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PHENOLOGY OF POSIDONIA OCEANICA (LINNEAUS) DELILE IN THE WEST COAST OF ALGERIA

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ABSTRACT

The Posidonia oceanica seagrass in the western coast of Algeria on the subject of annual monitoring from November 2008 to November 2009.Two sites are selected and each are represented by a station located 10meters deep. The first is Cap Carbon which is polluted site subject to various major releases, and the second one is Ain Franin considered as a reference site relatively far from sources of pollution other than pollution considered sporadic during the summer where there is a rare attendance of holidaymakers. A study of the phenology of Posidonia oceanica meadows, on the leaf biometry, the coefficient "A" and the surface shows that these parameters are strongly influenced by seasonal factors and not by the depth as our samples were made at same depth.

Key Words: Phenology, *Posidonia oceanica*, Seasonal, Depth, Cap carbon, Ain franin, Algeria.

INTRODUCTION

The meadows constituted by the seagrass *Posidonia oceanica* (L). Delile are considered one of the most important ecological assemblages of Mediterranean coastal systems Buia *et al.* (2000). In many areas of the Mediterranean coast, the *Posidonia* seagrass experienced significant regression due to many factors (Boudouresque and Meinesz, 1982; Peres, 1984; Krauss–Jensen *et al.*, 2004; Tunesi and Boudouresque, 2006):coastal development (right of hydrodynamics and sedimentation), pollution(hydrocarbons, pesticides, heavy metals) Kucuksezgin *et al.* (2006) organic matters ,suspended solids, macro-wastes, anchors, the negative influence of human impacts (Short and

Wyllie, 1996; Orth *et al.*, 2006) and all practices that can cause a tear leaves or shoots of Posidonia. Indeed, *Posidonia oceanica* seagrass in fundamental to the quality of coastal environments (Augier, 1985; Pergent, 1991; Pergent *et al.*, 1995) and (Pergent *et al.*, 2005) and it has been object of numerous studies (Boudouresque *et al.*, 1979; Boudouresque *et al.*, 1980) and (Meinesz and Laurent, 1980). The Magnoliophyta marine organisms appear to be very interesting in the context of an environmental monitoring Boudouresque (2006). Phenological characters of *Posidonia oceanica* Magnoliophyta certainly make account of the vitality of these species, but May also reflect the quality of the environment where these structures are developed Pergent *et al.* (1995).

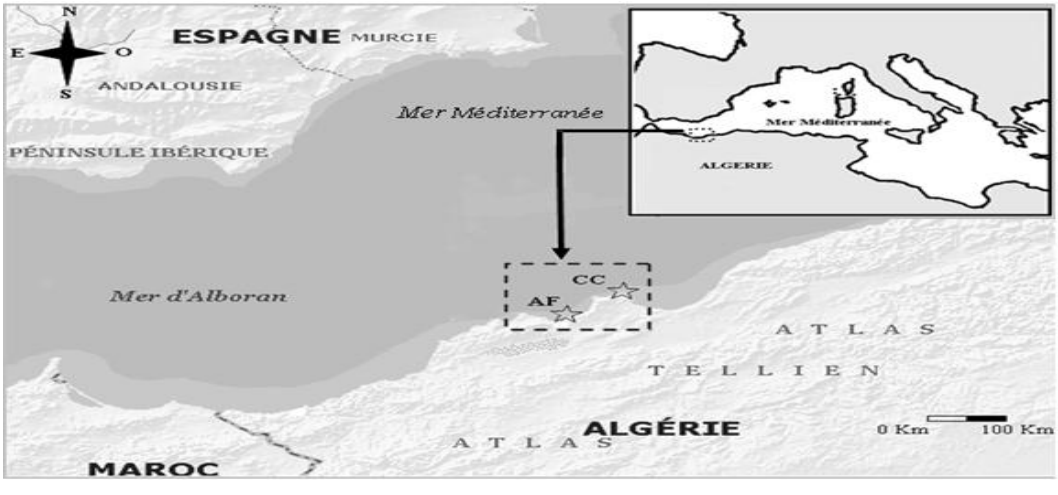
Any time despite the presence of *Posidonia oceanica* meadows along the Algerian coast, this research interest only one sector that is the coast of Algiers. We therefore seemed interesting to undertake a study of herbarium phenology of two sites of the basin on the west coast of Algeria because of their geographical conditions of different backgrounds, the first being a polluted site which is the site of Cap Carbon (Arzew), and the second one relatively considered as a reference site; namely, the site of Ain Franin (Oran).Therefore, we thought it is useful to compare the health status of both herbarium of the considered sites.

