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An Investigation on the Phenology of Some Endemic Plants Occurring in Amasya Kirkklar Mountain

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Abstract: In the present study phenological properties of six endemic taxa which occurred under a *Pinus nigra* Arn. subsp. *pallasiana* Holmboe forest at Kirkklar Mountain, Amasya were examined. Phenological life cycles of geophytic species were completed lower temperatures as compared to the other species. Vegetative growth was begun between 0.2-3.5°C and flowers and fruits were beared at 1.1 and 4.6°C, respectively in microthermic species. At the onset of vegetative growth temperature was 4.6°C in mesothermic species. The appearance of flowering and fruits were took place at 18.2-20.8°C and leaf abscission and dormancy was took place at 20.7-20.8°C in mesothermic species. Flowering is occurred in heliophilous species at the first half of May and June which daylight period was longer. However, flowering period of sciophilous species was February and March, respectively. Fruit ripening was followed similar pattern to flowering. Some significant correlations were found between the different climatic parameters and the number of fruits and flowers. Negative correlations were found between relative humidity and the number of flowers and fruits in all species and they were statistically significant. Mostly positive correlations were found between daylight hours and the number of flowers and fruits and most of them were not statistically significant.

Key words: Phenology of understory plants, *Pinus nigra* forests, endemic species, vegetative growth, flowering spectra, fruiting spectra

INTRODUCTION

Phenology is the study of periodically occurring natural phenomena and their relation to climate and changes in season, is a central focus of several aspects of ecology (Wieder *et al.*, 1984). Seasonal timing events can be critical for survival of life and reproduction. Phenology of different populations of the same species is determined by environmental parameters and allowed for genetic exchange (Rathcke and Lacey, 1985). Phenological observations also provide a background to functional rhythms of plant communities (Rawal *et al.*, 1991).

In a forest community the herb layer plays a very important role in the ecological characteristics and it also provides information on the interrelation between individual plants or plant communities and the environment (Kubicek and Brecht, 1970). Forest trees affect the climatic conditions of the regions which they stand in. Although, shade itself is not imposed by the physical environment it becomes important only in climatic regimes which are conducive to the development of dense canopies. Therefore the phenology of understory plants is conditioned by the microclimatic

factors specific to woods. A knowledge of the characteristic phenological variations of the understory plants is important for the understanding of species response to climatic conditions (Uemura, 1994a; Sierra *et al.*, 1996).

The main aim of this study is to examine the phenological cycle of 6 endemic species a *Pinus nigra* Arn. subsp. *pallasiana* forest in response to climate and growth season and to evaluate the similarities and differences among these species.

MATERIALS AND METHODS

Phenological patterns in forest understory were surveyed in four 20×20 m quadrats. Quadrats were selected according to elevation, height and percentage cover of forest and the distribution of endemic plants (at least two endemic plants should be occurred in a quadrat). Main properties of the selected quadrats were shown in Table 1. In the first quadrat all species are occurred. In the second quadrat, the number of the species are low because of the high percentage cover of the forest and this quadrat is northern-exposed. The third

quadrat is the second quadrat in respect to the number of species. The number of the species in the fourth quadrat are low due to high percentage cover of tree layer although it is southern-exposed.

The phenological state of six endemic taxa were recorded from December to August between 1997 and 1999. The beginning and the end of vegetative period, flowering and fruiting period, the number of leaves, flowers, fruits and seeds were recorded. The measurements were carried out by using a compass and a milimetrical ruler.

Vegetative and generative growth and dormancy periods were determined according to Leon and Bertiller (1982).

The climatological data were obtained from Amasya Meteorological Station (Fig. 1). Soil samples were taken using a 7 cm diameter auger to a depth of 20 cm. Soil samples were air-dried and sieved to pass through a 2 mm mesh prior to analysis. Soil texture was determined by Bouyoucous hydrometer method. pH values were measured in deionized water (1:1). Total salinity (%) was determined by conductivity bridge apparatus. Soil phosphorus (%) was determined spectrophotometrically following the extraction by ammonium acetate. Soil potassium (%) was determined by using a Petracourt

PFP-7 flame photometer after nitric acid wet digestion. Organic matter (%) and CaCO₃ (%) concentrations were determined by Walkley-Black method and Scheibler calcimeter respectively (Bayraklı, 1987). The results of soil analysis were explained according to Chapman and Pratt (1973) and Bayraklı (1987).

