	+	+	+
Sphacelariaplumula	-	-	-	-	-	+	+	+	-	-	-
Taoniaatomaria	-	-	-	-	-	-	-	+	+	+	+
Treptacanthaalgeriensis	-	-	-	-	-	-	+	+	-	-	-
Treptacanthaballesterosii	-	-	-	+	-	+	+	-	+	-	+
Treptacanthabarbata	-	+	+	-	+	-	+	-	+	+	+

Chlorophyceae (n=37)

Species	**Stations**										
	SM	**MH**	**ST**	**OR**	**SB**	**SL**	**AR**	**PP**	**BA**	**EG**	**EM**
Acetabularia acetabulum	+	+	+	-	+	+	+	+	+	+	+
Anadyomene stellata	-	-	-	-	-	+	+	+	-	-	+
Blidingia marginata	-	-	-	-	-	+	-	-	+	+	+
Bourse codium	+	+	+	-	+	+	+	-	+	-	+
Bryopsis duplex	-	-	+	-	+	+	-	+	-	+	+
Bryopsis hypnoides	+	-	+	-	-	+	+	+	-	+	+
Bryopsis muscosa	+	-	+	-	-	+	-	+	-		+
Bryopsis plumosa	+	+	+	-	-	+	-	+	-	+	+
Bryopsis secunda	+	-	+	-	-	+	-	-	+	-	+
Caulerpa prolifera	-	-	+	-	-	+	+	+	+	-	-
Caulerpa racemosa var. cylindracea	-	-	+	-	-	+	+	+	+	-	-
Chaetomorpha aerea	+	+	-	-	-	+	-	-	-	-	-

Chaetomorpha capillaris	+	+	-	-	-	+	-	-	+	-	-
Chaetomorpha linum	+	+	-	+	-	-	-	-	-	-	+
Cladophora coelothrix	-	-	-	-	-	-	+	+	-	-	-
Cladophora aetevirens	-	-	+	-	-	-	+	+	-	-	-
Cladophora prolifera	-	-	+	-	-	-	+	-	+	-	-
Cladophora rupestris	+	-	+	-	-	-	+	-	+	-	+
Cladophoropsis membranacea	+	+	-	-	-	-	-	+	-	-	+
Codium effusum	-	-	-	-	-	-	-	+	-	-	-
Codium fragile	+	+	+	+	+	+	-	-	-	-	+
Codium tomentosum	+	+	+	+	+	+	-	-	-	+	-
Flabellia petiolata	+	-	-	-	-	-	+	+	-	-	-
Lychete pellucide	+	-	-	-	-	-	+	+	-	-	+
Palmophyllum crassum	-	-	-	-	-	-	+	-	+	+	-
Rhizoclonium riparium	-	-	-	+	-	-	-	-	-	-	+
Ulva clathrata	-	-	-	-	-	+	-	-	-	-	+
Ulva compressa	+	+	-	+	-	+	-	-	-	-	-
Ulva elegans	-	+	-	-	-	+	-	-	-	-	+
Ulva fasciata	-	-	-	-	-	-	+	+	-	-	+
Ulva intestinalis	+	-	+	-	+	+	-	-	+	+	+
Ulva lactuca f. rigida	-	-	-	-	-	-	-	-	-	-	-
Ulva lactuca	+	+	+	+	+	+	+	+	-	+	+
Ulva linza	-	+	-	-	-	+	-	-	-	-	+
Ulva prolifera	+	+	-	-	-	-	-	+	-	-	+
Ulvaria obscura	-	-	+	-	-	+	+	-	+	-	+
Valonia macrophysa	-	+	+	-	+	-	-	+	-	+	+

The largest number of algae species was recorded in the Petit Port site (120 species) followed by Abdelmalek ramdhan (70 species) and Bahara (60 species). However, the lowest specific wealth is recorded at the Sablette station (24 species) (Fig. 3). The identified species have been previously observed on the Algerian coast (Perret-Boudouresque and Seridi, 1989).