MATERIAL AND METHODS

Zone Study

Annual cycles have involved two *Posidonia oceanica* seagrass, the first, located near the town of Arzewn (Cap Carbon) 35° 54' 6.36 N and 0° 20'20.22 W which is the headquarters, for several years of major urban and industrial discharges (Amar, 1998; Dermeche, 1998). In contrast, the second one is located about ten kilometers east of Oran (Ain Franin) 35° 46' 49.78'' N and 0° 31' 01.51'' W. (Figure1).Which is subject only to sporadic releases (summer, currents) Belkhedim (2010).

Figure-1. Geographic location of stations studied: Ain Franin (AF) and Cap Carbon (CC)



The Sampling

The sampling ranged from November 2008 to November 2009, at the rate of one sample per month and per site. The crops of rhizomes, terminated by a beam lifetime are made in diving (scuba) to 10meters deep. The studied seagrasses grow primarily on soft substrate. The harvested rhizomes are preserved in seawater formalin at 10% .This method of attachment allows you to work after rehydratation of the material which is very close to the fresh material. For each site, counting in situ shoots has been undertaken in scuba using a quadrate placed randomly within the homogeneous *Posidonia oceanica* seagrass (Panayotidis 1980; Panayotidis and Giraud, 1981).

The Study in Laboratory

Each shoot is rehydrated, and then husked one sheet couplet in the order of their insertion. The leaves are separated according to the protocol of Pergent (1987) according to their maturity:

- ✓ The « adult leaves » of over 50cm long, and equipped with a petiole whose length is greater than or equal to 2 mm.
- ✓ The « intermediate leaves » of more than 50cm long and devoid of petiole or petiole which is less than or equal to 2 mm.
- ✓ The « juvenile leaves » without petiole and the length does not exceeding 50 mm.

Only intermediates and adults leaves are considered in this work (number of leaves per shoot).The various parameters related to the phenology of *Posidonia oceanica* leaves are calculated for the intermediates and adults leaves, such as the forthcomings:

- ✓ The Mean number of sheets per bundle.
- ✓ The Mean length and width of adult leaves and intermediates.
- ✓ The coefficient "A" which is the percentage of the leaves having lost their apex Giraud (1977).
- ✓ The leaf area index (L.A.I) corresponds to the surface of the leaves per shoot or per m^2 [(Drew, 1971), (Drew and Jupp, 1976)].

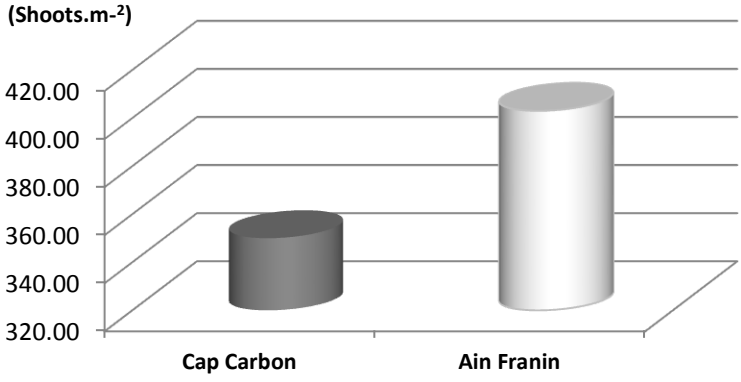
Only one side is taken into account, although the two sides of the leaves of *Posidonia oceanica* are chlorophyll. This index is therefore only half of the actual leaf area.

RESULTS AND DISCUSSION

The Meadow Density

The density is 350 shoots m^{-2} of the level of the herbarium of the Cap Carbon and 403 shoots m^{-2} of the level of Ain Franin. According to the classification of (Giraud, 1977), the herbarium of Cap Carbon is of type **III** which is described as « clearsown » ; on the other hand, the herbarium of Ain Franin is of type **II** described as « dense » (Figure2).According to the latest classification (Pergent *et al.*, 2005), the seagrasses of the studied sites are considered « poor state ».