RESULTS

H. micrantha is the only species which was present in all quadrats. Leaf width was almost same during the phenological life cycle. However, scape and leaf length was sharply increased in February. Flowering and fruiting was initiated in February and March, respectively. During the phenological life cycle a dry period was not observed.

B. gracilis was found in the first and the third quadrats. Scape and leaf length in *B. gracilis* was increased at the second half of May. Leaf length was constant during the growth cycle like *H. micrantha*. The number of leaves were constant. However, there were fluctuations in the number of flowers and fruits. During the phenological growth cycle there were a dry period in July.

I. galatica was found in all quadrats except for the fourth quadrat. The increases in the length of scape and leaf were initiated early in *I. galatica* like *H. micrantha* and leaf width was somewhat constant during the phenological growth period. Leaves were appeared at the second half of December and the number of leaves were constant in all quadrats. Flowers and fruits were appeared at the second half of February and at the beginning of April, respectively. A dry period was not observed during the phenological growth period and soil properties were similar to the other species.

S. salviifolia was found in the first and third quadrats. Leaf length and width of *S. salviifolia* was constant during the phenological growth period. Plant length was increased from the end of March to the first half of May and reached to a steady state. Maximum leaf and flower number was observed at the first half of May. Fruits were appeared at the second half of May. There were a dry period in July.

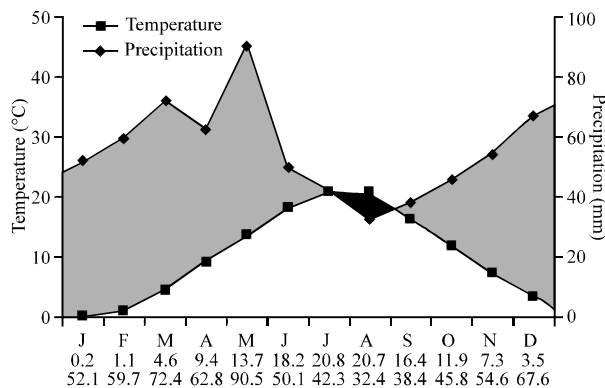


Fig. 1: Climatic diagram of Kırklar Mountain Meteorological Station During The Study Period

Table 1: The main properties of the selected quadrats and distribution of the species in the parcels

	I. Quadrat	II. Quadrat	III. Quadrat	IV. Quadrat
	450 m(1)	750 m(1)	750 m(1)	450 m(1)
	%25-30(2)	%10(2)	%25-30(2)	%25-30(2)
	%70-80(3)	%40-50(3)	%40-50(3)	%70-80(3)
Species	East (4)	Northern (4)	West (4)	Southern (4)
<i>H. micrantha</i>	+	+	+	+
<i>B. gracilis</i>	+	-	+	-
<i>I. galatica</i>	+	+	+	-
<i>S. salviifolia</i>	+	-	+	-
<i>A. limonifolium</i>	+	-	-	+
<i>D. lamarcikii</i>	+	-	-	+

