PHENOLOGICAL BEHAVIOUR AS A FUNCTION OF TEMPERATURE FOR SEVERAL SPECIES OF PSAMMOPHILOUS VEGETATION

por

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Resumen

GRATANI, L., E. FIORENTINO & C. FIDA (1986). Comportamiento fenológico en función de la temperatura en algunas especies de la vegetación psamófila. *Anales Jard. Bot. Madrid* 43(1): 125-135 (en inglés).

Se ha efectuado una primera aproximación a la fenología de algunas especies de la vegetación psamófila. Los efectos de las variaciones de temperatura en la fenología se han representado sobre base matemática, identificando una ecuación de regresión linear entre la temperatura media mensual y la altura media mensual de las especies estudiadas. La introducción del porcentaje medio mensual de cobertura en la variable dependiente no siempre mejora la significación de la regresión.

Palabras clave: Fenología, vegetación psamófila.

Abstract

GRATANI, L., E. FIORENTINO & C. FIDA (1986). Phenological behaviour as a function of temperature for several species of psammophilous vegatation. *Anales Jard. Bot. Madrid* 43(1): 125-135.

A first approach to the phenology of several species of psammophilous vegetation was done. The effects of changes in air temperature on phenology were represented on mathematical basis. Linear regression equations were identified between monthly mean air temperature and monthly mean height of the studied species. The introduction of monthly mean precentage of cover in the dependent variable does not always improve the significance of regressions.

Key words: Phenology, psammophilous vegetation.

INTRODUCTION

Phenology is described as the life cycle phases or activities of plants in their temporal occurrence throughout the year. These studies permit a phenological calendar such that the seasons of the year are marked by groups of phenological events. In order to describe an explain some aspects of ecological phenomena, these events are very significative. In any case they can be related to seasonal

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changes of the physical environment and compared to each other to provide indications of local differences in climate (BLACKMAN & BLACK, 1959; LIETH, 1970; MARTIN & ESCARRÉ, 1980). Besides it is evident that air temperature strongly influences growth and phenological events (BLACKMAN & *al.*, 1955; WILLIMS & *al.*, 1980).

The present study aims to investigate the phenological phases of several psammophilous species on the latial coast of Rome (Italy) and to determine, on mathematical basis, the effect of monthly changes in air temperature on phenology.

MATERIALS AND METHODS

Phenological phases were observed in several species of psammophilous vegetation on the latial coast at Castelporziano (S, SW of Rome, Italy) (NAPOLEONE, 1970; GRATANI & MARINUCCI, 1985).

The examined species were: *Agropyron junceum* (L.) Beauv., *Ammophila littoralis* (Beauv.) Rothm., *Eryngium maritimum* L., *Pancratium maritimum* L., *Anthemis maritima* L., *Crucianella maritima* L., *Calystegia soldanella* (L.) R. Br. and *Ononis variegata* L.

A sampling area of 8000 sq.m extending from the sea to the first stages of *Juniperus oxicedrus* subsp. *macrocarpa* (Sibth. & Sm.) Ball, excluded, was considered. 100 permanent random plots of 1 sq.m placed at a distance of 6 m from each other were sampled. Monthly (from December 1983 to December 1984), for each sampled species, mean height (from soil to the tip of stretched upper leaf, flower excluded), mean percentage of cover and phenological phases were determined. Height and cover were also considered when plants were completely dry (tab. 1).

According to SCHOBER & SEIBT (1973), phenological stages were defined as follows:

Phase	Phenological observation
0	FIRST GREEN (needle points emerging)
1	LEAVES FULLY UNFOLDED AND GREEN
2	BEGINNING OF FLOWERING
3	GENERATIVE PHASE
4	BEGINNING OF DECAY
5	LEAVES COMPLETELY DRY

During the sampling period, monthly changes in air temperature and rainfall (data relative to the meteorological station in Castelporziano) were recorded.

Since phenology is closely related to meteorology (LIETH, 1970), we studied by a regression analysis the effects of changes in air temperature on phenology. For the regression analysis, the following variables were used: mean monthly height, mean monthly percentage of cover and mean monthly air temperature.

RESULTS

The dependence on air temperature of phenological behaviour in psammophilous vegetation is shown in table 2 and in detail in figure 1,2. They show that generally the growth of these species began when average air temperature exceeded 7.8 °C and generally finished when average air temperature exceeded 19 °C.

