A phenological study of flowering period and flower colours of aromatic plants in Greece*

Dimitrios Voliotis
Institute of Systematic Botany & Phytogeography, Aristotle University of Thessaloniki, Thessaloniki, Greece

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Abstract

The flowering period and flower colour spectrum of 170 aromatic plant species are studied in 18 representative regions in Greece. The duration of the early to late flowering of the species is recorded for each region and for Greece as a whole. The basic flower colours (green, yellow, red and violet) are defined and the colour spectra for each region and for the whole country are given by converting absolute to relative values. The Sørensen similarity coefficient is applied to compare regions and the relationship among them as well as with a control region (Athos peninsula). Conclusions are drawn as to the time of maximum flowering and the decrease in the proportion of flowering species from north to south. In addition, interpretations are given for the symmetrical flowering curve of Greece as a whole, compared to the skewed curves of the islands.

Introduction

The intention of this study is to compare representative regions in Greece as to the flowering period and the flower colour spectrum of their aromatic plants. As such this study is an extension of an innovating paper by Diamantopoulos & Margaris (1981).

We included 170 aromatic plant species in our study (see Appendix). They belong to 100 genera, 39 families and to all life forms. 11% are annuals and biennials, 33% wooden and 56% perennial herbaceous plants; 26% are Ph, 15% Ch, 36% H, 15% G and 8% Th. Thus they present a representative picture of the floras of the 18 regions.

Materials and methods

The regions under study are 10 mountainous areas, 5 islands and 3 peninsulas, namely: Falakron, Lailias, Cholomon, Voras, Vermion, Olympos, Ossa, Parnassos, Parnis, Taygetos, Athos, Sithonia, Pilion, Samothraki, Skiathos, Santorini, Kythira and Leukas. Since it is well known that the flowering period depends partly upon latitude and partly upon height above sea level, we chose our areas as follows: the studied mountain regions are located from N to S along the central axis of the mountainous mainland of Greece, i.e. from Mts. Voras, Lailias, Falakron to Taygetos, whilst the lower maritime and island regions cover the entire mainland of Greece. An additional motive for this selection is the almost complete knowledge of their flora. Both own research and data from the literature are taken into account: Ade & Rechinger (1938), Bornmüller (1928), Diapoulis (1958), Economidou (1969), Ganiatsas (1939, 1955, 1963), Greuter & Rechinger (1967), von Halácsy (1900–1904), Hansen (1971), Hayek (1928), Heldreich (1890), Hofmann (1968), Katsikopoulos (1936), Kitanov (1942), Mavrommatis (1971), Pavlidis (1976), Quézel & Contandriopoulos (1968), Raus (1977), Rechinger (1939, 1943), Sarlis (1973),

* Nomenclature follows T. G. Tutin *et al.* (eds.) 1964–1980. Flora Europaea 1–5, Cambridge.

Vegetatio 56, 129–137 (1984).

Table 1. Monthly % values of early (upper) and (lower) late flowering species in 18 greek regions and absolute and % values of the total for all areas.