(1) Height, (2) Slope, (3) Canopy openness (Closed-Open), (4) Direction

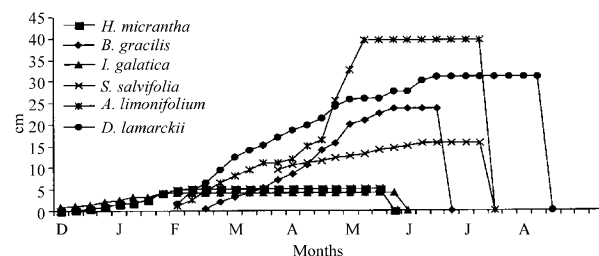


Fig. 2: Mean height of plant species

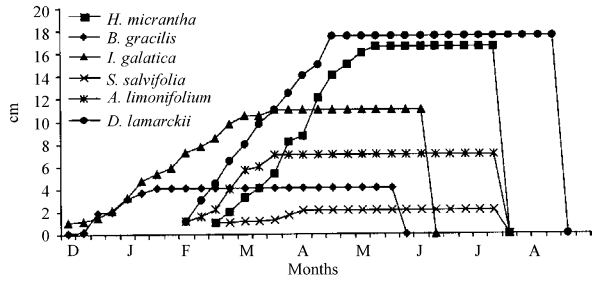


Fig. 3: Mean leaf length of species

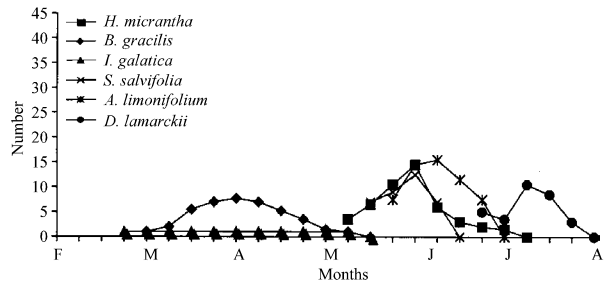


Fig. 7: Mean fruit number of species

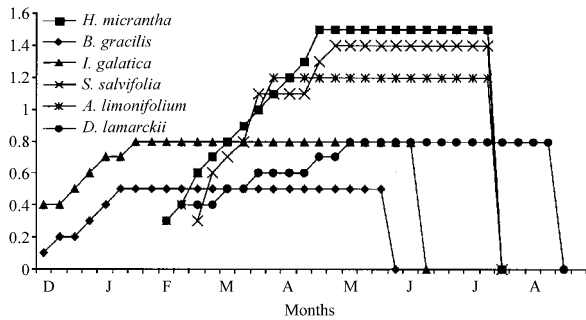


Fig. 4: Mean leaf width of species

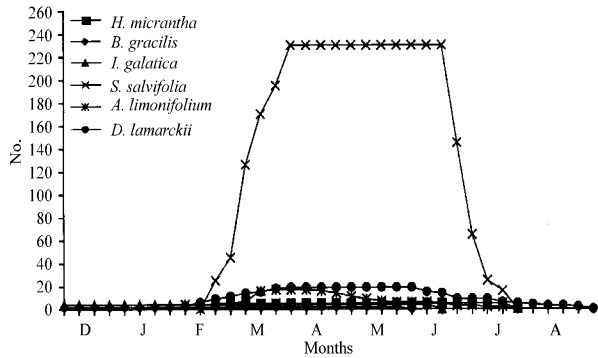


Fig. 5: Mean leaf number of species

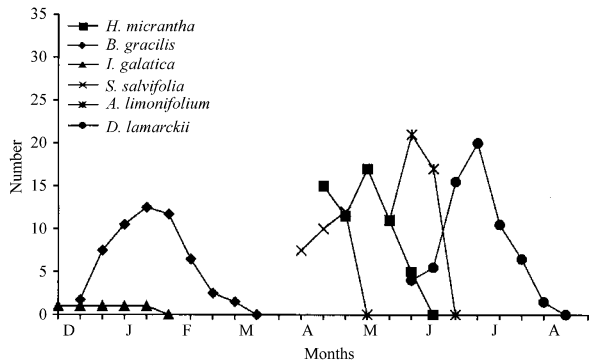


Fig. 6: Mean flower number of species

during the phenological growth period like other species. Plant height was increased at the first half of May and reached to a steady state like *S. salvifolia*. The number of leaves were increased from the beginning of February to the first half of April. After that the number of leaves were decreased and a dry period was observed in July. Maximum number of flowers and fruits were observed at the first half of June. A dry period was observed in July.

D. lamarckii was found in the first and fourth quadrats. Plant and leaf length and leaf width pattern during the phenological cycle was similar to *A. limonifolium* subsp. *pestolazae* except for the increases in leaf length which nearly constant in *A. limonifolium* subsp. *pestolazae*. The number of leaves were increased up to the abscission period at the second half of August. Flowering was initiated at the second half of May and at the first half of June fruiting was initiated. A dry period was observed in July. Scape and leaf length and leaf width and the number of leaves, flowers and fruits were shown in Fig. 2-7.

H. micrantha and *I. galatica* are microthermic species and vegetative growth was begun between 0.2-3.5°C. Flowers and fruits were beared at 1.1 and 4.6°C, respectively. Fruit maturation and retention period was begun at 9.4 and 13.7°C in *H. micrantha* and *I. galatica*, respectively. Leaf abscission and dormancy was took place at 13.7-18.2°C (Fig. 9).

Vegetative growth was begun when the daylight was 2.4 h in sciophilous species (*H. micrantha* and *I. galatica*). When the daylight was 3.7-6.5 h flowering was initiated.

The other species were mesothermic species and at the onset of vegetative growth temperature was 4.6°C. The appearance of flowering fruits were took place at 18.2-20.8°C. Leaf abscission and dormancy was took place at 20.7-20.8°C (Fig. 9). These species are also heliophilous. In heliophilous species vegetative and generative growth were occurred when the daylight was 3.7-4.3 and 6.5-10.4 h, respectively. In sciophilous species maximum of sunlighths occurred between April and May. However, in heliophilous species maximum of sunlighths occurred between June and July (Fig. 9).