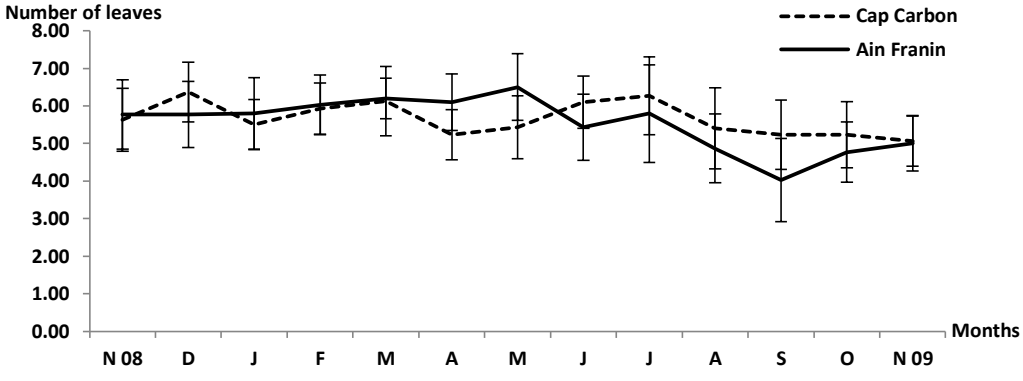
Figure-2. Mean density of *Posidonia oceanica* shoots per m^2 at study sites.



Shoot Structure

The overall mean number of the leaves (adults and intermediates) per shoot (Figure3) varies significantly depending on the season and this irrespective of the studied site ,corroborating the results of (Pergent and Pergent, 1988; Semroud, 1993; Boumaza, 1995; Rico-Raimondino, 1995; Belgacem *et al.*, 2007).This number is maximum in winter (6,37 ± 0,80 December) in Cap Carbon and in spring (6 ,50 ± 0,89 May) in Ain Franin on the other hand, it is minimum in autumn (5,07 ± 0,68 November) in Cap Carbon and in the late summer (4,03 ± 1,11 September) in Ain Franin.

Figure-3. Mean number of leaves (adults and intermédiates) per rhizome in the studied sites according to the harvest date.



The Structures of the Leaves

The Length of Leaves

Significant variations are recorded in the length of the adults leaves: 128,21 mm to 624,93 mm at the site of Ain Franin and ditto for the site of Cap Carbon where the minimum length is 145,24 mm and the maximum is 545,31 mm (Table 1).For both studied sites, we can notice that the longer leaves appear in summer , however, the shorter leaves are measured in winter (Table 2) confirms the results obtained by (Belgacem *et al.*, 2007) in Ras Jebel (Tunisia).

Table-1. Mean length (mm) of adults leaves in the studied sites as a function of rhizome sampling date (m: minimum, M: maximum).

Months	years	Cap Carbon	Ain Franin
November	2008	242,92	226,33
December	2008	231,19	181,18
January	2009	176,92	128,21 **m**
February	2009	145,24 **m**	140,79
March	2009	207,81	211,85
April	2009	235,64	237,83
May	2009	240,91	232,96
June	2009	352,84	311,76
July	2009	472,66	428,00
August	2009	545,31 **M**	624,93 **M**
September	2009	337,87	511,24
October	2009	187,32	273,12
November	2009	186,87	247,31
Mean		**274.12**	**288.89**

The table above shows that the length of intermediates leaves is always less than that of adults' leaves in the two studied sites. This is explained by the fact that have not completed their growth (Semroud, 1993; Boumaza, 1995; Rico-Raimondino, 1995; Belgacem *et al.*, 2007) to 73,63mm in October and to 498,24mm in June for the site of Cap Carbon and to 89,48mm in October to 488,68mm in August for the site of Ain Franin (Tables 1 and 2).

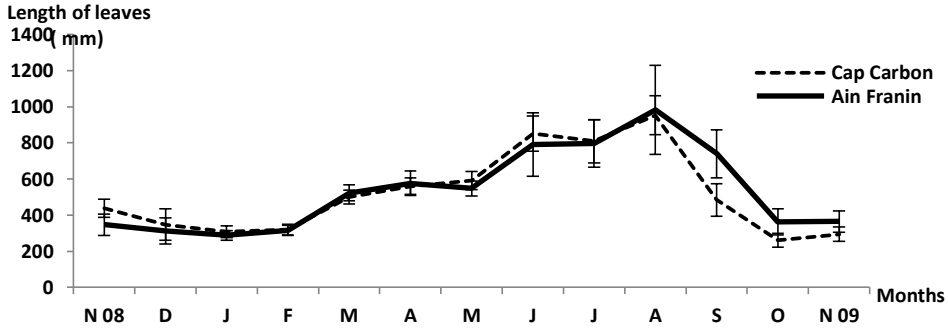
Table-2. Mean length (mm) of intermediates leaves of the studied sites as a function of rhizome sampling date (m: minimum, M: maximum).