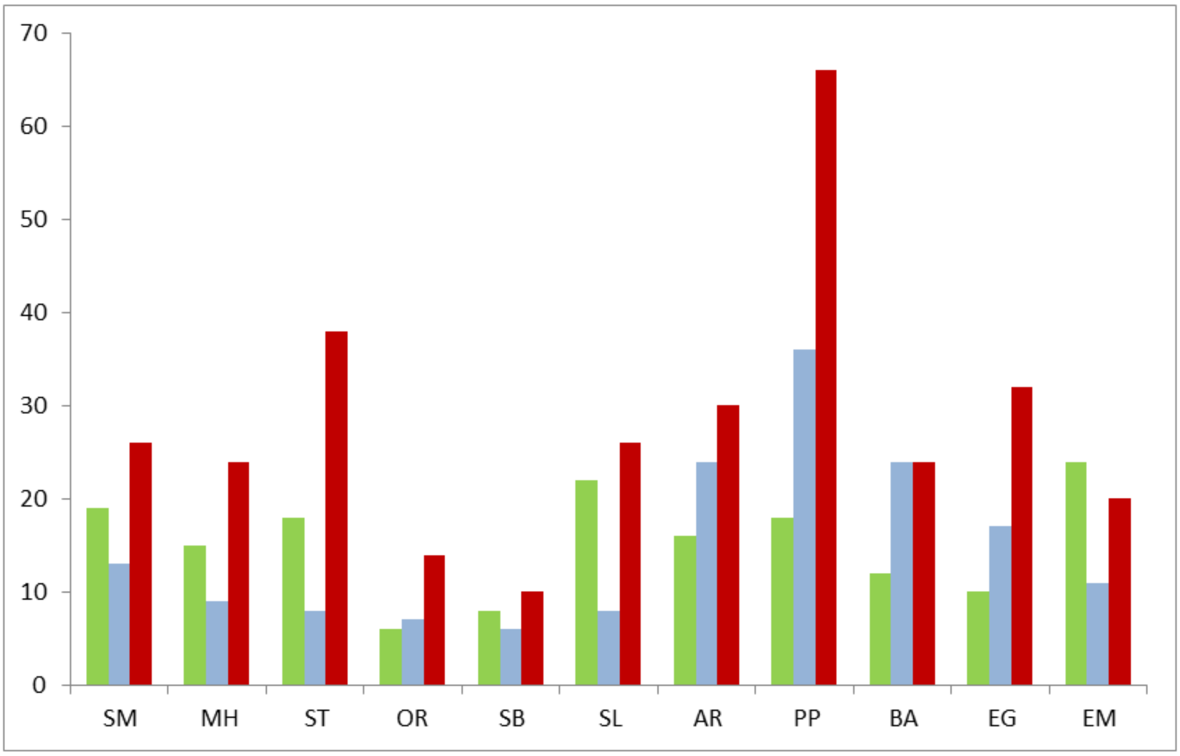

Fig. 3. Distribution of species numbers by group at the stations studied. ■ ,Rhodopyhyceae; ■ ,Phaeophyceae; ■ ,Chlorophyceae.

The Rhodophyceae are best represented by a strong dominance of *Ellisolandia elongata* and *Corallina officinalis* which are located at the upper horizon of the infralittoral stage between 0.5 and 10 m. In addition, *Asparagopsisarmata*, *A.taxiformis*, *Janiarubens* and *Mesophyllum lichenoides* dominate the depths with a covering that reaches 60%. Phaephyceae are also well represented in Petit Port, Abdmalekramadane and Bahara with a dominance of Cystoseires: *Cystoseira stricta* as well as *Colpomenia sinuosa*, *Dictyota dichotoma*, *Dictyota spiralis* and *Padina pavonica*. Cholorophyceae represent a low value of 22% at the level of the stations surveyed compared to other groups. This group is dominated by *Acetabularia acetabulum*, *Chaetomorpha aerea*, *Bourse codium*, *Ulva compressa*, *Ulva intestinalis* and *Ulva sp*.

Floristic composition/total covering

The floristic composition of our surveys varies according to the stations and the observation periods, the average number of species per survey, for the entire study area the maximum is perceived in March, spring season, which is a period of specific algal diversification Ballesteros (1992), with 77 species per survey then falls in November (autumn period) to reach 54 species then a slight increase in June (summer season) with 66 Taxa (Fig. 4).