A. limonifolium subsp. *pestolazae* was only found in the first and fourth quadrats. Leaf length and leaf width of *A. limonifolium* subsp. *pestolazae* was quite constant

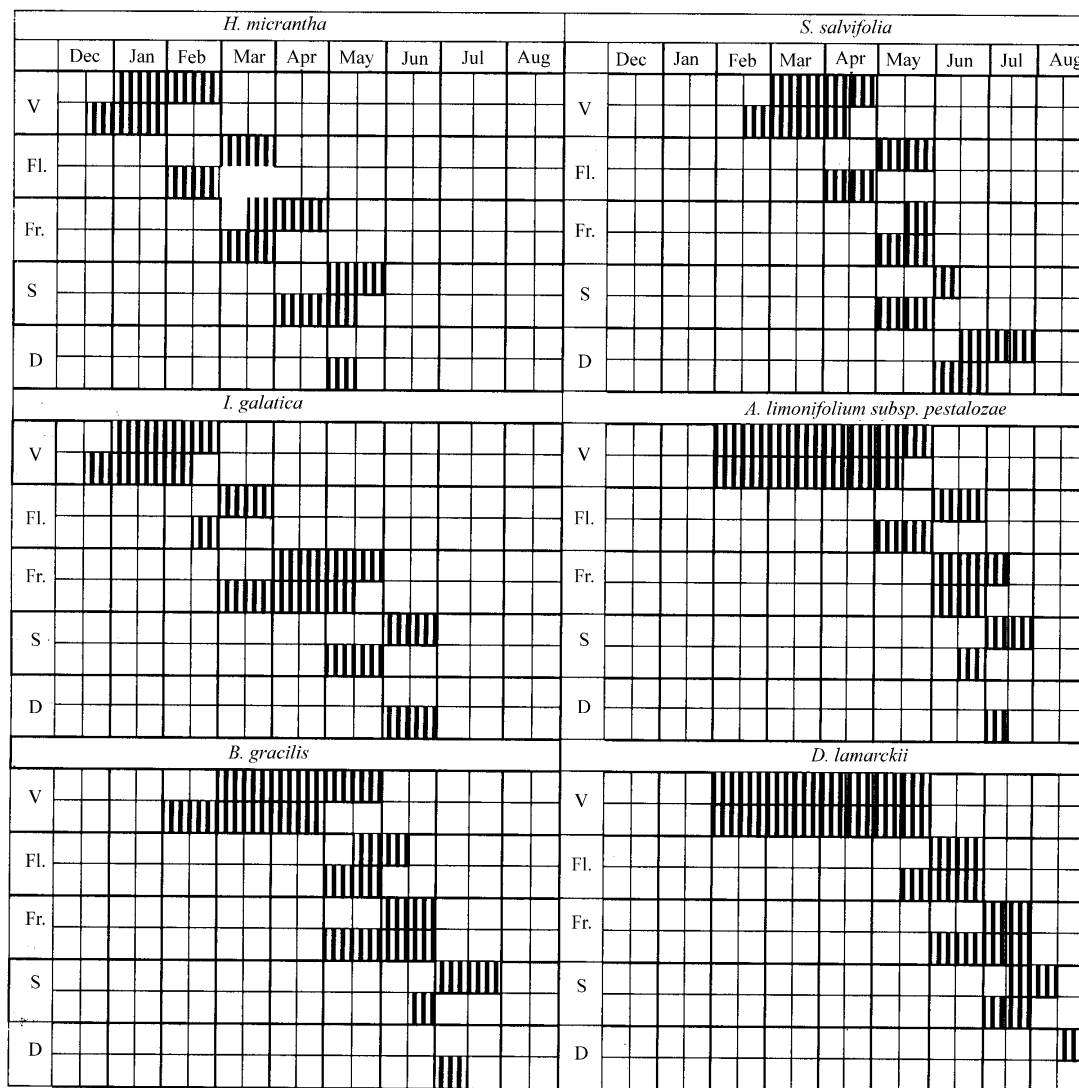


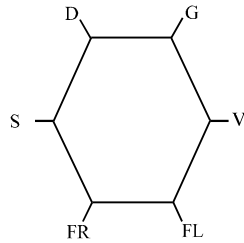
Fig. 8: Phenological spectra of the species V: Vegetative period Fl. Flowering Period Fr. Fruiting Period S: Seed Period D: Dormancy every square indicates weeks relating to the months in the table. Figs defined with vertical lines indicate phenologic growth periods of species