Months	years	Cap Carbon	Ain Franin
November	2008	195.18	120.46
December	2008	116.16	132.21
January	2009	132.04	159.66
February	2009	174.95	174.73
March	2009	293.65	311.38
April	2009	324.79	338.59
May	2009	350.91	314.98
June	2009	498.24 **M**	479.55
July	2009	336.04	368.84
August	2009	406.93	488.68 **M**
September	2009	146.93	300.50
October	2009	73.63 **m**	89.48 **m**
November	2009	107.43	117.35
Mean		**242.84**	**261.26**

According to the table above, the monthly overall Mean of the leaves (adults and intermediates) is characterized by significant variations. These can be explained by the formation rate of the fall of

the leaves, therefore the succession of different types of the leaves in the shoot (Sanchez-Lizaso, 1993) .The longest leaves (monthly Mean) appear in summer. According to (Wittman, 1984) and (Caye, 1980), the period most favorable to the growth of the leaves is spring; on the other hand the fall autumn and winter correspond to the period where the growth of leaves is low (Figure 4).The same evolutionary aspect is recorded in the Mediterranean according to the literature and the lengths of the leaves and the same depth corroborate with those obtained by (Boumaza, 1995; Rico-Raimondino, 1995) and (Belgacem *et al.*, 2007).

Figure-4. The average length of the leaves (in mm)per beam (adults and intermadiates) in the studied as function of rhizome sampling date.



The Leaves Width

The width of the leaves increases from the inside of a shoot to the outside (Pergent and Pergent-Martini, 1988) .They are the outermost leaves that are larger whatever the station and the period of the year are considered. The Mean width of adult leaves (monthly Mean) is always larger than the intermediate leaves. The Mean width of adult leaves showed extreme values ranging from 9, 79 mm in December (Ain Franin) to 11,81mm in May (Cap Carbon) (Table 4).

Table-4. Mean width (in mm) of adult leaves in the studied sites according as a function of rhizome sampling date (m: minimum, M: maximum).

Months	years	Cap Carbon	Ain Franin
November	2008	10.69	10.94
December	2008	10.68	9.79 **m**
January	2009	10.80	9.92
February	2009	10.17 **m**	9.98
March	2009	11.53	10.93
April	2009	11.51	11.51 **M**
May	2009	11.81 **M**	11.34
June	2009	10.57	10.00
July	2009	10.95	10.65
August	2009	11.04	10.24
September	2009	11.21	10.78
October	2009	10.61	11.14

November	2009	11.12	10.42
Mean		**10.98**	**10.59**

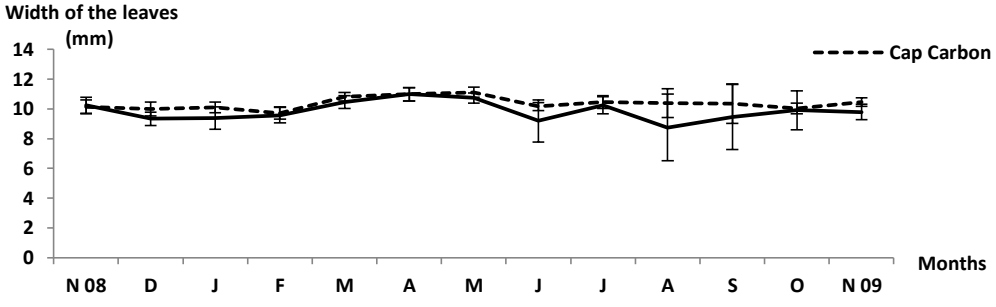
The width of the intermediates leaves also shows seasonal variations; with extreme values of 8,40mm in June (Ain Franin) to 10,48mm in April (Cap Carbon) (Table5).These results are also shown by (Belgacem *et al.*, 2007).

Table-5. Mean width (mm) of the intermediates leaves in the studied sites as a function of rhizome sampling date (m: minimum, M: maximum).

