The effect of management treatments on pheno-morphological traits of *Phillyrea latifolia* L.

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Abstract

Vegetative growth, blooming and fruiting of Phillyrea latifolia L. were monitored through 5 years under different management regimes in a Mediterranean garrigue in Israel. Vegetative growth and blooming occurred constantly and massively each spring, with slight inter-annual temporal fluctuations, probably controlled by water availability. Frequency, rate and intensity of vegetative growth were also constant and massive. Reproductive performance was very irregular and variable, both at population and individual levels. Management treatments had no effect on the timing of the phenological events, but caused massive growth of elongated shoots accompanied by decrease of leaf sclerophylly. Management intervention enhanced blooming and fruit production. The adaptive significance of the phenological pattern and the short-term modifications by management is discussed.

Aims of Study

The evergreen sclerophyllous shrub Phillyrea latifolia L. was chosen as a model plant for the study of the effects of management interventions on the phenological pattern. In this study, we asses the basic phenological pattern of east-Mediterranean populations of P. latifolia and its natural fluctuations. Distinction is made between long-term adaptation to the current environment, due to phylogenetic heritage, and the short-term reactions, expressed by phenotypic plasticity. Management treatments like shrub-removal and grazing, serve as factors that induce short term reactions, which may modify the basic phenological pattern. These modifications are interpreted by the parameters of timing, frequency, rate and intensity of the phenological events and are examined in terms of resource allocation and trade-off mechanisms.

Study area

Location - Ramat Hanadiv Park, at the southern edge the Carmel ridge, Israel.

Site 1: 14582183 Israel grid, altitude 120 m., on a slight slope facing south-east. This area serves as a "fire break", aimed to diminish spread the spread of fire into the park from adjacent settlements (Perevolotsky et al., 2003).

Site 2: 14462174 Israel grid, at 100 m. altitude, on a moderate slope facing the north.

Rainfall Average annual precipitation: 650 mm. See fig. 1 for seasonal cumulative rainfall 1994-1997.

Substrate Cenomanic hard limestone and dolomite rocks, covered partly with brown-reddish terra-rossa soil.

Natural Vegetation

Site 1: recovered from a fire in 1980. transition state between shrubland and a degraded maquis, defined as "sparse" ***Phillyrea latifolia*** vegetation unit (Cohen, 1987). This plant community is dominated by ***P. latifolia,*** accompanied by ***Pistacia lentiscus, Calycotome villosa, Rhamnus lycioides, Sarcopoterium spinosum, Rubia tenuifolia, Asparagus aphyllus*** and ***Smilax aspera.***

Site 2: No documentation exists about fires in the last 50 years. The vegetation is a transition formation between open and dense maquis, defined as "typical" P. latifolia unit (Cohen, 1987). Plant species composition is similar to site 1, except for the more prominent domination of P. Latifolia.

Management treatments

Site 1

1. **Control** - no intervention
2. **Shrub-removal** - removal of the shrubs and sub-shrubs prior to the study.
3. **Grazing** - herd of beef cattle (150-200 heads) was introduced to the fire break producing very high grazing pressure for a short duration (7-10 days), at the beginning of April.
4. **Shrub-removal + grazing** - combination of 2 and 3.

Site 2

Natural - no intervention, no fire and cutting in the last 50 years.

Aerial Photograph of the study area (site 1)

Observations and measurements

Phenology. 40 shrubs per plot (200 total) were visited and recorded weekly (February- April), Monthly (May-September) and twice a month (October- January). **Vegetative growth, Blooming and Ripe fruits yield** were recorded for **presence, frequency, intensity** and **timing.** Observations of vegetative growth were completed by recording the presence of **elongated shoots.**

Sclerophylly. Leaves were sampled randomly (40 per treatment). The ratio **dry weight/leaf area** served as sclerophylly index.

Sex type. Individual plants of the investigated population were identified as **hermaphrodites** or **"males"** during the blooming period in the field. This was completed in the laboratory by microscopic observations of preserved flowers.