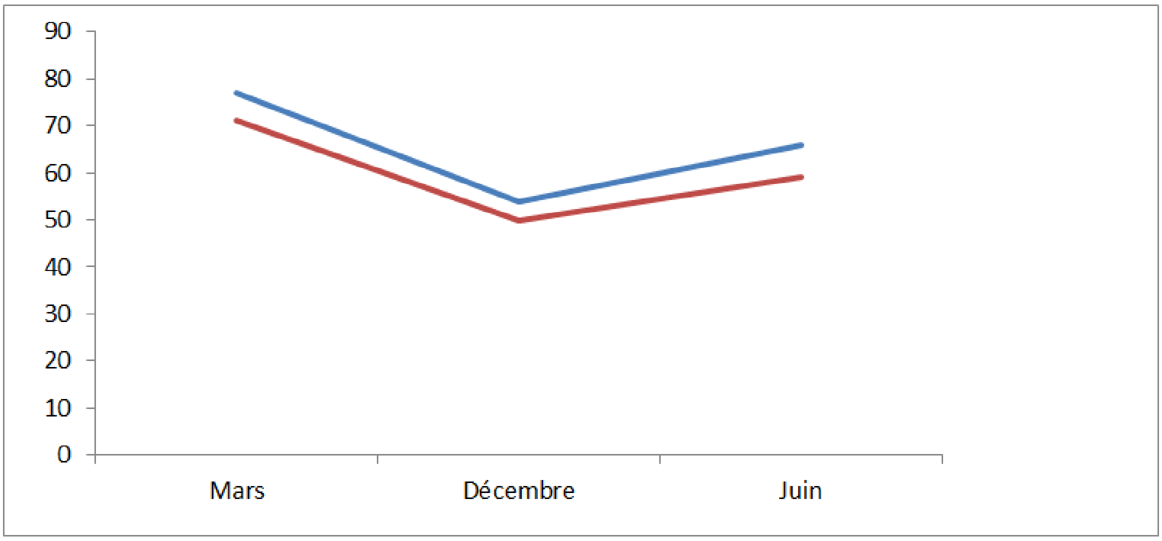

Fig. 4. Distribution of the average number of species per survey according to the observation seasons. —2018-2019; —2019-2020.

R/P Ratio

The overall ratio of Rhodophyceae to Pheophyceae "*R/P*" is estimated to 2.19 for the overall study area. Bahara station has the lowest value (1) while Stidia station has the highest value (4.75) (Table 3).

Table 3. *R/P* ratio of the different observation stations in the study area.

Stations	***R/P***
Saint-Michel	2
Mers El Hadjadj	2.66
Stidia	4.75
Ouréah	2
Sablette	1.66
Salamandre	3.25
Abdmalek Ramdan	1.25
Petit port	1.83
Bahara	1
El-Guelta	1.88
El-Marsa	1.81

The diversity index of Shannon-Weaver (H') and equitability (E)

The diversity estimated using the Shannon-Weaver index (*H'*) as well as the equitability index (*E'*) for all observation stations show that the least wealthy stations are (Saint-Michel, Mers el-Hadjadj, Stidia, Ouréah, Sablette, Salamandre and El-Marsa) (Fig. 5) with low values ranging from 1.03 to 1.24 for diversity (*H'*), faithfully followed by a equitability index (*E'*) oscillating between 0.55 to 0.84.These indices reflect algal stands in imbalance (Belsher *and*Boudouresque,1976). However, the remaining stations are more or less stable and in equilibrium(2.53 ≤ H' ≤ 3.09; 1.38 ≤ E' ≤ 1.75).

Fig. 5. Graphical illustration of the *H′* diversity index and the equitability index *E′* of the observation sites. ■ ,*H′*; ■ , *E′*.

Multivariate analysis

The Most of the total variance is represented on the first axis (Dim 1) with 72.61% of information while the second axis (Dim 2) represents 27.39% of information (Fig. 6). The Chlorophyceae are well projected on the positive part of Dim 1 and more or less well projected on the positive part of Dim 2 and are associated with the stations El Marsa and Salamandre in particular and to a lesser extent the stations Sablettes and Saint Michel. In addition, the Phaeophyceae are well represented on the negative part of Dim 1 and more or less well represented on the positive part of Dim 2 and are associated with the Bahara and Abdelmalek Ramdan stations. As for the Rodophyceae, they are very well projected on the negative part of Dim 2 and are associated with the stations of Ouréah, El Guelta, Petit Port and especially Stidia.