Months	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII
Falakron	–	–	2	8	27	48	50	45	23	6	2	–
	2	3	12	33	67	76	61	35	12	3	–	–
Lailias	–	–	6	11	34	57	60	51	26	9	–	–
	3	3	14	40	66	71	66	40	9	–	–	–
Cholomon	–	–	2	6	28	57	58	48	26	9	2	–
		2	14	40	68	75	58	34	8	3	–	–
Voras	–	–	2.5	6	32.5	54	54	44	21	6	–	–
	1	4	12.5	31	66	77.5	56	29	7.5	1	–	–
Vermion	–	–	2	9	37.5	52	56	44	20	6	–	–
	–	5	17	42	67	77	52	23	5	2	–	–
Olympos	–	–	1	8	29	50	50	42	23	9	2	–
	–	2	13	36	64	74	54	33	11	4	–	–
Ossa	–	–	1	9	33	55	54	45	19	6	–	–
	–	1	16	42	72	73	46	27	4	1	–	–
Parnassos	–	–	2	2	19	51	51	45	25	11	2	–
	–	2	13	36	64	70	60	32	8	2	–	–
Parnis	–	–	2	6	23	40	42	35	22	5	2	–
	2	3	22	46	71	69	51	28	11	9	3	3
Taygetos	–	–	1	3	19	40	39	32	19	8	2	–
	–	2	15	34	64	72	62	37	11	5	1	–
Athos	–	–	1	8	27	44	42	34	18	8	2	–
	1	4	16	38	65	70	56	33	12	5	1	1
Sithonia	–	–	1	9	24	45	46	39	25	9	1	–
	–	3	24	45	67	70	54	38	17	7	1	–
Pilion	–	–	–	6	28	46	45	38	23	9	2	–
	–	3	20	43	65	71	57	31	6	5	–	–
Samothraki	–	–	–	11	30	51	51	40	21	8.5	–	–
	–	4	26	45	66	70	51	34	11	4	–	–
Skiathos	–	–	–	8	21	37.5	29	21	15	6	2	–
	2	4	23	52	67	60	50	31	17	6	–	–
Santorini	–	–	–	–	15	35	31	27	19	8	4	–
	4	8	27	46	81	77	65	31	15	8	4	4
Kythira	–	–	–	2	21	36	29	26	19	5	5	–
	2	5	21	50	67	64	52	33	17	10	2	5
Leukas	–	–	–	7	20	44	41	30.5	17	3	2	–
	3	5	24	41	69.5	64	53	32	15	8	5	5
Months	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII
Late flowering in absolute values			2	14	43	63	61	48	26	11	3	
Early flowering in absolute values	3	7	28	58	99	115	98	61	22	8	3	3
Late flowering %			1	8	25	37	36	28	15	6	2	
Early flowering %	2	4	16	34	58	68	58	36	13	5	2	2

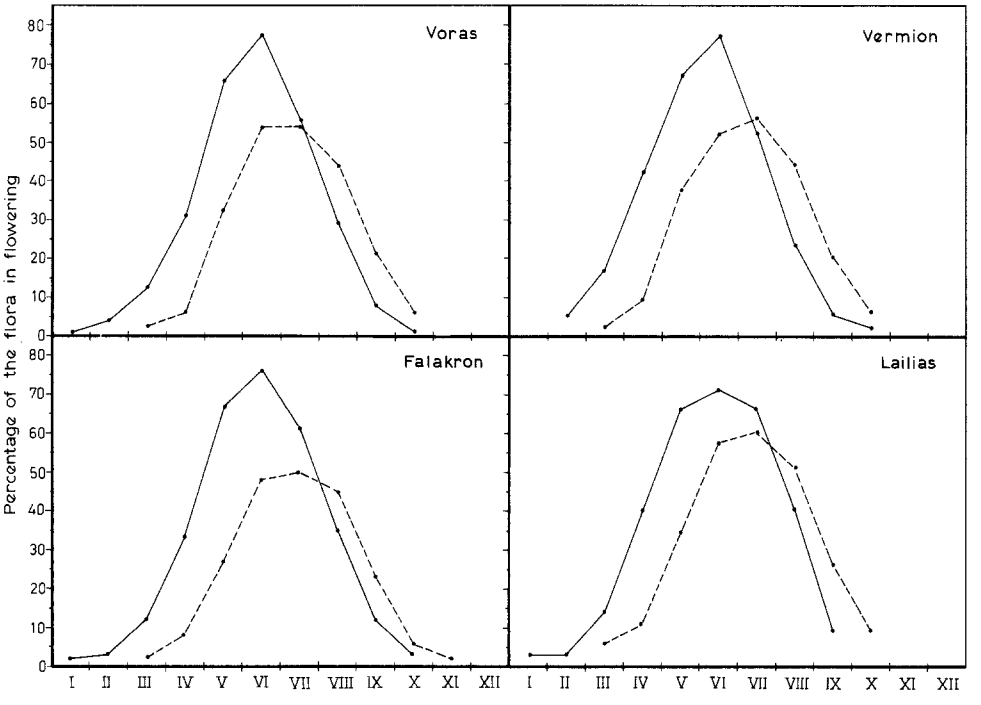
Voras
Vermion
Falakron
Lailias
Percentage of the flora in flowering
0
10
20
30
40
50
60
70
80
I II III IV V VI VII VIII IX X XI XII

Fig. 1a.