Flowers of *P. latifolia*

Phillyrea latifolia L.
Natural History in brief

- Evergreen sclerophyllous shrub
- Widely distributed through the Mediterranean biogeographic region (Feinbrun-Dothan, 1978; Browitz, 1984; Zohary, 1973). Dominant in some Mediterranean shrub communities in Israel.
- Blooming and new vegetative growth occur in spring. The small yellowish flowers contain 2 sepals, 4 petals 2 stamens and a gynoecium consisting of an ovary with 2 ovules, style and 2 lobed stigmas. Wind pollinated.
- Androdioecious species by which the hermaphroditic individuals have flowers with big stigmas, whereas the "males" bear flowers with ovaries, style and degenerated stigmas or lack female parts at all (Herrera, 1994; Aronne and Wilcock, 1994; Pollak and Schwartz-Tsachor, 2003).
- Ripe fleshy bluish-black fruits are found in September-January.

General phenological pattern at the population level (fig. 2)

- Spring is the main activity season of vegetative growth and blooming. This timing reflects a long term adaptation to the Mediterranean climate regime.
- Blooming peaking in March precedes vegetative growth which reaches its' peak in April
- Ripe fruits are found between the end of September and January.
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- Inter-annual fluctuations of 3-4 weeks occur in the timing of vegetative growth and blooming. The inter-annual fluctuations can be explained by the changing availability of water: when rains occur in early winter, spring vegetative growth and blooming occur earlier and reflect short-term phenotypic plasticity.
- A second vegetative growth period, sporadic and much less intensive, may occur sometimes in November and December. High cumulative rainfall until December induces the sporadic winter vegetative growth.

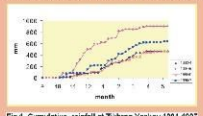

Fig.1. Cumulative rainfall at Zikhron Yaakov, 1994-1997

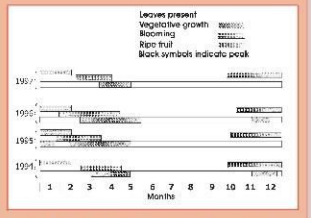

Figure 2. The timing of vegetative growth, blooming and ripe fruits in *Phillyrea latifolia*.

Frequency and intensity of blooming and ripe fruits at the population and the individual levels (Tables 1 and 2)

- The average **rate of blooming** for all management plots throughout all the study years was **58 %.**
- Many individuals **avoided blooming** in certain years and about 20% of the shrubs had never bloomed during the study period.
- Blooming frequency, rate and intensity were significantly **higher in the "male" shrubs**, compared with hermaphroditic potential fruit producers. This can be explained in terms of trade-off, by lower demand for internal resources investment in males.
- The average percentage of shrubs bearing ripe fruits was very low (20.2% on average). **The majority of the hermaphroditic shrubs avoided ripe fruits** at all through the study period.
- Fruiting frequency and average fruiting intensity in the individual hermaphrodite shrubs throughout the observation years, was very low.
- The ovaries of *P. latifolia* are attacked by *Probruggmannielia phillyreae* (Cecidomyiidae), and galls are formed instead of normal fruits (Pollak and Schwartz-Tsachor, 2003). We assume, that **low and irregular reproductive performance can be explained,** at least partially, **as a selection against insect damage.**

Table 1. Rates of blooming and fruiting at the population level during the study period (1994-1997)

Year	Blooming (%)	Fruiting (%)
1994	43.0 b	19.8 ab
1995	59.5 b	9.5 b
1996	81.5 a	31.5 ab
1997	47.2 b	20.0 a
Average	57.8	20.2

Percentages refer to the total studied population, in all management treatments (N= 200). Identical letters indicate non-significant differences.

Table 2. Frequency and intensity of blooming and fruiting in hermaphroditic and "male" plants (average of categories)

Sex type	Blooming frequency	Blooming intensity	Fruiting frequency	Fruiting intensity
Hermaphroditic	3.15 B	1.29 b	1.84	0.60
"Male"	3.77 a	1.83 a	0	0

Figures are averages of 5 years of observations and refer to those individuals which bloomed at least once during the study period and whose sex type was certainly determined. Frequency scale: 0-5 intensity scale: 0-3 Different letters in each column indicate significant difference.

