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Phenology, rhizome growth rate and rhizome production of *Posidonia oceanica* (L.) Delile along a depth gradient : preliminary approach using lepidochronology

Phénologie, taux de croissance et production de rhizomes de Posidonia oceanica *(L.) Delile sur un gradient bathymétrique : approche préliminaire utilisant la lépidochronologie*

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Mots clés : *lépidochronologie, phénologie,* Posidonia oceanica, *taux de croissance, production de rhizomes, littoral d'Alexandrie, Egypte.*

ABSTRACT

Mostafa H.M., Y. Halim, 1995 - Phenology, rhizome growth rate and rhizome production of Posidonia oceanica *(L.) Delile along a depth gradient : preliminary approach using lepidochronology.* Mar. Life, **5** (1) : 19 - 27.

The rhizome production and the rhizome growth rate of Posidonia oceanica *along depth gradient at El-Agami (west of Alexandria) was determined using lepidochronology. The shoot density showed maximal values at shallower meadows (616 and 576 sh. per m² at 4 and 7 m depth respectively) and minimal values at the deeper meadows (414 sh. per m²). The leaf density showed maximal values at shallower meadows (2563 L. per m² at 4 m depth) and minimal values at deeper meadows (1716 L. per m² at 13 m depth). The mean annual rhizome production was maximal at 7 m (35.9 mg dw). The mean annual rhizome production values (g. m². year) were comparable with other values recorded from different localities around the Mediterranean basin. The mean annual rhizome growth rate showed maximal values at shallower meadows (4.3 mm at 4 and 7 m depth respectively) and minimal values at deeper meadows (3.2 mm at 13 m depth). The rhizome growth rate was more or less comparable with other values recorded from other Mediterranean localities. Two main differences were detected between Egyptian meadows and other Mediterranean meadows. The first variation is the mean length of intermediate leaves was much higher than that of adult ones. This trend was reversed in most other Mediterranean localities. This reversed trend in Egyptian waters is most probably indirectly related to intensive colonization by epiphytes that leads to the intensive grazing rate on adult and intermediate leaves as well. Another variation concerns the absence of floral indications or remains along the rhizomes in Egyptian waters. The flowering of* P. oceanica *appears to be synchronous in the Mediterranean basin. The lepidochronology method appears to be a good tool for monitoring and restoration of the* P. oceanica *seagrass.*

RÉSUMÉ

Mostafa H.M., Y. Halim, 1995 - [Phénologie, taux de croissance et production de rhizomes de Posidonia oceanica *(L.) Delile sur un gradient bathymétrique : approche préliminaire utilisant la lépidochronologie].* Mar. Life, **5** (1) : 19 - 27.

La production de rhizomes de Posidonia oceanica *et leur taux de croissance sur un gradient bathymétrique à El-Agami (à l'ouest d'Alexandrie, Egypte) ont été estimés en utilisant la technique de la lépidochronologie. La densité des faisceaux présente des valeurs maximales dans les herbiers situés à faible profondeur (606 et 576 faisceaux par m², respectivement à 4 et 7 m de profondeur, et minimales dans les herbiers situés à profondeur plus élevée (414 faisceaux par m²). La densité foliaire présente des valeurs maximales dans les herbiers implantés à faible profondeur (2563 feuilles par m² à 4 m de profondeur) et minimales dans les herbiers situés à profondeur* *plus importante (1716 feuilles par m² à 13 m de profondeur). La production annuelle moyenne des rhizomes est maximale à 7 m de profondeur (35,9 mg poids humide). Les valeurs moyennes de production annuelle des rhizomes (g. m². année) sont comparables aux mêmes valeurs mesurées en différents points du bassin méditerranéen. Le taux moyen annuel de croissance des rhizomes est maximal dans les herbiers implantés à faible profondeur (43 mm à 4 m et 7 m de profondeur, respectivement) et minimal dans les herbiers situés à profondeur plus importante (3,2 mm à 13 m de profondeur). Le taux de croissance des rhizomes est plus ou moins comparable à ceux mesurés en d'autres sites méditerranéens. Deux différences principales sont notées entre les herbiers égyptiens et ceux d'autres régions méditerranéennes. La première variation concerne la longueur moyenne des feuilles intermédiaires, qui est ici plus importante que celle des feuilles adultes. Cette tendance est inverse à celle observée dans la plupart des autres régions méditerranéennes. Cette particularité des eaux égyptiennes est vraisemblablement liée à la colonisation intensive des feuilles par des épiphytes, qui conduit à un taux intensif de broutage aussi bien des feuilles adultes qu'intermédiaires. Une autre variation concerne l'absence des indications ou des vestiges floraux le long des rhizomes dans les eaux égyptiennes. Les inflorescences de* P. oceanica *sembleraient se produire de façon synchronique tout autour du bassin méditerranéen. La technique de la lépidochronologie apparaît comme un outil efficace pour le suivi et la restauration des herbiers à* P. oceanica.