At the onset of early vegetative growth in *H. micrantha* was January and the development of the leaves was February, in other words intermediate vegetative growth. At the end of February early vegetative growth begins in *B. gracilis* and from the first half of March to the beginning of May was intermediate vegetative growth. Early and intermediate vegetative growth periods in *A. limonifolium subsp. pestalozae* and *D. lamarekii* was similar to *B. gracilis* except a bit early beginning of early vegetative growth. Early vegetative growth in *I. galatica* was at the first half of December. Intermediate vegetative growth period was similar to *B. gracilis*. Early and intermediate vegetative growth in *S. salvifolia* was at

the end of March and in the middle of April, respectively. In all species the length of shoots and internodes were increased during late vegetative growth period (Fig. 8).

Vegetative growth period of *B. gracilis* begins later as compared to *H. micrantha* and *I. galatica* and maximum scape height was observed at the second half of May in *B. gracilis*. Maximum scape height in *I. galatica* was observed at the second of May (Fig. 8).

For the onset of vegetative growth in *H. micrantha* and *I. galatica* relative humidity should be 70%. When the relative humidity was decreased (58.3-59.6%) flowering was occurred in February and May, respectively.



G: Seed germination, outset of leafing stage, V: Vegetative stage, FL: Flowering period Fr: Fruiting period, S: Seed maturation, D: Death (Sing and Yagava, 1974)

Species	Months								
	D	J	F	M	A	M	J	J	A
<i>H. micrantha</i>	☐	☐	☐	☐	☐	☐			
<i>I. galatica</i>	☐	☐	☐	☐	☐	☐	☐		
<i>B. gracilis</i>			☐	☐	☐	☐	☐	☐	
<i>S. salviifolia</i>			☐	☐	☐	☐	☐	☐	
<i>A. limonifolium</i>			☐	☐	☐	☐	☐	☐	
<i>D. lamarckii</i>			☐	☐	☐	☐	☐	☐	☐

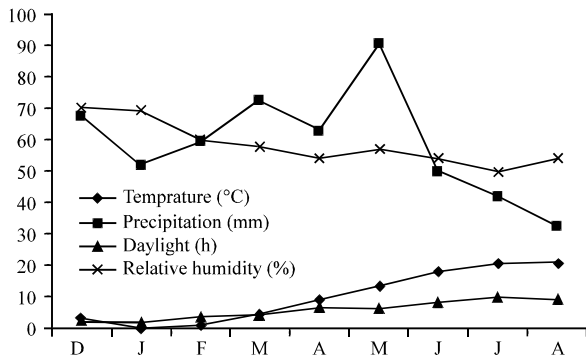


Fig. 9: Phenological spectra of the species and climatic properties

Table 2: Soil analysis results of the selected quadrats

Quadrats	1		2		3		4	
Depth (cm)	0-10	10-20	0-10	10-20	0-10	10-20	0-10	10-20
P (%)	0.007	0.002	0.001	0.0008	0.004	0.0009	0.001	0.001
K (%)	0.048	0.028	0.046	0.0272	0.080	0.0244	0.018	0.027
Organic mat. (%)	8.27	6.77	3.81	3.62	9.42	3.66	5.1	5.2
CaCO ₃ (%)	32.1	32.1	28.6	25	7.1	11.8	30.4	30.4
pH	7.9	7.95	7.96	7.83	7.88	7.87	7.8	7.87
Soil moisture (%)	77	72	71	68	85	66	74	74
Total salinity (%)	0.029	0.026	0.025	0.033	0.033	0.029	0.027	0.028

When the relative humidity was about 57.3% dormancy begins. When the relative humidity was 58.3-59.6% vegetative growth period begins in other species. Relative humidity for the onset of generative growth period was similar to the value of vegetative growth period in other

species and when the relative humidity was 57.3% generative growth begins. The outset of generative growth period is coincided with the decrease in relative humidity in other species like *H. micrantha* and *I. galatica* (Fig. 9).

In *H. micrantha* vegetative growth pattern was changed due to the height and direction of a quadrat. Vegetative growth begins at the end of December in the first quadrat. However, in the second and third quadrats vegetative growth begins three weeks later as compared to the first quadrat. The second and third quadrats were exposed to northern and western facing slopes. In the fourth quadrat vegetative growth of *H. micrantha* begins four weeks later as compared to the first quadrat. In the fourth quadrat percentage cover of tree species was quite high and as a result of this it was expected to low light availability. The differences at the onset of vegetative growth period according to quadrats were not observed in other species.