Agropyron junceum

The beginning of growth is generally observed in March. Flowering takes place in June with a maximum in August. In September leaves begin drying up and in October there is an evident phase of decay.

Ammophila littoralis

In March plant shows the growth of buds. Flowering begins in May with a maximum in July. The decay begins in September.

Anthemis maritima

The plants placed in the examined area do not seem to follow a synchronized growth. Buds come out generally in February-March. In May there is the maximum growth, followed by flowering that goes on till August. In September the phase of decay begins and in November plants are completely dry. A few plants have buds in September: however this new vegetative renewal does not reach the flowering stage because of the arrival of winter.

Pancratium maritimum

Its vegetative growth begins in February. It reaches the maximum vigour in April and the beginning of flowering in June. Peak flowering is in August and leaves are totally dry in October.

Ononis variegata

Buds come out in February and maximum height and flowering are attained towards the end of May. Between August and February the plants are completely dry.

Eryngium maritimum

All the examined plants show a synchronized annual cycle, the first buds coming out in February and flowering in June-July. In August the phase of decay begins.

Calystegia soldanella

First buds are in January. In May this species is very well grown and flowers in July. In September the phase of decay begins.

Crucianella maritima

Most of the studied plants begin growing in February and attain maximum growth in May-June. In September the phase of decay begins and in November the species is completely dry. In September-October a few plants have a vegetative renewal.

The effect of monthly changes in air temperature on growth of studied species can be explained by a linear equation of mean monthly height (y = dependent variable). The mathematical relationship was also determined when plants were completely dry. In this case height (from soil to the tip of stretched upper leaf,