INTRODUCTION

The endemic seagrass *Posidonia oceanica* (L.) Delile (Boudouresque, Meinesz, 1982) forms large and dense meadows along the north western Mediterranean coast of Egypt extending from about 3 m down to more than 25 m depth (Thelin *et al.*, 1985; Mostafa, 1991). The rhizomes of the seagrass show two types of growth forms: the plagiotropic (horizontal growth) and the orthotropic (vertical growth) (Caye, 1980). According to Blanc (1958), the rhizomes are connected together, with sediments filling the interstices, forming the most common feature of *P. oceanica* meadows: the *matte* (Pergent, 1990). The green leaves are connected to the rhizomes through the leaf sheaths, which remain attached to the rhizomes after the leaves fall. The leaf sheaths can persist within the matte for decades (Pergent *et al.*, 1983).

Leaf sheaths show cyclic variations in their thickness and anatomical parameters according to their insertion rank (Pergent, 1990). In fact, these cyclic variations are universal in the Mediterranean, and are always present whatever the locality, depth and sample period (Pergent *et al.*, 1989). The cyclic variations have a chronological significance as each cycle will correspond to a one year period (Pergent, 1987)

For the study of these cyclic variations, the term *lepidochronology* was introduced by Boudouresque *et al.*,1984. On the basis of this technique, numerous applications have been developed (Pergent, 1990) including the estimation of the annual rhizome production and their growth rate (Pirc, 1983) attempted during the present study. This technique has already been tested successfully (Pergent *et al.*, 1983; Boudouresque *et al.*, 1984; Pergent, 1987; Pergent and Pergent-Martini, 1990).

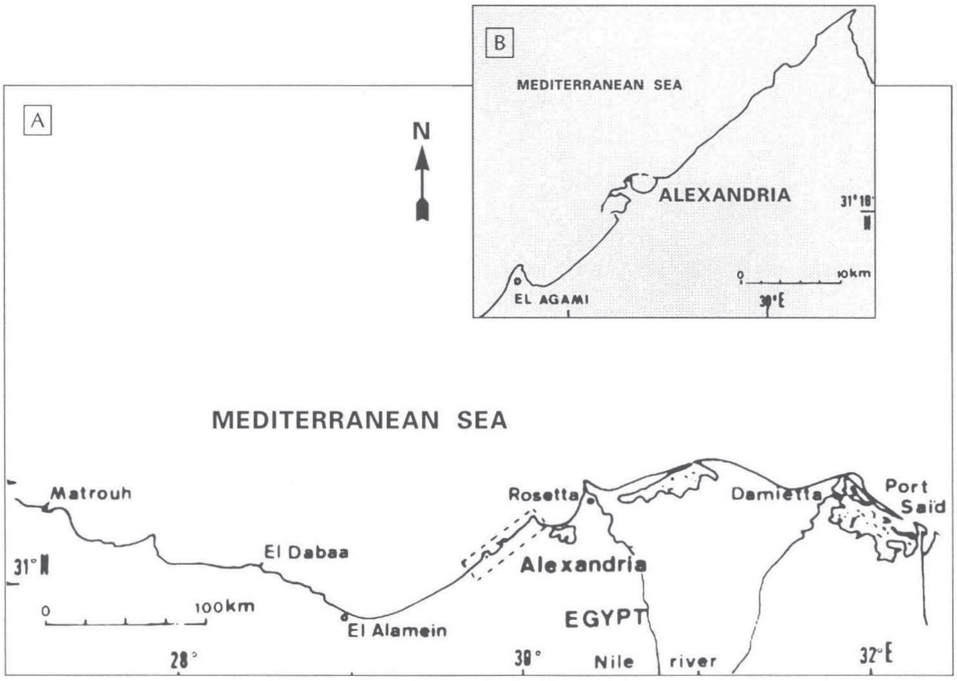

Figure 1 - Location of the study site in the Egyptian waters (A), near Alexandria (B) / *Situation du site d'étude dans les eaux égyptiennes (A), à proximité d'Alexandrie (B).*

Table I - Results of significance tests of the difference between the means of the different parameters measured at different depths at 0.05 confidence limit (S = Significant, NS = Non-Significant, n = number of observations) / *Résultats des tests de différences entre les moyennes des différents paramètres, mesurés à des profondeurs différentes, à une limite de confiance de 0,05 (S = significatif ; NS = Non Significatif ; n = nombre d'observations).*