Months	years	Cap Carbon	Ain Franin
November	2008	9.58	9.53
December	2008	9.31	8.88
January	2009	9.39	8.85
February	2009	9.26 **m**	9.19
March	2009	10.12	9.98
April	2009	10.48 **M**	10.46 **M**
May	2009	10.43	10.14
June	2009	9.77	8.40 **m**
July	2009	9.95	9.85
August	2009	9.76	9.75
September	2009	9.52	10.20
October	2009	9.43	8.68
November	2009	9.79	9.15
Mean		**9.75**	**9.47**

As it is shown clearly in the table above, the overall Mean width of the leaves (adults and intermediates) evolves in the same way that the width of adults leaves and intermediates with values ranging from 9,34 mm in December in Ain Franin to 11, 12 mm in May in Cap Carbon (Figure5).These values follow the same seasonal pattern as those mentioned in the literature (Sanchez- Lisazo, 1993; Semroud, 1993; Boumaza, 1995).

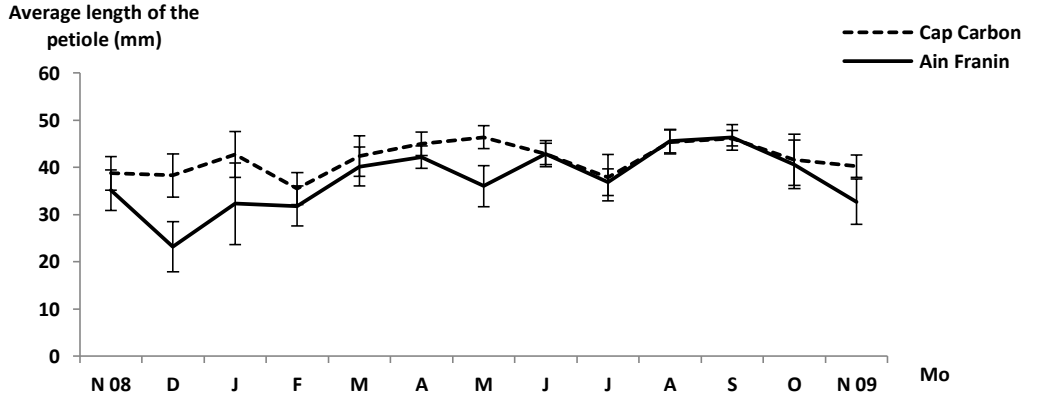
Figure-5. The average width of the leaves (adults and intermediates) in the studied sites as function of rhizome sampling date.



The Length of Petiole

The length of petiole varies with the rank of the leaf. It is up to the older leaves (elevated rank) that their growth is completed (Giraud, 1977; Giorgi and Thellin 1983; Pergent, 1987). The Mean length of the petiole varies not only with the rank of the leaf, but also with the harvest period of the rhizomes and the sites or samplings that were performed. The length (monthly Mean) of the petioles reaches its peaks in May 46 46 mm (Cap Carbon) and in September 46,37mm (Ain Franin) .The length (monthly Mean) of the petioles minimum is reached in December for the two sites with the respective values of 38,28mm in Cap Carbon and 23,18mm in Ain Franin. (Figure-6).

Figure-6. Variation of the average length of the adult leaves of the petiole (in mm) in the studied sites in relation of the dates of the harvest.



The State of Apex

The state of apex provides information for a given site, the rate of predation by consumers (Velimirov 1984; Zupo, 1985; Verlaque 1987) and the action of the hydrodynamics (Mazzella *et al.*, 1981; Witman *et al.*, 1981). The state of the apex is determined by the coefficient "A" of (Giraud, 1977), which is the percentage of the leaves having lost their apex. In the studied sites, the apex of the adult's leaves is almost always broken whatever the time of the year. We observe throughout the year that the large values of the coefficient "A" are greater than 43% except for the winter the percentage is 39,74% (December) and 35,13% (January) in Ain Franin and 42,17% (February) in Cap Carbon (Table 6). The coefficient "A" of intermediates leaves is significantly lower than that of adults leaves (Table7) because they are younger and better protected from the action of the predators, and because of their position within the shoot (Giraud, 1977; Buia *et al.*, 1985; Pergent and Pergent-Martini, 1988; Rico and Pergent, 1990). The maxima and minima are respectively between February and July in Cap Carbon and between February and June in Ain Franin.

Table-6. Coefficient "A" adult leaves as a percentage in the studied sites as a function of rhizome sampling date (November2008 to November 2009). m :minimum, M :maximum.