The effect of management treatments

1. Growth of elongated shoots

Management treatments stimulated the growth of elongated shoots. Elongated shoots were especially frequent in the grazing + shrub removal treatment. Strong response was found also in grazing and shrub-removal treatments. The percentage of shrubs with elongated hoots in the natural and control plots was very low (Table 3). **This reaction expresses short-term phenotypic plasticity, which can be interpreted as a compensation growth under strong grazing Pressure, which is facilitated by shrub removal.**

Table 3. The Effect of management treatments on the growth of elongated shoots

Natural	Control	Shrub removal	Grazing	Shrub removal+Grazing	All
7.5 cd	5.6 d	31.3 b	25.6 bc	73.8 a	28.9

Figures indicate the average percentage of plants which developed elongated shoots in 1996, 1997. Different letters indicate significant difference.

Elongated shoots

2. Sclerophylly

Less scleromorphic leaf structure was found in the shrub removal + grazing treatment. Tendency toward less scleromorphic leaf was also observed in grazing treatment, but was not significant (Table 4). This can be interpreted as **trade-off of resource allocation** between massive shoot elongation and deposition of wall material in leaf cells which contributes to high sclerophylly index.

Table 4. The effect of management treatments on leaf dry weight, leaf area and the ratio dry weight/leaf area

Treatment	Dry weight (gr.)	Area (cm²)	Dry weight/area
Natural (n=39)	0.036±0.021 a	1.680±0.086 a	0.0212±0.008 a
Control (n=40)	0.030±0.012 a	1.522±0.535 ab	0.0194±0.003 a
Shrub-removal (n=39)	0.031±0.017 a	1.477±0.610 ab	0.0203±0.004 a
Grazing (n=39)	0.029±0.008 ab	1.524±0.392 ab	0.0189±0.003 ab
Shrub-removal + Grazing (n=40)	0.023±0.011 b	1.261±0.410 b	0.0173±0.004 b

Leaf area refers only to one side. Different letters in each column indicate significant difference

3. Blooming and fruit yield

High disturbance management treatments (shrub-removal and shrub-removal + grazing) induce higher frequency, rate and intensity of blooming and fruit production, compared with non-disturbance treatments (natural and control). The figures for the grazing treatment were especially low (Table 5). Shrub-removal (and the combination with grazing) may cause better light penetration, thus enabling more blooming. From long-term adaptation point of view, enhanced reproductive performance under disturbance can be explained as selection for potential ability to colonize new gaps by more-dispersed fruits.

We have difficulty suggesting an explanation as to why grazing alone differs from the other management treatments.

Table 5. The effect of management treatments on frequency, rate and intensity of blooming and fruiting, during the study period (1994-1998)

Management Treatment	Blooming			Fruiting		
	Frequency	Rate	Intensity	Frequency	Rate	Intensity
Natural	2.68 b	51.3 bc	1.33 b	0.80 bc	16.3 b	0.26 ab
Control	2.43 bc	51.9 bc	0.91 c	0.70 c	18.1 ab	0.26 ab
Shrub removal	3.53 a	75.0 a	1.61 a	1.28 a	33.8 a	0.40 a
Grazing Shrub	2.00 c	39.6 c	0.88 c	0.40 c	8.9 b	0.13 b
Removal grazing	3.50 a	71.3 ab	1.56 ab	1.13 ab	24.1 ab	0.36 a

Frequency: No. of blooming/fruiting events per individual during 1994-1998. Scale: 0-5 Rate: % of blooming/fruiting plants for each population averages for 1994-1997 Intensity: Estimated flowers/fruit amount per individual on scale 0-3. Averages for 1994-1998. Different letters in each column indicate significant difference.

Conclusions

The basic phenological timing pattern of *P. latifolia* represents a long-term adaptation to Mediterranean climate, mainly to the rainfall regime. The slight inter-annual fluctuations in timing reflect phenotypic response to the current availability of water. The irregularity, low performance and partial avoidance of blooming and fruit production, suggest long-term adaptation to other selective forces, probably constraints of floral biology, dispersal biology and insect attacks. Deliberate management treatments modify certain pheno-morphological components in a manner that may contribute to the success in the dynamic processes in the community. This short-term effects at the population and individual levels of one species should be considered when management treatments are applied.