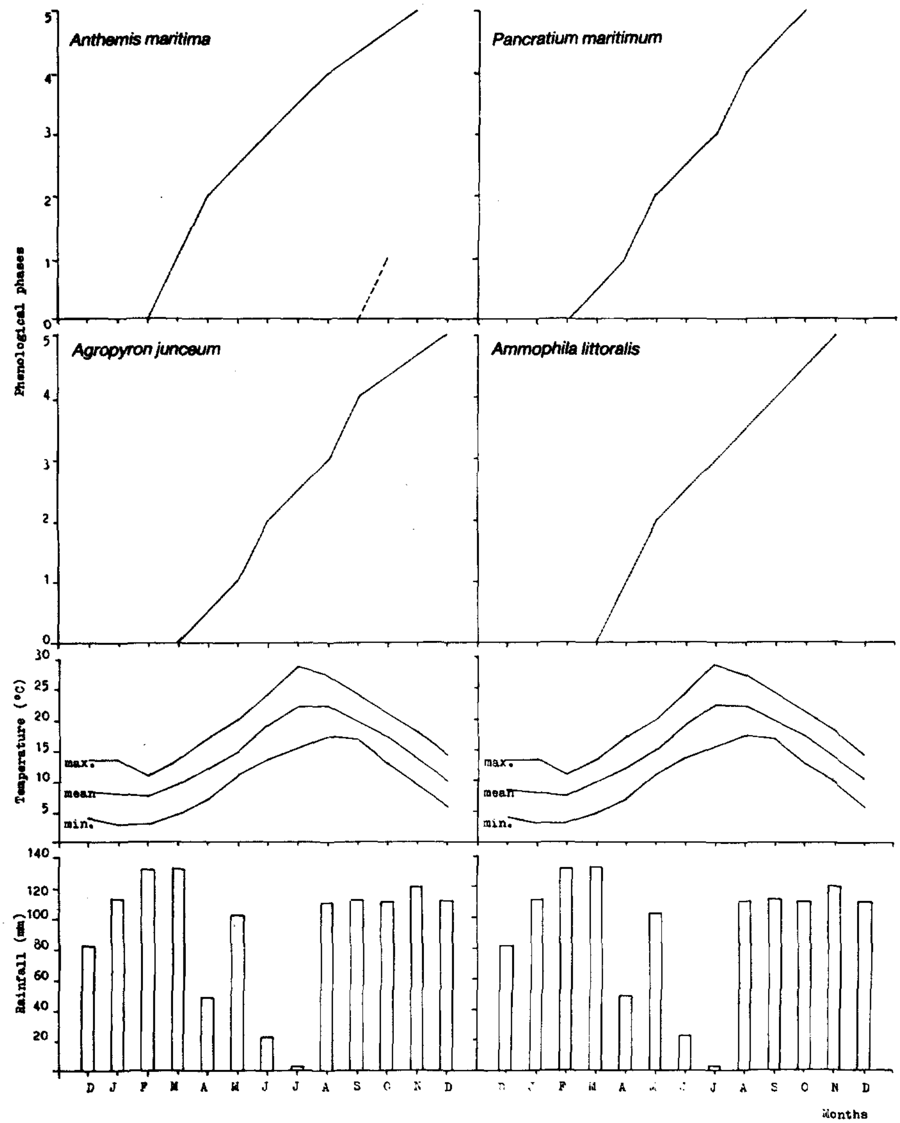
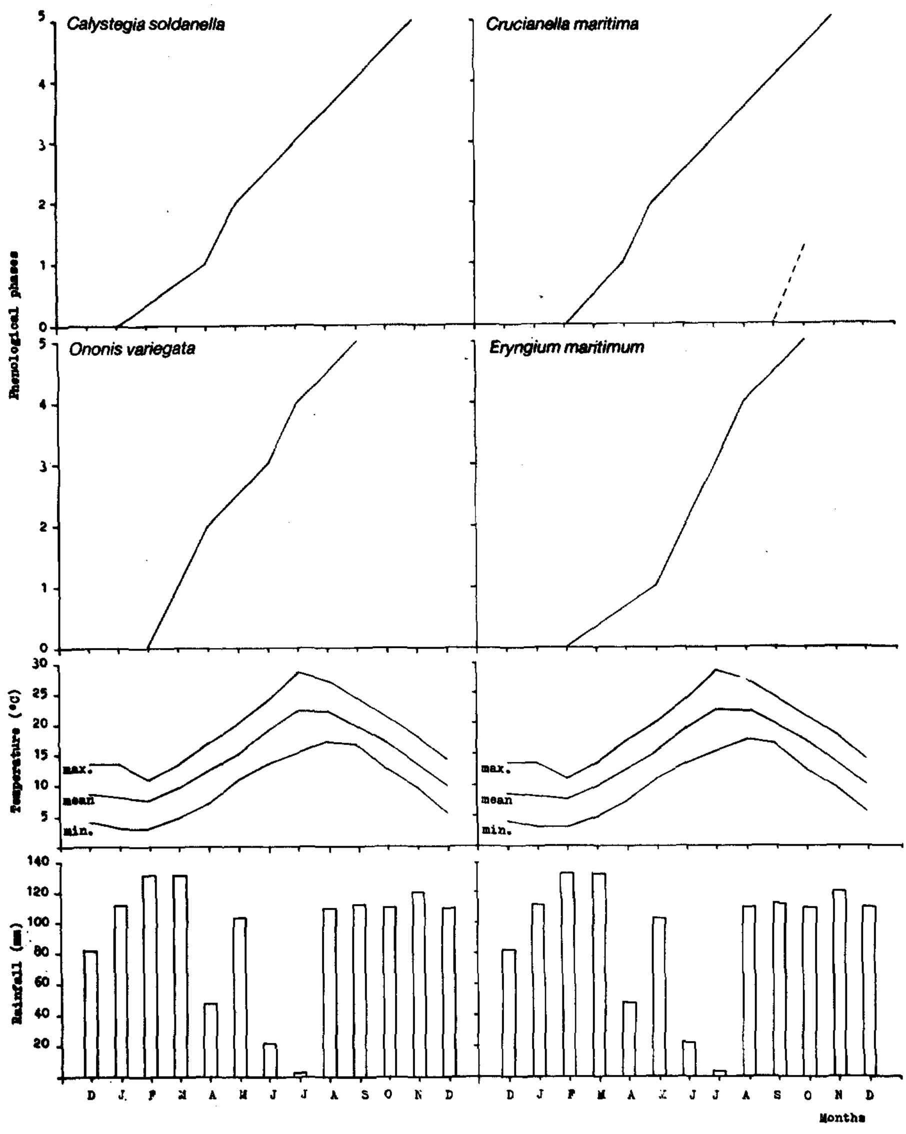


Figure 1, 2.—Phenological behaviour of the studied species related to air temperature and rainfall from December 1983 to December 1984.

flower excluded) of dry plants was taken (tab. 3). Standard errors for each equation are found. These are about the square roots of the residual mean squares. The introduction of mean monthly percentage of cover as a second parameter in the independent variable does not improve the relationships that are fairly positive (tab. 3 and fig. 3, 4).