Parameter	Depth 4-7m	Depth 7-13m	n 4m	n 7m	n 13m
Shoot density	NS	S	3	3	3
Leaf density	S	S	3	3	3
Leaf area index	NS	NS	3	3	3
Number of leaves per shoot	S	S	38	36	26
Mean length of intermediate leaves (mm)	NS	S	97	76	55
Mean length of adult leaves (mm)	S	S	57	54	39
Mean width of intermediate leaves (mm)	S	S	97	76	55
Mean width of adult leaves (mm)	S	S	57	54	39
Mean annual rhizome production	S	NS	10	11	7
Mean annual rhizome growth rate	NS	S	10	11	7

Table II - The shoot density, leaf density (number per m^2) and leaf area index (m^2 per m^2) of *Posidonia oceanica* along the depth gradient at El-Agami (Egypt) (± standard deviation). *Densité des faisceaux, densité foliaire (nombre par m^2) et indice de surface foliaire (m^2 par m^2) de* Posidonia oceanica *le long du gradient bathymétrique à El-Agami (Egypte) (± écart type).*

Depth (- m)	Shoot density	Leaf density	Leaf area index
4	616 ± 80.4	2563 ± 253	12.9 ± 4.9
7	576 ± 65.8	2050 ± 196	9.8 ± 4.5
13	414 ± 44.2	1716 ± 133	5.9 ± 2.0

The aim of the present study is to assess and compare various phenological parameters, rhizome production and growth rate of *Posidonia oceanica* along a depth gradient at El-Agami, west of Alexandria, Egypt, using lepidochronology. This is the first attempt to apply the technique of lepidochronology to the *Posidonia oceanica* meadows in Egyptian waters.

MATERIAL AND METHODS

Shoots with leaves and rhizomes of *P. oceanica* were collected by scuba diving in Spring 1994, along a depth gradient at El-Agami, West of Alexandria (Figure 1). All shoots and rhizomes within three replicated quadrates (0.16 m^2) were collected at three successive depths (4-7 and 13 m). The shoots with their rhizomes were well rinsed with sea water. The epiphytes and the epifaunal were cleaned off the leaves and rhizomes using razor blades. The shoots were separated from the rhizomes, except for the last leaf sheath carrying the oldest adult leaf on each shoot. Shoots were counted in the three replicates and the mean number of shoots was used to estimate the meadow density (number of shoots per m^2). The green leaves of each shoot were sorted for phenological analysis (leaf length, leaf width, leaf area index... using the technique described by Giraud (1977). For each rhizome, the leaf sheaths were carefully detached from the rhizomes and were numbered from the oldest (near the base of the rhizome) to the most recent (near the living leaves) (Pergent and Pergent-Martini, 1991). The leaf sheaths were counted into sets of 20 rhizomes from each depth for different successive lepidochronological years. It should be méntioned that the length of the rhizome depends on the sampling depth within the matte (about 25-30 cm in the present work). The length (in mm) and the dry weight of rhizome segments (in mg dry weight) corresponding to different successive lepidochronological years were measured. The lepidochronological years were obtained by measuring (under the microscope) the length between each pair of leaf sheaths of minimal thickness using a hand micrometer.

The annual growth rate of rhizomes was estimated from the length of different rhizome segments that correspond to different lepidochronological years. The annual rhizome production was estimated from the dry weight of different rhizome segments.

A general formula was used to test for the significant differences between the different means for all the parameters measured at the 5 per cent significant level using the mean, the standard deviation and the total number of observations.

$$d = \frac{\overline{X}_1 - \overline{X}_2}{\sqrt{\frac{S_1^2 + S_2^2}{n_1 - n_2}}}$$

Where x_1, s_1 and n_1 are the mean, the standard deviation and the number of observations for group 1: and x_2, s_2 and n_2 are the mean, the standard deviation and the number of observations for group 2.

RESULTS AND DISCUSSION

Phenology

The total shoot density (sh.) (number per m2) was maximal in the shallower meadows (616 and 576 sh. per m2 at 4 and 7 m depth respectively) and minimal in the deeper meadows (414 sh. per m2 respectively) (Table II). The shoot density showed no significant differences between the shallower meadows (4 and 7 m depth) (Table I). The shoot density was much higher than that recorded earlier by Mostafa (1991) at El-Agami, (381 ± 36 sh. per m2) and was comparable to the densities recorded by Thelin *et al.*, 1985, at El-Dabbaa (400-700 sh. m2), about 100 km west of El-Agami. It is most probable that the shoot density increases somewhat towards the west and this could be attributed to the less intensive trawl fishing activity in that area.

The total leaf density (number per m2) along a depth gradient showed significant differences between shallower and deeper meadows (Table I) being maximal at 4 m (2563 L. per m2) and minimal at 13 m (1716 L. per m2) (Table II).