Maximum plant height was observed in February in *H. micrantha* and *B. gracilis*. However, the other species were reached to maximum height in May and June. Maximum leaf length was observed in February in *H. micrantha*. In *I. galatica*, *A. limonifolium* subsp. *pestolazzae* and *D. lamarckii* maximum leaf length was observed in April. *B. gracilis* and *S. salviifolia* were reached to maximum leaf length one month later as compared to *I. galatica*, *A. limonifolium* subsp. *pestolazzae* and *D. lamarckii*. In *I. galatica* leaf length was increased after flowering. However, in other species leaf length was somewhat constant during all of the growth period (Fig. 3).

Maximum leaf width was observed at the second half of January and at the first half of February in *H. micrantha* and *I. galatica*, respectively. In *B. gracilis* and *S. salviifolia* leaves were reached to maximum width at the second half of April. *A. limonifolium* subsp. *pestolazzae* and *D. lamarckii* was similar to *B. gracilis* and *S. salviifolia* with respect to leaf width. However, in these species maximum leaf width was observed a bit earlier as compared to *B. gracilis* and *S. salviifolia* (Fig. 4).

According to the results of soil analysis phosphorus, potassium, organic matter concentrations and soil moisture were lower at 10-20 cm depth than 0-10 cm depth. Phosphorus and potassium concentrations (%) were low. Organic matter (%) concentration was low in the second and fourth quadrats. CaCO₃ (%) concentration was rather high in the first, second and fourth quadrats. pH was slightly to medium alkaline. Soil moisture (%) was usually high. Total salinity (%) was rather low (Table 2).

DISCUSSION

H. micrantha and *I. galatica* are sciophilous species. However, *D. lamarckii*, *B. gracilis*, *S. salviifolia* and *A. limonifolium* subsp. *pestolazae* are heliophilous species. *H. micrantha*, *I. galatica* and *B. gracilis* are geophytes. *S. salviifolia* is chamaephyte. *A. limonifolium* subsp. *pestolazae* and *D. lamarckii* are hemicytrophites.

Phenological life cycles of geophytic species (*H. micrantha* and *I. galatica*) were completed lower temperatures as compared to the other species. Geophytes are the plants in which the perennating bud is borne on a subterranean storage organ and their annual growth cycle usually includes a dormant period. The reserves in geophytic plants in their storage organ support leaf growth at the beginning of the growing season and, to a varying degree, also reproduction (Mendez, 1999).

Ralhan *et al.* (1985) indicated that most species exhibit a large variation in time-separation between leaf drop and leafing and the number of leaves. The number of leaves in *H. micrantha* (two leaves), *B. gracilis* (four or five leaves) and *I. galatica* (four leaves) were somewhat constant during all of the growth period. However, in *A. limonifolium* subsp. *pestolazae*, *D. lamarckii* and especially in *S. salviifolia* it was observed that there were sharp increases in the number of leaves during the growth period.

The intensity of shade experienced near the ground surface depends upon the member of layers of foliage present and upon the light absorbing and reflecting characteristics of the canopy. Although the amount of light intercepted by a dense community of herbaceous species may be comparable with that intercepted by a forest (Monsi and Saeki, 1953) there is, of course a major difference with respect to the height of the shaded stratum. Within herbaceous vegetation, the shaded stratum is low and all or part of it is renewed annually by extension of shoots and individual leaves from position near the ground. In forests, however, the shaded stratum is high and arises by expansion of foliage *in situ*. In *D. lamarckii* increase in the number of leaves was begun at lower temperature, rainfall and daylight as compared to the other two species. In 1998 rainfall in May was higher than the mean rainfall in Amasya. So that, drying period of leaves was a bit delayed. Leaf abscission in *H. micrantha* and *A. limonifolium* subsp. *pestolazae* was begun early as compared to the other species and it was observed at the end of April to the first half of May. However leaf abscission in *B. gracilis* and *I. galatica* was observed at the second half of May. Leaf abscission in *S. salviifolia* was observed at the first half of June. It has been stated that a random or even an aggregated distribution of flowering periods may be sufficient to

Table 3: Pearson correlation coefficients between relative humidity and the other climatic parameters