———————— = phenological phases
- - - - - - - - - - - = vegetative renewal

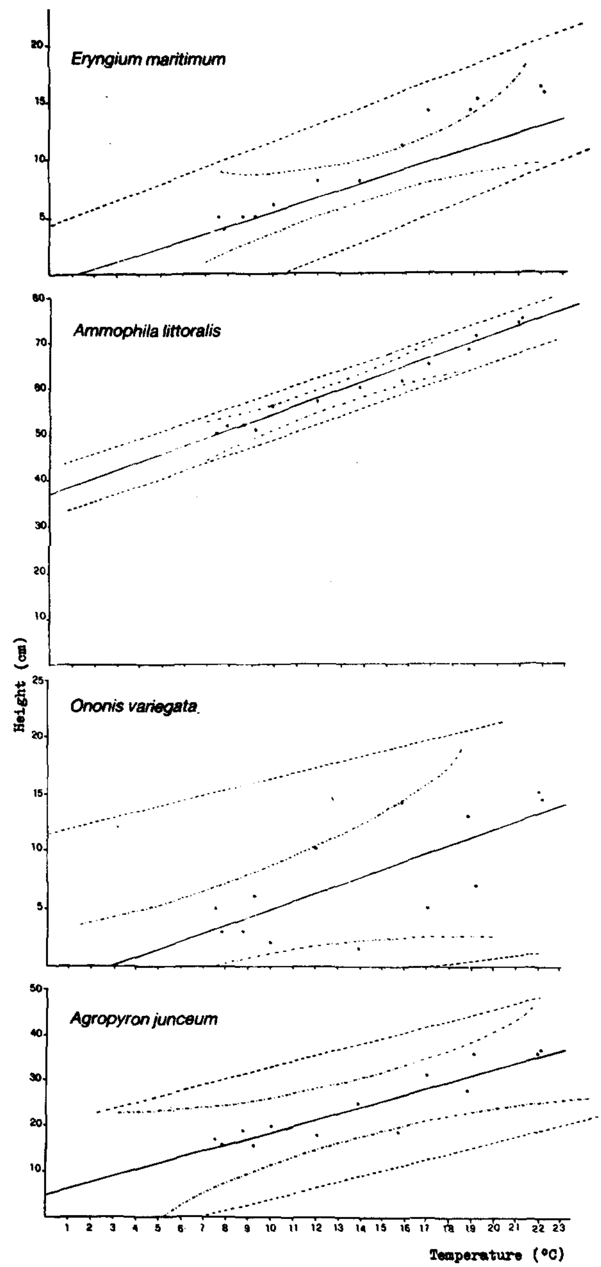
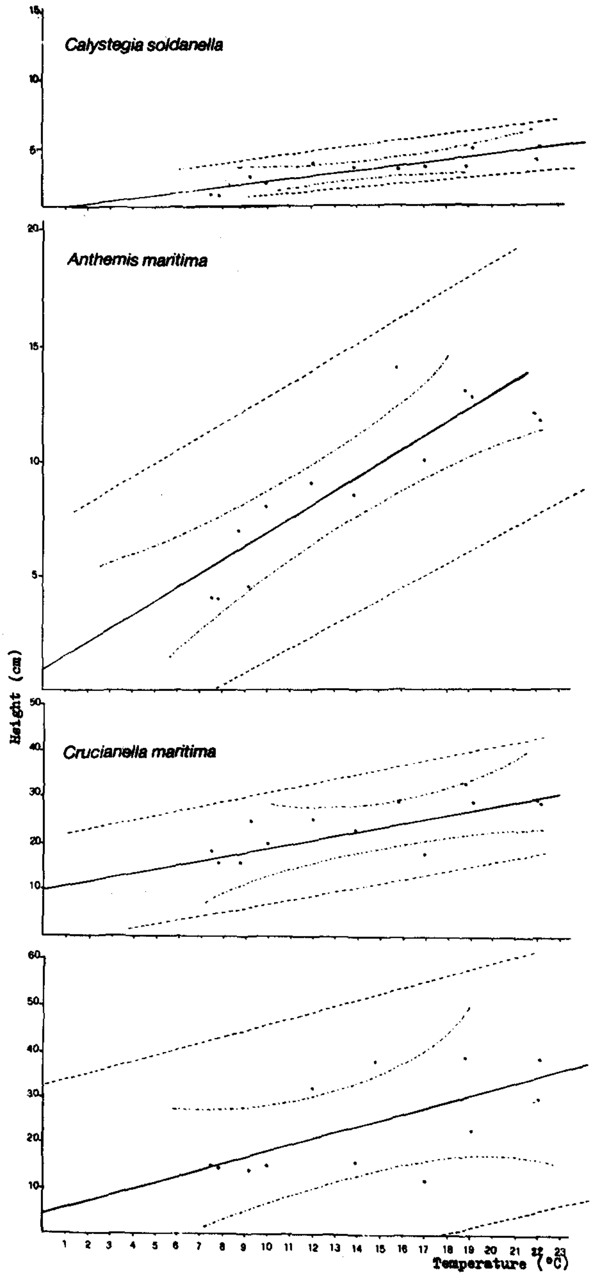