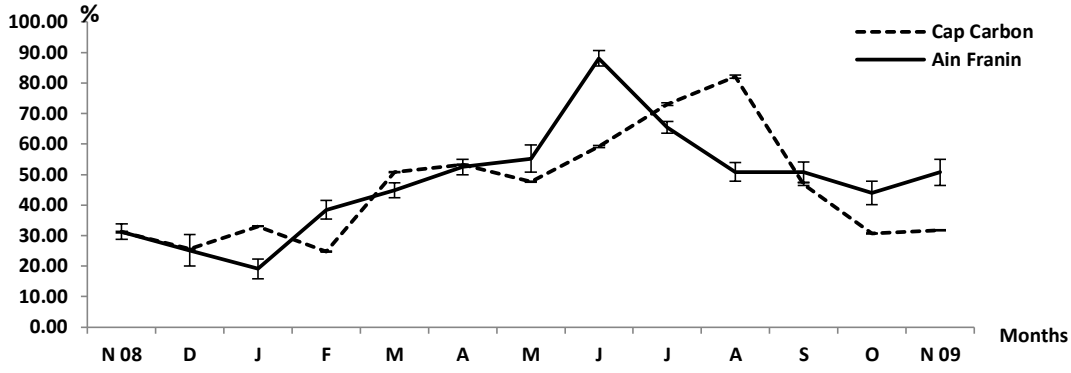
Months	years	Cap Carbon	Ain Franin
November	2008	54.26	50.62
December	2008	50.00	39.74
January	2009	54.65	35.13 **m**
February	2009	42.17 **m**	76.83
March	2009	88.89	89.53
April	2009	**71.76**	86.67
May	2009	72.37	83.81
June	2009	66.66	100.00 **M**
July	2009	90.91 **M**	94.68
August	2009	83.78	90.32
September	2009	65.79	93.02
October	2009	42.50	78.65
November	2009	53.03	89.28
Mean		**64.39**	**77.56**

Table-7. Coefficient"«A" leaves intermediates percentage in the studied sites as a function of rhizome sampling date m : minimum, M : maximum.

Months	Years	Cap Carbon	Ain Franin
November	2008	8.00	11.96
December	2008	1.08 **m**	10.53
January	2009	11.39	3.00
February	2009	7.37	0.00 **m**
March	2009	12.77	0.00 **m**
April	2009	34.72	18.28
May	2009	22.99	26.27
June	2009	51.47	76.12 **M**
July	2009	55.13	36.25
August	2009	80.39 **M**	11.32
September	2009	27.91	8.58
October	2009	18.92	9.25
November	2009	10.47	12.12
Mean		**26.35**	**17.24**

The coefficient "A" overall, which is the percentage of adults and intermediates leaves having lost their apex (Figure-7) shows that if we consider the annual Means, the *Posidonia oceanica* meadows of Cap Carbon and Ain Franin are characterized by similar state while varying with the seasons.

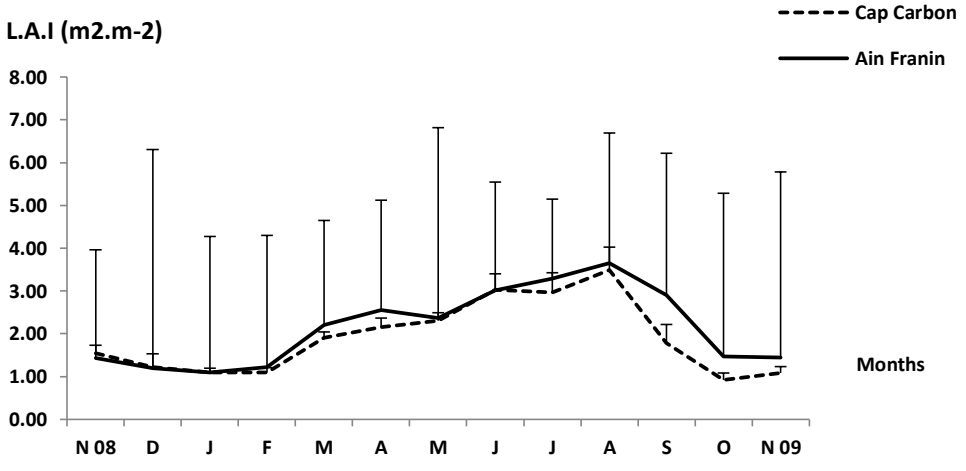
Figure-7. Variation of the global coefficient "A " adult and intermediary leaves in percentages, in the studied sites as function of rhizome sampling date .m:minimum M:maximum.