<i>H. micrantha</i>	
Parameter	r
Relative humidity-temperature	-0.982 **
Relative humidity-precipitation	0.303 NS
Relative humidity-daylight hours	-0.988 **
<i>B. gracilis</i>	
Parameter	r
Relative humidity-temperature	-0.971 **
Relative humidity-precipitation	0.313 NS
Relative humidity-daylight hours	-0.994 **
<i>I. galatica</i>	
Parameter	r
Relative humidity-temperature	-0.976 **
Relative humidity-precipitation	0.050 NS
Relative humidity-daylight hours	-0.998 **
<i>S. salviifolia</i>	
Parameter	r
Relative humidity-temperature	-0.979 **
Relative humidity-precipitation	0.320 NS
Relative humidity-daylight hours	-0.997 **
<i>A. limonifolium subsp. pestolazae</i>	
Parameter	r
Relative humidity-temperature	-0.971 **
Relative humidity-precipitation	0.313 NS
Relative humidity-daylight hours	-0.994 **
<i>D. lamarckii</i> Parameter	
Parameter	r
Relative humidity-temperature	-0.968 **
Relative humidity-precipitation	0.125 NS
Relative humidity-daylight hours	-0.994 ***

p<0.05 **p<0.01 NS: Not significant

minimize competitive forces to a tolerably low level (Wieder, *et al.*, 1984). In general, the timing of spring phenological events in plants from temperate regions is dependent on the breaking of the winter dormancy which includes two periods: rest and quiescence. During the rest period, buds remain constant due to intrinsic growth-arresting physiological conditions. After plants exposed to chilling temperatures for some time, these conditions cease, and a period of quiescence starts, during which the buds do not grow due to unfavourable environmental conditions. Bud burst and leaf unfolding occur following the accumulation of a sum of forcing temperatures (Milan and Lubomir, 1998).

Climatic constraints leading to ecological convergence seemed to be sufficiently strong to prevent the expression of segregated patterns within guilds of the most frequent species (Diaz *et al.*, 1994). Flowering is occurred in *B. gracilis*, *S. salviifolia*, *A. limonifolium* subsp. *pestolazae* and *D. lamarckii* (heliophilous species) at the first half of May and June which daylight period was longer. Flowering period of sciophilous species (*H. micrantha* and *I. galatica*) was February and March, respectively. In February temperature was 1.1°C, rainfall was 59.7 mm, daylight was 3.7 h. In March these values were 4.6°C, 72.4 mm and 4.3 h, respectively. Peak flowering in *H. micrantha* and *I. galatica* were observed at the first half of March. *S. salviifolia* underwent two peaks of flowering at the first and the second half of May, respectively. Peak flowering in *B. gracilis* was observed at the first and second half of May, respectively.

Table 4: Pearson correlation coefficients between relative humidity, daylight hours, temperature and the number of flowers and fruits

Parameter	1#	2	3	4
<i>H. micrantha</i>				
Relative humidity-The number of flowers	-0.997**	-0.994**	-0.995**	-0.996**
Relative humidity-The number of fruits	-0.994**	-0.995**	-0.995**	-0.994**
Daylight hours-The number of flowers	0.807**	0.707**	0.792**	0.714**
Daylight hours-The number of fruits	-0.096NS	-0.080NS	-0.084NS	-0.096NS
Temperature-The number of flowers	0.331NS	0.329NS	0.375NS	0.235NS
Temperature-The number of fruits	-0.278NS	-0.274NS	-0.301NS	-0.305NS
<i>B. gracilis</i>				
Relative humidity-The number of flowers	-0.958**		-0.995**	
Relative humidity-The number of fruits	-0.984**		-0.991**	
Daylight hours-The number of flowers	0.131NS		0.488NS	
Daylight hours-The number of fruits	0.027NS		0.543*	
Temperature-The number of flowers	-0.311NS		0.117NS	
Temperature-The number of fruits	-0.462NS		-0.259NS	
<i>I. galatica</i>				
Relative humidity-The number of flowers	-0.999**	-0.995**	-0.993**	
Relative humidity-The number of fruits	-0.999**	-0.999**	-0.995**	
Daylight hours-The number of flowers	-0.919**	-0.925**	-0.925**	
Daylight hours-The number of fruits	-0.919**	-0.925**	-0.919**	
Temperature-The number of flowers	-0.677*	-0.625*	-0.610*	
Temperature-The number of fruits	0.610*	0.610*	0.685*	
<i>S. salvifolia</i>				
Relative humidity-The number of flowers	-0.342NS		-0.459NS	
Relative humidity-The number of fruits	-0.896**		-0.899**	
Daylight hours-The number of flowers	0.610*		0.424NS	
Daylight hours-The number of fruits	0.602*		0.376NS	
Temperature-The number of flowers	0.503*		0.294NS	
Temperature-The number of fruits	0.281NS		0.011NS	
<i>A. limonifolium</i> subsp. <i>pestalozzae</i>				
Relative humidity-The number of flowers	-0.966**			-0.955**
Relative humidity-The number of fruits	-0.989**			-0.978**
Daylight hours-The number of flowers	0.282NS			0.351NS
Daylight hours-The number of fruits	0.345NS			0.758*
Temperature-The number of flowers	-0.293NS			-0.172NS
Temperature-The number of fruits	-0.535*			0.129NS
<i>D. lamarckii</i>				
Relative humidity-The number of flowers	-0.973**			-0.990**
Relative humidity-The number of fruits	-0.996**			-0.985**
Daylight hours-The number of flowers	0.600*			0.626*
Daylight hours-The number of fruits	-0.455NS			-0.027NS
Temperature-The number of flowers	-0.312NS			-0.673*
Temperature-The number of fruits	-0.919**			-0.764*