Figure 3, 4.—Correlation between height (from soil to the tip of stretched upper leaf, flower excluded, cm) and air temperature (°C). Height has been also taken from dry plants.



——————— = regression line
- - - - - - - - - - - - = P 0.05 confidence interval of the regression line
.... = P 0.05 confidence interval for individual data

TABLE 1

Mean monthly height (from soil to the tip of stretched upper leaf, flower excluded, cm) and mean monthly percentage of cover (%) for the studied species of psammophilous vegetation. Each value is the mean of 20 measurements ± standard error. * Means that height has been taken from dry plants

	D	J	F	M	A	M	J	J	A	S	O	N	D
	h(cm)±E.S.	h(cm)±E.S.	h(cm)±E.S.	h(cm)±E.S.	h(cm)±E.S.	h(cm)±E.S.	h(cm)±E.S.	h(cm)±E.S.	h(cm)±E.S.	h(cm)±E.S.	h(cm)±E.S.	h(cm)±E.S.	h(cm)±E.S.
Agropyron junceum	19±0.1*	16±0.5*	17±0.4*	16±0.5*	18±0.3	19±0.1	28±0.2	36±0.3	36.5±0.3	36±0.3	31±0.2	25.2±0.1*	20±0.2*
Ammophila littoralis	52±0.2*	52±0.2*	50±0.5*	51±0.5	57±0.1	61±0.4	68±0.5	74.5±0.7	75±0.8	71±0.5	65±0.3	60±0.3*	56±0.1*
Anthemis maritima	7±0.5*	4±0.3*	4±0.3	4.5±0.3	9±0.4	14±0.2	13±0.3	12±0.3	11.7±0.3	12.8±0.2	10±0.1	8.5±0.4	8±0.4*
Pancratium maritimum	—	15±0.7*	15±0.7	14±0.5	32±0.3	38±0.4	39±0.4	30±0.3	38.5±0.1	23±0.4	12±0.6	16±0.7*	15±0.7*
Ononis variegata	3±0.1*	3±0.1*	5±0.2	6±0.2	10±0.3	14±0.4	13±0.4	15±0.3	14.5±0.3	7±0.3	5±0.2*	2±0.3*	2±0.2*
Eryngium maritimum	5±0.2*	4±0.5*	5±0.5	5±0.5	8±0.1	11±0.4	14±0.1	16±0.2	15.5±0.2	15±0.4	14±0.1*	8±0.2*	6±0.3*
Calystegia soldanella	—	1±0.09	1±0.09	2.6±0.1	3.6±0.1	3.2±0.4	3.5±0.2	4.3±0.3	5±0.3	5±0.3	3.5±0.2	3.5±0.2*	2±0.1*
Crucianella maritima	16±0.5*	16±0.5*	18±0.3	22±0.3	25±0.2	29±0.4	33±0.3	29.5±0.4	28.5±0.4	28.5±0.4	18±0.3*	23±0.3*	20±0.2*
	c(%)±E.S.	c(%)±E.S.	c(%)±E.S.	c(%)±E.S.	c(%)±E.S.	c(%)±E.A.	c(%)±E.A.	c(%)±E.A.	c(%)±E.A.	c(%)±E.A.	c(%)±E.A.	c(%)±E.A.	c(%)±E.A.
Agropyron junceum	1.7±0.3*	1.4±0.2*	1.6±0.2*	1.8±0.3	2±0.3	2.2±0.3	2.6±0.2	2.7±0.3	2.7 ±0.2	2.6±0.2	2.3±0.3	2±0.3*	1.6±0.2*
Ammophila littoralis	0.9±0.3*	0.9±0.3*	0.9±0.3*	1±0.2	1.1±0.2	1.2±0.1	1.3±0.1	1.6±0.2	1.4±0.1	1.3±0.1	1.2±0.1	1±0.2*	1±0.2*
Anthemis maritima	0.5±0.03*	0.5±0.03*	0.6±0.05	0.8±0.1	0.5±0.1	1±0.1	1.5±0.5	3.3±0.6	2.5±0.4	2.2±0.5	1.8±0.3	1.4±0.5	1±0.1*
Pancratium maritimum	—	0.07±0.01*	0.07±0.01	0.13±0.02	0.2±0.02	0.2±0.02	0.25±0.03	0.3±0.03	0.3±0.03	0.25±0.03	0.2±0.02	0.15±0.02*	0.09±0.01*
Ononis variegata	0.01±0.003*	0.01±0.003*	0.01±0.003	0.01±0.002	0.02±0.002	1.2±0.3	1.1±0.1	1±0.1	0.7±0.2	0.6±0.2	0.4±0.08*	0.3±0.08*	0.3 ±0.08*
Eryngium maritimum	0.7±0.09*	0.7±0.09*	0.6±0.09	0.9±0.1	1.3±0.2	1.1±0.2	3.5±0.6	3.4±0.6	2.8±0.5	2.5±0.5	2.2±0.6*	1.6±0.1*	1.1±0.2*
Calystegia soldanella	—	0.004±0.001	0.007±0.002	0.02±0.009	0.037±0.01	0.6±0.1	0.05±0.01	0.09±0.02	0.12±0.05	0.11±0.05	0.1±0.05	0.09±0.02*	0.05±0.02*
Crucianella maritima	0.02±0.01*	0.02±0.01*	0.04±0.02	0.06±0.01	0.08±0.02	0.6±0.1	0.7±0.1	0.63±0.1	0.56±0.1	0.4±0.08	0.3±0.08*	0.4±0.08*	0.35±0.07*