The mean length of intermediate (int.) leaves (mm) showed no significant difference between shallower meadows (4 and 7 m depth) (Table I). The mean length of intermediate leaves was higher in shallower meadows than in deeper ones (Table III). On the other hand, the mean length of adult leaves showed significant differences between shallower and deeper meadows (Table I), being maximal at 4 m depth (252 mm) and minimal at 13 m depth (157 mm) (Table III). There is a considerable difference between the Egyptian meadows and most other Mediterranean meadows regarding the relative length of intermediate to adult leaves in Spring. Adult leaves in the meadows in Egyptian waters were always shorter than intermediate leaves (Table IV). This suggests that the grazing pressure on the adult leaves in the Egyptian meadows may be much greater than on intermediate leaves (Mostafa, 1991). The proportions of intact apex leaves for adult leaves were very low 8.2 %, 7.8 % and 5.3 % from shallower to deeper depths respectively.

On the other hand, the mean width of intermediate and adult leaves showed significant differences between shallower and deeper meadows (Table I), with maximal values at 7 m (8.8 and 8.6 mm for int. and ad. leaves respectively) and minimal values at 13 m (8.1 and 7.9 mm for int. and ad. leaves respectively (Table III).

The mean width values recorded in the present work were comparable with those recorded by Rico and Pergent (1990) in Sardinia (Italy) and by Pergent and Pergent-Martini (1988), at Banyuls (France), but smaller than other Mediterranean meadows (Table V).

The number of leaves per shoot showed significant differences between shallower and deeper meadows (Table I), with maximal values recorded at 4 and 13 m depth (4.2 and 4.1 leaves per shoot, respectively) and minimal at 7 m depth (3.6 leaves per shoot) (Table III).

The leaf area index (m2.m2) showed no significant difference between shallower and deeper meadows (Table I), with maximum leaf area index

Table III - The mean length (M L), mean width (M W) of intermediate (int.) and adult (ad.) leaves (ls) and the number (No.) of leaves per shoot of *Posidonia oceanica* along the depth gradient at El-Agami (Egypt) (± standard deviation) / *Longueur moyenne (M L), largeur moyenne (M W) des feuilles intermédiaires (int.) et adultes (ad.) et nombre (N°) de feuilles par faisceau de* Posidonia oceanica *le long du gradient bathymétrique à El-Agami (Egypte) (± écart type).*

Depth (-m)	M L int. ls (mm)	M L ad. ls (mm)	M W int. ls (mm)	M W ad. ls (mm)	No. of ls per shoot
4	326±41	252±68	8.6±.5	8.4±.6	4.2±.1
7	315±86	211±86	8.8±.4	8.6±.5	3.6±.1
13	264±29	157±43	8.1±.6	7.9±.8	4.1±.2

Table IV - The mean length of intermediate (int.) and adult (ad.) leaves (mm) of *Posidonia oceanica* at different localities along the Mediterranean Sea / *Longueur moyenne des feuilles intermédiaires (int.) et adultes (ad.) de* Posidonia oceanica *en différents points du littoral méditerranéen.*

References	Locality	Depth (-m)	Mean length (mm) int.	Mean length (mm) ad.	Season
Present work	Egypt	4	326	252	Spring
Present work	Egypt	7	315	211	Spring
Present work	Egypt	13	264	157	Spring
Pergent, Pergent Martini (1988)	Turkey	2	239	355	Annual cycle
Pergent, Pergent Martini (1988)	Port-Cros (France)	2	306	401	Annual cycle
Pergent, Pergent Martini (1988)	Port-Cros (France)	11	258	395	Annual cycle
Pergent, Pergent Martini (1988)	Banyuls (France)	2	111	115	Annual cycle
Pergent, Pergent Martini (1988)	Banyuls (France)	12	201	303	Annual cycle
Rico, Pergent (1990)	Sardinia (Italy)	4-6	216	304	Annual cycle
Rico, Pergent (1990)	Sardinia (Italy)	8-12	187	298	Annual cycle
Pergent (1990)	Ischia (Italy)	4-6	802		Spring
Pergent (1990)	Ischia (Italy)	8-12	799		Spring
Semroud *et al.*, 1990	Algeria	2-8	277	476	Spring

for shallower meadows (12.9 $m^2.m^2$ at 4 m depth) and minimum values for deeper meadows (5.9 $m^2.m^2$ at 13 m depth) (Table II). The results were comparable with most other localities around the Mediterranean Sea (Table VI).