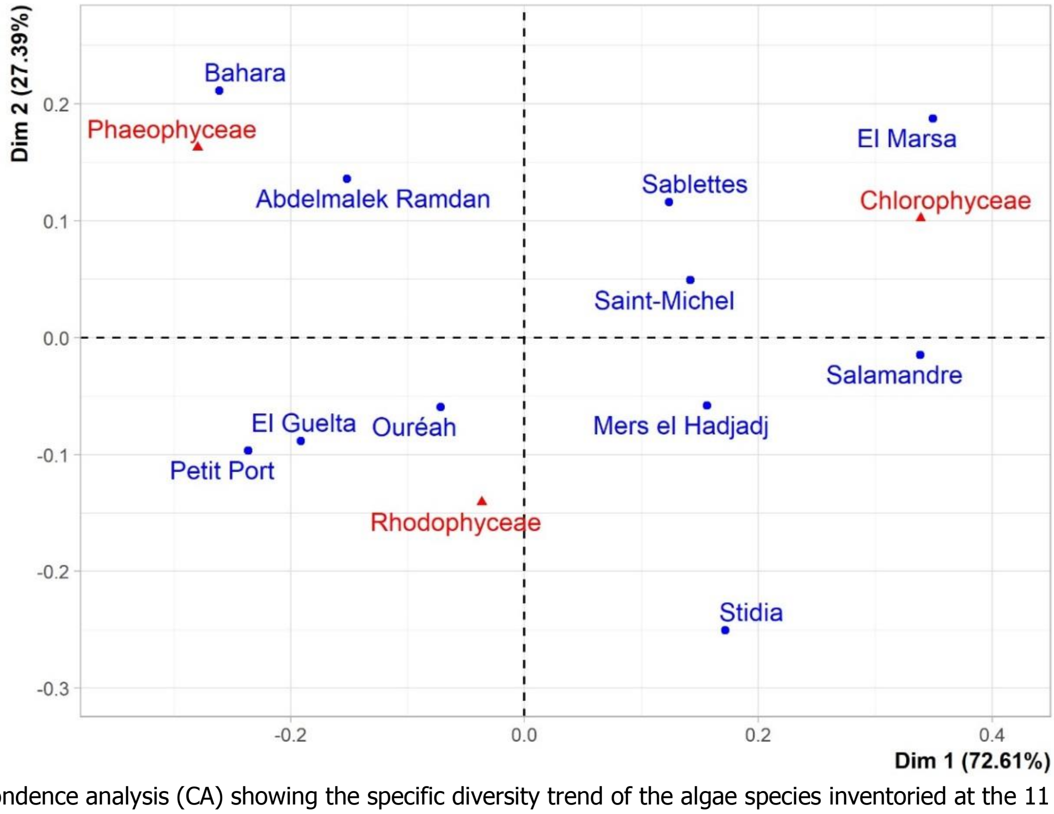

Fig. 6. Correspondence analysis (CA) showing the specific diversity trend of the algae species inventoried at the 11 study sites.

Introduced/invasive algal species

Among the inventoried algae,sixare invasive: *Acrothamnion preissii*, *Asparagopsis armata*, *Asparagopsis taxiformis*, *Caulerpa racemosa* var. *cylindracea*, *Codium fragile*, *Codium tomentosum*. These species represent 3.70% of the total number of sampled seaweed.

Discussion

This study is an approach to the knowledge of the macrophytobenthos of the Algerian west coasts. We draw up a qualitative inventory of algae from the infralittoral floor in order to complete the database of the Algerian marine flora. We could identify 162 species divided into 3phyla: 77 species of Rhodophyceae, 48 species Pheophyceae and 37 species Chlorophyceae. There is more or less a similarity in the hierarchy of dominances of the systematic groups between the results of the present study and that of Bachir-Bouiadjra et al., (2010) and this in descending order with Rhodophyceae in the lead, followed by Phaeophyceae thenChlorophyceae.This represents a rate of 32.79% of the total number of 494 species inventoried nationally (Ould Ahmed, 1994; Seridi, 1990; Perret-Boudouresque and Serridi, 1989). Among the listed algae, six are invasive in the Mediterranean: *Acrothamnion preissii*, *Asparagopsis armata*, *Asparagopsis taxiformis*, *Caulerpa racemosa* var. *cylindracea*, *Codium fragile*, *Codium tomentosum.*