TABLE 2

Phenological behaviour of psammophilous vegetation as a function of air temperature and rainfall from December 1983 to December 1984

Month	Temperature			Rainfall	PHENOLOGICAL OBSERVATIONS AT THE END OF THE EXAMINATION MONTH							
	min. °C	mean °C	max. °C	(mm)	*Agropyron junceum*	*Ammophila littoralis*	*Anthemis maritimum*	*Pancratium variegata*	*Ononis maritimum*	*Eryngium soldanella*	*Calystegia maritima*	*Crucianella*
D	4.4	8.7	13.8	93.0	all leaves dry	all leaves dry	all leaves dry	all leaves dry	all leaves dry	all leaves dry	all leaves dry	all leaves dry
J	3.3	7.8	13.2	112.0	all leaves dry	all leaves dry	all leaves dry	all leaves dry	all leaves dry	all leaves dry	first buds emerging	all leaves dry
F	3.4	7.5	11.5	133.4	all leaves dry	all leaves dry	first buds emerging	first buds emerging	first buds emerging	first buds emerging	first leaves green	first buds emerging
M	4.9	9.2	13.5	133.3	first buds emerging	first buds emerging	all leaves green	first leaves green	all leaves green	first leaves green	leaves almost green	leaves almost green
A	7.0	12.0	17.0	48.6	leaves almost green	all leaves green	beginning of flowering	all leaves green	beginning of flowering	leaves almost green	all leaves green	all leaves green
M	11.0	15.7	20.5	101.4	all leaves green	beginning of flowering	maximum height	beginning of flowering	flowering	all leaves green	beginning of flowering	beginning of flowering
J	13.66	18.8	24.0	11.0	beginning of flowering	maximum height	full flowering	flowering	full flowering	beginning of flowering	maximum height	maximum height
J	15.7	22.1	28.4	0.8	flowering	full flowering	flowering	full flowering	beginning of decay	full flowering	full flowering	full flowering
A	17.0	22.11	27.2	110.4	full flowering	flowering	beginning of decay	beginning of decay	leaves almost dry	first leaves yellow	flowering	first leaves yellow
S	14.1	19.1	24.1	113.8	beginning of decay	first leaves yellow	vegetative renewall	leaves almost dry	all leaves dry	leaves almost dry	first leaves yellow	vegetative renewall
O	12.7	17.1	21.4	110.4	first leaves dry	leaves almost dry	leaves almost dry	leaves almost dry	leaves almost dry	leaves almost dry	leaves almost dry	leaves almost dry
N	9.8	13.8	17.9	120.4	all leaves dry	all leaves dry	all leaves dry	all leaves dry	all leaves dry	all leaves dry	all leaves dry	all leaves dry
D	6.0	10.0	14.0	112.2								