Estimation of annual rhizome production and rhizome growth rate

The annual rhizome production [1 mg dw per rhizome segment (rh. seg.^{1}) per year (y.^{1})], showed variability in successive lepidochronological years at the three depths. The variations between length and weight of different rhizome segments corresponding to successive years, along the depth gradient, were statistically significant (one way analysis of variance, 95 % confidence level). The annual rhizome production (mg dw rh. seg.^{1} y.^{1}) ranged between 5.1 and 34.2 mg dw at 4 m, 4.4 and 51.0 mg dw at 7 m and between 5.2 and 50.4 mg dw at 13 m (Table VII). The mean annual rhizome production showed significant differences between shallower and deeper meadows (Table I) with maximal value recorded at 7 m (35.9 mg dw) (Table VII).

From the density of the *P. oceanica* shoots per square meter, it was possible to estimate the mean annual rhizome production per m^2. y.^{1} (Table VIII). This was maximal at 7 m (40.8 g dw) and minimal at 13 m (17.1 g dw). These results are comparable with the values recorded from different localities around the Mediterranean Sea (Table VIII).

The annual rhizome growth rate (mm rh. seg.^{1} y.^{1}) ranged between 3.0 and 7.1 at 4 m: 2.3 and 5.2 at 7 m and 1.5 and 4.3 mm at 13 m (Table IX). The mean annual rhizome growth rate showed no significant difference between 4 and 7 m depth (Table I). We conclude that the maximum rhizome growth rate values in shallower depths were higher than those recorded at deeper meadows (Table IX). The mean annual rhizome growth rate was comparatively lower than the values recorded from other Mediterranean localities (Table X).

According to Pergent and Pergent-Martini (1990), the annual variations for the growth rate of rhizomes of *P. oceanica* may be related to exogenous (sedimentation) and endogenous (distance between orthotropic and plagiotropic rhizome) factors. The mean growth rate appeared to be closely related to sedimentation rate (Caye, 1982). As sedimen-

Table V - The mean width of intermediate (int.) and adult (ad.) leaves (mm) of *Posidonia oceanica* at different localities along the Mediterranean Sea / *Largeur moyenne des feuilles intermédiaires (int.) et adultes (ad.) de* Posidonia oceanica *en différents points des côtes méditerranéennes.*

References	Locality	Depth (-m)	Mean width (mm) int.	Mean width (mm) ad.	Season
Present work	Egypt	4	8.6	8.4	Spring
Present work	Egypt	7	8.8	8.6	Spring
Present work	Egypt	13	8.1	7.9	Spring
Pergent, Pergent Martini (1988)	Turkey	2	9.7		Annual cycle
Pergent, Pergent Martini (1988)	Port-Cros (France)	2	9.8		Annual cycle
Pergent, Pergent Martini (1988)	Port-Cros (France)	11	10.4		Annual cycle
Pergent, Pergent Martini (1988)	Banyuls (France)	2	8.3		Annual cycle
Pergent, Pergent Martini (1988)	Banyuls (France)	12	9.8		Annual cycle
Rico, Pergent (1990)	Sardinia (Italy)	4-6	8.3	8.6	Annual cycle
Rico, Pergent (1990)	Sardinia (Italy)	8-12	8.6	8.9	Annual cycle
Caltagirone (1986)	Italy	4-6	9.6		Annual cycle
Caltagirone (1986)	Italy	8-12	10		Annual cycle
Semroud *et al.*, 1990	Algeria	2-8	10.1	11	Spring

Table VI - Leaf area indices per m^2 at different localities along the Mediterranean Sea. *Indice de surface foliaire par m^2 en différents points du littoral méditerranéen.*

References	Locality	Depth (-m)	Season	LAI m^2.m^2
Present work	Egypt	4-13	Spring	6-13
Mostafa (1991)	Egypt	5	Summer	3.2
Drew (1971)	Malta	6-27	_	4.5-10
Giraud *et al.*, 1977	Elbo (France)	5-30	Spring	20-52
Giraud *et al.*, 1977	Marseille (France)	10-25	Spring	6-19
Thelin, Giorgi (1984)	Port-Cros (France)	0.5-2	Annual cycle	4-20
Cinelli *et al.*, 1984	Ischia (Italy)	1-30	Autumn, Spring	25-37
Pergent (1987)	Turkey	2-5	Annual cycle	5-10
Pergent (1987)	Banyuls (France)	2-19	Annual cycle	6-8
Pergent (1987)	Port-Cros (France)	2-23	Annual cycle	4-6

Table VII - Mean annual rhizome production (mg.dw per rhizome segment per year) along a depth gradient at El-Agami (Egypt) (± standard deviation) / *Production moyenne annuelle des rhizomes (mg. poids humide par tronçon de rhizome par année) le long d'un gradient bathymétrique à El-Agami (Egypte)(± écart type).*