Leaf Index Area (LAI)

The total leaf area index (adults and intermediates leaves) shoot varies significantly during the year, is usually the maximum in summer and the minimum between October and January. This variation in leaf area index during the year was also highlighted by (Pergent and Pergent-Martini, 1988) in Port Cros (France), (Semroud, 1993) in La Marsa and Tamenfoust (Algeria) and (Rico-Raimondino, 1995) in Ischia (Italy), (Boumaza, 1995) in l'anse de Kouali (Algeria) and (Belgacem *et al.*, 2007) in Ras Jebel(Tunisia).The leaf area index passes from single to double in two sites of study (Figure-8) which leads us to say that both sites are under the same influences of the large waves and are there fore subject to the same hydrodynamic force.

Figure-8. Variation of the mean index overall in $m^2.m^{-2}$ of the herbarium in relation to the period of the harvest of the rhizomes in the studied sites



Our data are among the lowest values. In all regions of the Mediterranean, we find relatively low values by maintaining that high values are higher a 10 $m^2.m^{-2}$ (Table-8).

Table-8. Values of leaf area indexes (L.A.I) per shoot (in cm^2) and per m^2 of *Posidonia oceanica* bed as found in the literature, for different localities and depths.

Locations	References	Depth (m)	L.A.I (cm^2/shoot)	L.A.I ($m^2.m^{-2}$)
Cap Carbon (Algéria)	Chahrour, 2012	10	99,04 August 26,23 October	3,49 August 1.09 January
Ain Franin (Algeria)	Present study		90,04 August 27,10 January	3,65 August 1,09 January
Calvi (Corsica)	(Bay, 1984)	10	347 June 117 October	10,32 March 6,53 December
Anse de Kouali (Algeria)	(Boumaza, 1995)	10	435,50 May 264,00 February	16,80 May 10,20 February
La Marsa (Algeria)	Semroud, 1993)	8	305,00 July 202,50 January	5,20 July 3,50 January
Tamentfoust (Algeria)			207,5 April 117,40 October	2,40 April 1,30 October
Iles Medes (Spain)	(Romero, 1985)	13	233,00 August 80,00 December	7,90 August 2,70 December
Banyuls-sur-Mer (France)	(Pergent, 1987)	12	251,00 July 72,00 December	13,40 July 3,90 December
Tabarca (Spain)	(Sanchez, 1993)	12,5	152,00 November 321,00 March	7,00 November 14,40 March
Mondello (Sicily, Italy)	(Frada *et al.*, 1993)	10	136,00 September/October	8,40 September/October
Ras Jebel (Tunisia)	(Belgacem *et al.*, 2007)	10	----------	14.92 Spring

CONCLUSION

This study assessed the status of the *Posidonia oceanica* seagrass at the studied sites (Cap Carbon and Ain Franin).In fact the results, obtained in the realization of this work are generally similar and corroborate with the majority of studies which are discussed earlier and made in the different sectors of the Mediterranean.

The low density variation of the shoots, raised, in Posidonia meadows of the two studied sites is probably due to the fact that it is the same type of substrate and that our samples were made at depths similar, although the Posidonia meadows of Cap Carbon is under the influence of a very diverse pollution as opposed that of Ain Franin which is concerned with only a sporadic pollution especially in summer. This similarity of results can also be due to the current patterns that submit the two seagrasses to the same environmental conditions.

The evolution of phenological parameters along an annual cycle showed their seasonal character frankly:

- ✓ The Mean number of leaves per shoot and the proportion of different types of leaves vary during the year.
- ✓ The Means lengths of adults and intermediates leave change during the year.
- ✓ The Mean width of adults and intermediates leaves increases with them age. The leaves of rhizomes from Cap Carbon are slightly larger than those of Ain Franin, this can be seen as a response to particular environmental conditions (high turbidity, excess nutrients).
- ✓ The Mean length of petioles varies with age of the leaf and the harvest period made in the studied sites.
- ✓ The coefficient "A" varies depending on the harvest period with a maximum value during summer and minimum in winter.
- ✓ The maximum leaf area index is minimum in autumn and maximum in summer.

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