*p<0.05 **p<0.01 NS:Not significant. # Quadrat number.

Maximum number of flowers were observed in the third quadrat which has a lower percent cover as compared to the first quadrat in *B. gracilis* and *S. salvifolia*. Maximum flowering was observed at the first and second half of May in *A. limonifolium* subsp. *pestalozzae* and *D. lamarckii*, respectively. Flowering was usually coincided with the increase in air temperatures in all species.

Fruit ripening was followed similar pattern to flowering. In other words, fruit ripening in sciophilous species was earlier as compared to heliophilous species. Maximum fruit number was observed in June in heliophilous species (Fig. 7). Sierra *et al.* (1996) stated rainfall was one of the most important factors for the onset and peaking of flowering and seed dispersal and the flowering ended to coincide with a drop in the relative humidity. In the present study, there were some differences between species in respect to the required precipitation for the seed dispersal. For instance in *H. micrantha* and *I. galatica* for the onset of flowering

high precipitation (72.4 mm) was required. The dispersal of seeds in *H. micrantha* was occurred when the precipitation was 90.5 mm. However, for seed dispersal in *I. galatica* high precipitation was not required and the dispersal of seeds was initiated when the precipitation was 50.1 mm. For the dispersal of seeds in the other species precipitation should be 90.5 mm. In all species the fall in temperatures coincided with the end of the reproductive cycles. Fruiting and flowering time periods were strongly coupled. These two phenomena may be mutually constrained: just as flowering is partially influenced by temperature. Precipitation seems to be one of the most important factors in the development of the phenological cycles than previously thought (Sierra *et al.*, 1996).

Soil properties in all quadrats were remained more or less same and this suggests that these properties do not have a direct bearing on the temporal differentiation of phenophases in the species (Table 2). Low soil phosphorus could be due to high organic matter

concentration especially in the first and third quadrats or alkaline pH values. Most of the soil phosphorus are bound to the organic matter. In addition to this, alkaline pH could be restricted phosphorus availability (Chapmann and Pratt, 1973). The lack of potassium affects the water economy of a plant (Marschner, 1995). Especially in the leaves of *S. salviifolia* individuals severe chlorosis and necrosis was observed and this could be due to potassium deficiency (Marschner, 1995).

It has been stated that annual cycles in the appearance of vegetation are obviously closely associated with annual changes in the weather and plant phenological cycles depend on air temperature (Sierra *et al.*, 1996). According to the results of the present study phenological cycles of endemic plants under a *P. nigra* subsp. *pallasiana* forest were greatly affected by air temperature and precipitation. Agrawal (1990) and Uemura (1994b) stated that the distribution of forest and grassland plants were primarily affected by temperature.

Some significant correlations were found between the different climatic parameters and the number of fruits and flowers (Table 3). Similar correlations were obtained by Sierra *et al.* (1996). Relative humidity was negatively correlated with temperature and daylight hours, however positively correlated with precipitation as expected. The correlations between relative humidity and temperature and daylight hours were statistically significant. However, the correlation between relative humidity and precipitation was not significant. Negative correlations were found between relative humidity and the number of flowers and fruits in all species and they were statistically significant. Mostly positive correlations were found between daylight hours and the number of flowers and fruits and most of them were not statistically significant. Similar results were obtained between temperature and the number of flowers and fruits (Table 4).

Species showing the same growth form had similar floral syndromes and fruiting and flowering temporal patterns. Evidently, understory species under a *P. nigra* subsp. *pallasiana* forest often show similar response to the climatic rhythm although some differences may be occurred.

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