Year	4 m	7 m	13 m
1984	___	26.9 ± 1.9	___
1985	18.9 ± 21.5	32.4 ± 14.9	___
1986	28.5 ± 14.2	34.9 ± 16.7	___
1987	14.9 ± 8.6	46.5 ± 29.9	___
1988	20.6 ± 12.7	48.7 ± 26.1	50.3 ± 19.1
1989	20.1 ± 21.5	43.4 ± 19.2	50.4 ± 28.3
1990	31.2 ± 12.3	51.0 ± 19.5	47.5 ± 32.9
1991	34.2 ± 13.2	43.9 ± 18.9	40.5 ± 25.4
1992	33.5 ± 19.3	42.2 ± 22.6	28.1 ± 18.7
1993	17.8 ± 19.6	20.9 ± 28.6	7.7 ± 5.7
1994	5.1 ± 4.2	4.4 ± 4.1	5.2 ± 1.6
Mean	20.4 ± 11.1	35.9 ± 14.1	20.9 ± 22.5

Table VIII - Mean annual rhizome production ($g.m^2$.year) of *Posidonia oceanica* at different localities along the Mediterranean Sea / *Production annuelle moyenne ($g.m^2$. année) de rhizomes* de Posidonia oceanica *en différents points du littoral méditerranéen.*

References	Locality	Depth -m	Density .m^2	$g.m^2$ .y^1
Present work	Egypt	4	616	30.7
Present work	Egypt	7	576	40.8
Present work	Egypt	13	414	17.1
Ott (1980)	Ischia (Italy)	4	1138	30
Boudouresque *et al.*, 1984	Corsica (France)	8	-	42
Bay (1984)	Corsica (France)	10	410	34
Rico, Pergent (1990)	Sardinia (Italy)	6	518	37.7
Rico, Pergent (1990)	Sardinia (Italy)	14	395	25.2
Semroud *et al.*, 1990	Algeria	2	467	30.1
Semroud *et al.*, 1990	Algeria	8	172	21.2

tation increases, it results in the burial of the vegetative apex of the plant and might cause death if it persists. Boudouresque *et al.* (1984); Pergent and Pergent-Martini (1990); Pergent *et al.* (1989) concluded that lepidochronological cycles are subject to modulations. These modulations are not random and could indicate the plant response to endogenous and exogenous factors. Depth, light intensity, water movement, locality.... are the main factors for cyclic variations. The lepidochronological study of *P. oceanica* has made it possible to assign an accurate age for each rhizome segment and to assess accurately the growth rate and annual production of each rhizome segment (Pergent, 1987, 1990; Pergent *et al.*, 1989).

CONCLUSION

There are probably two main differences that have been detected between the Egyptian meadows and other Mediterranean meadows. The first variation concerns the phenology of *P. oceanica* (the

Table IX - Mean annual rhizome growth rate (mm per rhizome segment per year) along a depth gradient at El-Agami (Egypt) (± standard deviation / *Taux annuel moyen de croissance des rhizomes (mm par tronçon de rhizome) le long d'un gradient bathymétrique à El-Agami (Egypte)(écart type).*

Year	4 m	7 m	13 m
1984	——	4.0 ± 0.7	——
1985	3.0 ± 3.3	4.5 ± 1.0	——
1986	4.9 ± 2.1	5.0 ± 1.0	——
1987	3.5 ± 1.1	4.8 ± 1.1	——
1988	3.9 ± 1.5	4.8 ± 1.6	1.5 ± 0.5
1989	4.4 ± 1.6	4.1 ± 1.4	2.8 ± 0.9
1990	5.5 ± 1.1	4.5 ± 1.4	3.8 ± 1.7
1991	6.1 ± 0.9	5.2 ±2.6	4.3 ± 1.8
1992	7.1 ± 3.1	4.3 ± 1.7	3.6 ± 1.5
1993	5.7 ± 5.0	4.2 ± 1.9	3.2 ± 1.2
1994	3.4 ± 1.9	2.3 ± 1.5	3.3 ± 2.1
Mean	4.3 ± 1.9	4.3 ± 0.8	3.2 ± 1.8

Table X - Mean annual growth rate (mm.year) of rhizomes of *P. oceanica* at different localities along the Mediterranean Sea / *Taux de croissance annuel moyen en (mm. année) des rhizomes de* P. oceanica *en différents points du littoral méditerranéen.*