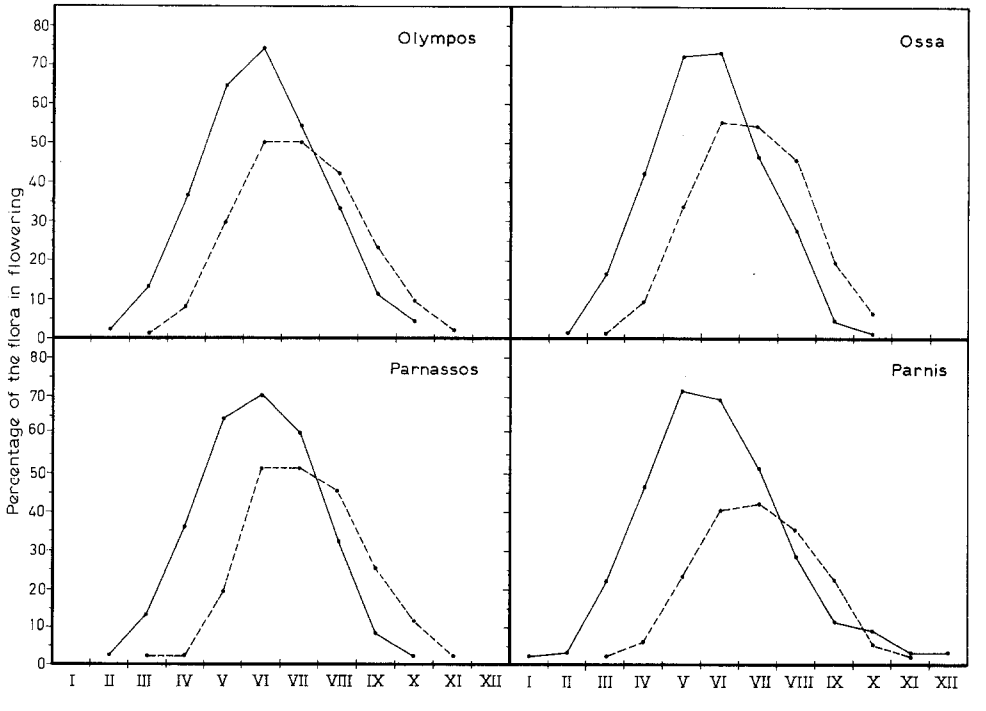
Olympos
Ossa
Parnassos
Parnis
Percentage of the flora in flowering
0
10
20
30
40
50
60
70
80
I II III IV V VI VII VIII IX X XI XII

Fig. 1b.