The dominance of Rhodophyceae compared to other taxonomic groups correlates with the Mediterranean algal flora in general. Indeed, the global*R/P* ratio obtained is estimated to 2.19 for the study area which is slightly lower than the Algerian average estimated to3 (Seridi, 2004).However, the global *R/P* ratio obtained is close to that reported by Kazzaz (1989) (2.7 for Cabo-Negro, Tetouan-Morocco), Conde (1984) (2.41 for Malaga-Spain), Soto and Conde, (1993) (2.45 for Alboran Island) as well as Riadi (2000)(2.4for the Area of the Strait of Gibraltar). This result of *R/P* ratio reflects the presence in Algeria of a marine algal flora with temperate affinity of the Mediterranean type (Ould Ahmed et al., 2013). This ratio increases steadily from the cold seas of Northern Europe to the warm regions of the tropical Atlantic. It is close to 3 in the western Mediterranean, lessthan 3 in the eastern Mediterranean, 2.42 in the Adriatic (Giaccone, 1978), 2.5 in Greece and 2in Turkey (Boudouresque and Perret-Boudouresque, 1979).

The diversity estimated using the Shannon-Weaver index (H') as well as the Equitability index (E') for all the observation stations show that the least wealthy stations are Saint-Michel, Mers El-Hadjadj, Stidia, Ouréah, Sablette, Salamandre and El-Marsa with low values of$H'$and E'($1.03 \leq H' \leq 1.24$; $0.55 \leq E' \leq 0.84$) (Fig. 5).These indices reflect algal populations in disequilibrium (Belsher and Boudouresque, 1976). Indeed, these seaweeds are heavily affected by direct industrial, domestic and urban discharges of water without treatment, thus generating increasing pollution, inevitably affecting the algal community in its diversity (personal observation).However, the anthropogenic action characterized by urban discharges could also be the reason for the loss of algal diversity. Indeed, these stations are characterized by species of the genus *Ulva* such as *Ulva institinalis*, *Ulva rigida* and *Ulva compressa* (Table 2) which tolerate eutrophication and are known to be nitrophilic nitrogen-accumulating species (Arévalo et al., 2007; Hoffmann and Parson, 1988).

On the other hand, the stations Abelmalek Ramdane, Petit Port, Bahara and El-Geulta are relatively spared by pollution with slightly higher indices of diversity and equitability ($2.53 \leq H' \leq 3.09$; $1.38 \leq E' \leq 1.75$) (Fig. 5). This indicates populations well differentiated, stable and in equilibrium (Chaabane, 2019; Verlaque et al., 1977) particularly for the Bahara population, Petit port and Abdmalek Ramdane (Fig. 5). The sites of Bahara and Abdelmalek Ramdan have an important floristic composition with the highest values of H'(3.09; 2.95) and E'(1.75; 1.6) respectively (Fig. 5). The species that characterize these two stations are algae of Pheophyceae phyla such as *Cystosera sticta* and *Cystoseira compressa* that are enormously sensitive to anthropogenic pressure and the slightest variation in the marine environment. For this purpose, these algae could be considered as bioindicators for a healthy environment. Indeed, both Bahara and Abdelmalek Ramdan are areas characterized by high hydrodynamics, a non-vertical substrate and good lighting testifies to a good environmental situation (Belmokhtar, 2012).

Moreover, the Correspondence Analysis (CA) in Fig. 6 indicates that the two sites Bahara and Abdelmalek Ramdanare diversified witha floristic composition representative of clean waters, whereas Saint-Michel, Stidia, Salamandre, Sablette and El-Marsa populations seem to be strongly disturbed by anthropogenic pollution (port areas and coastal discharges of wastewater) (Personal observation). Whereas, the sites Saint-Michel, Salamandre and El-Marsa are harbours and the rest of the stations (Saint-Michel, El-Marsa, Salamandre, Sablette, Mers el Hadjadj and Stidia) are located just near relatively polluted harbours. This is confirmed by their rarity in species sensitive to pollution as algae from Cystoseire group (Table 2) whilewe can mention the presence of pollution indicator species of the genus *Enteromorpha*, *Chaetomorpha* and *Ulva* (Table 2) (Rodriguez-Prieto and Polo, 1996; Ballesteros et al., 1984; Golubic, 1970).

The presence of the invasive species *Caulerpa racemosa* var. *cylindracea* (Table 2), which tends to colonize disturbed ecosystems, could explain the reduction in native algal flora (Klein andVerlaque, 2008; Klein 2007; Piazzi and Ceccherelli, 2006). Although other factors such as pollution of inorganic chemicals, increased turbidity levels, overgrazing and climate change have been suggested as other possible causes (Cormaci and Furnari, 1999). This means a highly disturbed environment that requires follow-up in the future.

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