References	Locality	Depth	mm.y^{-1}
Present work	Egypt	4-13	2.1-4.3
Thelin *et al.*, 1985	Egypt	18-24	14-15
Drew, Jupp, 1976	Malta	-	6
Pergent *et al.*, 1983	Port-Cros (France)	1-23	4-10
Mosse, 1983	Port-Cros (France)	28-35	5-6
Boudouresque *et al.*, 1984	Corsica (France)	3-35	5-18
Romaro-Martinengo, 1985	Iles Medes (Spain)	3-15	10
Pergent, 1987	Port-Cros (France)	1-5	3-8
Pergent, 1987	Banyuls (France)	1-19	6-9
Pergent, 1987	Urla (France)	1-32	4-8
Rico, Pergent, 1990	Sardinia (Italy)	4-16	4
Semroud *et al.*, 1990	Algeria	2-8	6.8-12.7

mean length in Spring of the intermediate and adult leaves). In the present study, the mean length of intermediate leaves in this season was much higher than that of adult leaves (also in Mostafa, 1991). Panayotidis and Giraud (1981), however, observed the same trend in early June at two localities: Carry and La Couronne (Gulf of Marseille). This reverse trend in Egyptian waters may be associated with intensive grazing of adult leaves due to their high colonization by epiphytes. Secondly, we observed no evidence of floral remains along the rhizomes collected in Egyptian waters. Flowering of *P. oceanica* appears to be synchronous in the Mediterranean basin (Pergent and Pergent-Martini, 1990), and is an infrequent event that only takes place in particular years (1961, 1973, 1982 and 1983). This was observed in France (Pyrénées orientales, Bouches-du-Rhône and Alpes-Maritimes) and also in Turkey and Tunisia (Giraud, 1977; Thelin and Boudouresque, 1985, and Pergent and Pergent, 1990). Flowering was recorded by Thelin *et al.*, 1985, at El-Dabbaa (Egypt), but never observed in the present area (Mostafa, 1991).

The present study is a preliminary attempt to use one of several applications of lepidochronological analysis for *P. oceanica,* to estimate the growth rate and annual rhizome production. Further work is needed to apply this method to other aspects which will require month-to-month sampling along a depth gradient to detect the seasonal cyclic variations and to estimate the net leaf production and validate other lepidochronological applications.

BIBLIOGRAPHY

Bay D., 1984 - A field study of the growth dynamics and productivity of *Posidonia oceanica* in Calvi Bay, Corsica. *Aquat. Bot.*, **20** : 43-64.

Blanc J.-J., 1958 - *Recherches de sédimentologie littorale et sous-marine en Provence occidentale.* Thèse Doct. Etat. Univ. Paris. Masson, 140 pp.

Boudouresque C.-F., A. Meinesz, 1982 - Découverte de l'herbier de Posidonies. *Cah. Parc natl Port-Cros,* **4** : 1-79.

Boudouresque C.-F., A. Jeudy de Grissac, A. Meinesz, 1984 - Relation entre la sédimentation et l'allongement des rhizomes orthotropes de *Posidonia oceanica* dans la baie d'Elbu (Corse). In : *Intern Workshop on* Posidonia oceanica *Beds.* C.-F. Boudouresque, A. Jeudy de Grissac, J. Olivier (eds), GIS Posidonie Publ., **1** : pp 185-191.

Caltagirone A., 1986 - Fauna epifita cella *Posidonia oceanica* (L.) Delile dl Pta Garavano (Ventimiglia). Idroidi e briozoi. Tesi Laurea. Univ. Stud. Torino, 154 pp.

Caye G., 1980 - Sur la morphogenèse et le cycle végétatif de *Posidonia oceanica* (L.) Delile. Thèse Doct. Univ. Aix-Marseille II., Fr., 121 pp.

Caye G., 1982 - Etude sur la croissance de la Posidonie *Posidonia oceanica* (L.) Delile. Formation des feuilles et croissance des tiges au cours d'une année. *Tethys,* **10** : 229-235.

Cinelli F., M. Cormaci, G. Furnari, L. Mazzella, 1984 - Epiphytic macroflora of *Posidonia oceanica* (L.) Delile leaves around the Island of Ischia (Gulf of Naples). In : *Intern Workshop on* Posidonia oceanica *Beds.* C.-F. Boudouresque, A. Jeudy de Grissac, J. Olivier (eds), GIS Posidonie Publ., **1** : pp 91-99.

Drew E.-A., 1971 - An introduction to experiments by divers. Woods, Lithgoe (eds.), Botany. Underwater Science. London, pp. 175-233.

Drew E.-A., B.-P. Jupp, 1976 - Some aspects of the growth of *Posidonia oceanica* in Malta. In : *Underwater Research,* Woods, Lithgoe (eds) Academic Press, London, pp. 357-367.

Giraud G., 1977 - Contribution à la description et à la phénologie quantitative des herbiers à *Posidonia oceanica* (L.) Delile. Thèse Doct. 3e cycle, Univ. Aix-Marseille II, Fr., 150 pp.