TABLE 3

Correlation between height (from soil to the tip of stretched upper leaf, flower excluded) and air temperature and correlation between height × cover and air temperature for the studied species of psammophilous vegetation [h = height (cm); h × c = height (cm) × cover (%); t = temperature (°C)]. Height and cover have been also taken from dry plants

SPECIES	Numbers of data points	Equation of the regression line	Depend. variable	Independ. variable	Average depend. variable ± standard error	Correl. coeff.	Standard deviation of the line
Agropyron junceum	13	$y = 1.39x + 4.81$	y = h	x = t	24.4 ± 3.6	0.92	3.07
Agropyron junceum	13	$y = 5.06x - 17.06$	y = hxc	x = t	54.4 ± 9.3	0.96	7.96
Ammophila littoralis	13	$y = 1.66x + 37.54$	y = h	x = t	60.9 ± 1.5	0.99	1.30
Ammophila littoralis	13	$y = 4.29x + 10.11$	y = hxc	x = t	70.9 ± 5.6	0.98	4.76
Anthemis maritima	13	$y = 0.57x + 1.06$	y = h	x = t	9.1 ± 1.9	0.87	1.67
Anthemis maritima	13	$y = 2.15x - 16.17$	y = hxc	x = t	14.2 ± 4.6	0.95	3.65
Pancratium maritimum	12	$y = 1.29x + 5.05$	y = h	x = t	23.9 ± 8.4	0.64	7.95
Pancratium maritimum	12	$y = 0.46x - 1.41$	y = hxc	x = t	4.9 ± 2.3	0.88	1.63
Ononis variegata	13	$y = 0.69x - 2.14$	y = h	x = t	7.6 ± 3.8	0.73	3.30
Oncnis variegata	13	$y = 0.68x - 5.47$	y = hxc	x = t	4.1 ± 5.1	0.62	4.38
Eryngium maritimum	13	$y = 0.79x - 2.21$	y = h	x = t	9.7 ± 1.9	0.92	1.71
Eryngium maritimum	13	$y = 3.39x - 27.04$	y = hxc	x = t	16.7 ± 7.4	0.94	6.31
Calystegia soldanella	12	$y = 0.22x - 0.09$	y = h	x = t	3.2 ± 0.6	0.89	0.57
Calystegia soldanella	12	$y = 0.03x - 0.21$	y = hxc	x = t	0.2 ± 0.1	0.86	0.09
Crucianella maritima	13	$y = 0.89x + 10.38$	y = h	x = t	23.6 ± 3.9	0.81	3.35
Crucianella maritima	13	$y = 1.14x - 6.33$	y = hxc	x = t	8.7 ± 5.3	0.91	3.26

Discussion

The results of this investigation fully confirm that air temperature factor operates in controlling phenology (HARTMANN, 1971). Besides, the phenological behaviour of psammophilous vegetation seems to be dependent on rainfall, influencing some species with a vegetative renewal in autumn (e. g. *Anthemis maritima* and *Crucianella maritima*). Generally the studied species start growing in midwinter-spring, when the risk of low temperatures to new tissue is low (DAGET & DAVID, 1982; MITRAKOS, 1982) and finish in autumn. Only few species show a second vegetative renewal due to the first rainfalls after the summer drought. Generally they do not progress much because of the arrival of winter.

The regression analysis confirms that in the course of the year, growth of these species is well represented by height as function of temperature (MOONEY & KUMMEROW, 1978; WILLMS & *al.*, 1980).

Finally it can be concluded that seasonal changes in air temperature may operate in controlling the vegetative development of psammophilous vegetation in such environment.

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