Giraud G., C.-F. Boudouresque, J. Marcot-Coqueugniot, A. Meinesz, M. Verlaque, 1977 - Indices foliaires de *Posidonia oceanica* (Linné) Delile en Corse et dans la région marseillaise. *Rapp. P.v. Réun. CIESM.* **24** (4) : 131-132.

Mosse R.-A., 1983 - Variations cycliques dans les écailles de *Posidonia oceanica :* rhizomes plagiotropes et orthotropes. Laboratoire Ecol. Benthos. Fac. Sci. Luminy et Parc national Port-Cros. Fr. : 1-276.

Mostafa H.-M., 1991 - Ecological study of the marine phanerogam *Posidonia oceanica* and some of the associated communities in the Mediterranean Sea off Alexandria. Thesis Doct. Alexandria Univ., 288 pp.

Ott J.-A., 1980 - Growth and production in *Posidonia oceanica* (L.) Delile. *Mar. Ecol.,* **1** : 47-64.

Panayotidis P., G. Giraud, 1981 - Sur un cycle de renouvellement des feuilles de *Posidonia oceanica* (Linnaeus) Delile dans le golfe de Marseille. *Vie Milieu,* **31** (2) : 129-136.

Pergent G., 1987 - Recherches lépidochronologiques chez *Posidonia oceanica* (Potamogetonaceae). Fluctuations des paramètres anatomiques et morphologiques des écailles des rhizomes. Thèse Doct. Oceanol., Univ. Aix-Marseille II, 853 pp.

Pergent G., 1990 - Lepidochronological analysis of the seagrass *Posidonia oceanica* (L.) Delile : a standardized approach. *Aquat. Bot.,* **37** : 39-54.

Pergent G., C. Pergent-Martini, 1988 - Phénologie de *Posidonia oceanica* (Linnaeus) Delile dans le Bassin méditerranéen. *Annls Inst. oceanogr., Fr., Paris,* **64** (2) : 79-100.

Pergent G., C. Pergent-Martini, 1990 - Some applications of lepidochronological analysis in the seagrass *Posidonia oceanica. Botanica mar.,* **33** : 299-310.

Pergent G., C. Pergent-Martini, 1991 - Leaf renewal cycle and primary production of *Posidonia oceanica* in the bay of Lacco Ameno (Ischia, Italy) using lepidochronological analysis. *Aquat. Bot.,* **42** : 49-66.

Pergent G., C.-F. Boudouresque, A. Crouzet, 1983 - Variations cycliques dans les écailles des rhizomes orthotropes de *Posidonia oceanica. Trav. sci. Parc national Port-Cros,* Fr., **9** : 107-148.

Pergent G., C.-F. Boudouresque, A. Crouzet, A. Meinesz, 1989 - Cyclic changes along *Posidonia oceanica* rhizomes (lepidochronology) : Present state and prespectives. *Mar. Ecol.,* **10** (3) : 221-230.

Pirc H., 1983 - Belowground biomass of *Posidonia oceanica* (L.) Delile and its importance to the growth dynamics. Parc Int. Symp. Aquatic Macrophytes. Nijmegen (1973) : 177-181.

Rico V., G. Pergent, 1990 - Evaluation de la production primaire de l'herbier à *Posidonia oceanica* de la baie de Port-Conte (Sardaigne) par la méthode lépidochronologique. GIS Posidonie, Marseille, Fr. : 1-136.

Romero-Martinengo J., 1985 - Estudio écologico de las fanerogamas marinas de la costa catalana : Production primaria de *Posidonia oceanica (L.)* Delile en las Islas Medes. Tesis Doct., Facultad Biol., Barcelona. Spain, 261 pp.

Semroud R., S. Mezegrame, L. Soltane, 1990 - Étude lépidochronologique de *Posidonia oceanica* dans la région d'Alger (Algérie) : données préliminaires. *Rapp. P.-v. Réun. CIESM,* **32** (1) : 10.

Thelin I., J. Giorgi, 1984 - Production de feuilles dans un herbier superficiel à *Posidonia oceanica,* évaluée par une méthode dérivée de la méthode de Zieman. In : *Intern Workshop on* Posidonia oceanica *Beds.* C.-F. Boudouresque, A. Jeudy de Grissac, J. Olivier (eds), GIS Posidonie Publ., pp. 271-276.

Thelin I., C.-F. Boudouresque, 1985 - *Posidonia oceanica* flowering and fruiting recent data from an international inquiry. *Posidonia Newsletter,* **1** : 5-14.

Thelin I., R.-A. Mosse, C.-F. Boudouresque, R. Lion, 1985 - Le benthos littoral d'el Dabaa (Mediterranée, Égypte). II - l'herbier à *Posidonia oceanica. Rapp. P.-v. Réun. CIESM,* **29** (5) : 247-248.

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