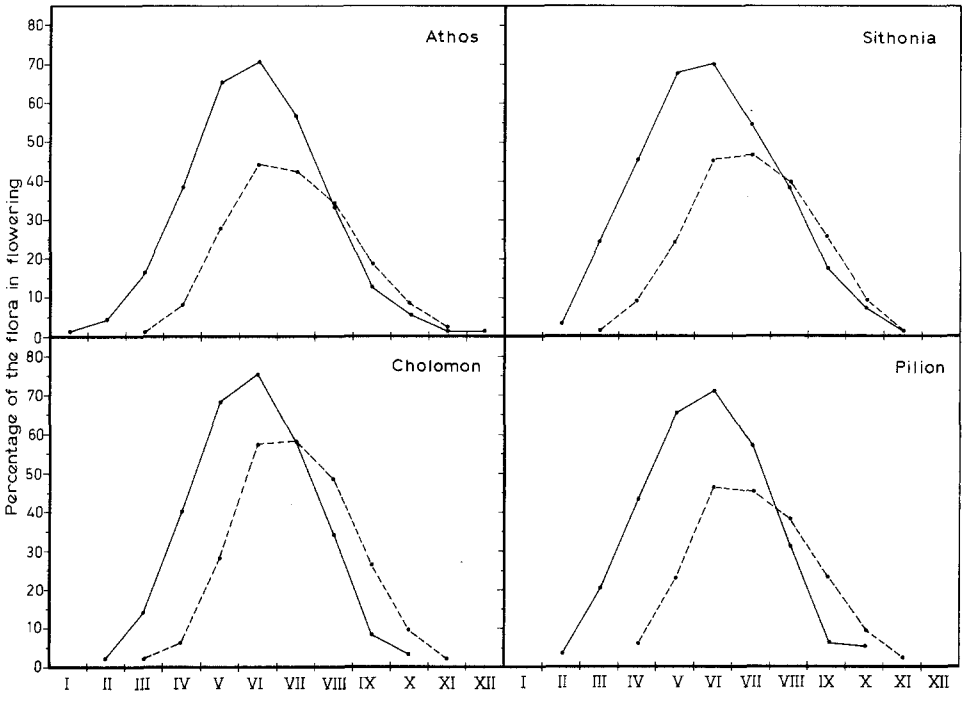
Athos
Sithonia
Cholomon
Pilion
Percentage of the flora in flowering
0
10
20
30
40
50
60
70
80
I II III IV V VI VII VIII IX X XI XII

Fig. 1c.

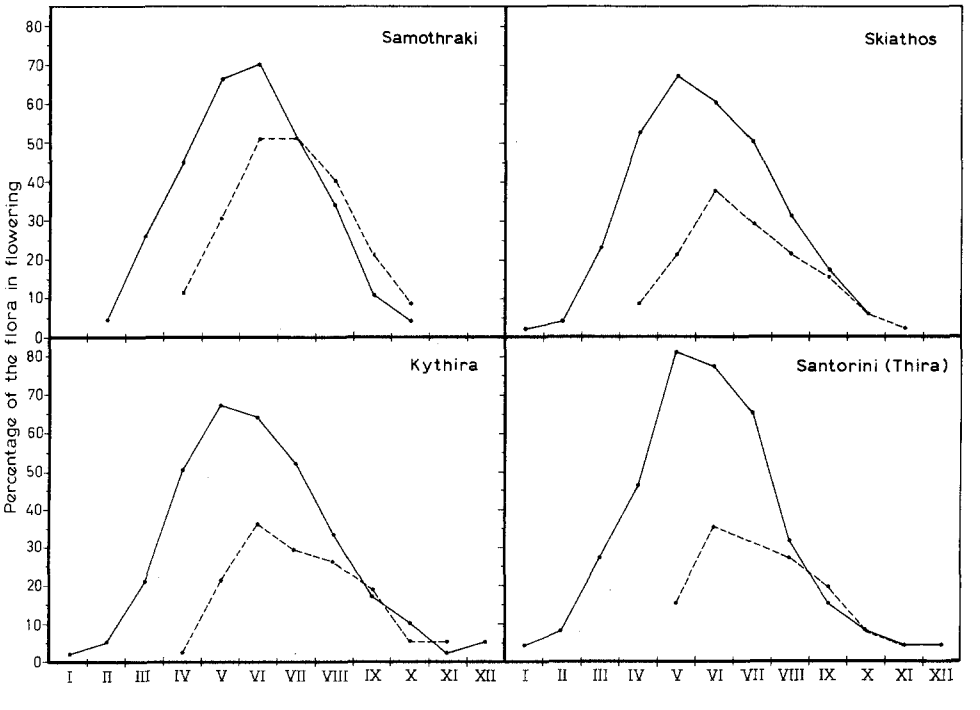
Samothraki
Skiathos
Kythira
Santorini (Thira)
Percentage of the flora in flowering
0
10
20
30
40
50
60
70
80
I II III IV V VI VII VIII IX X XI XII

Fig. 1d.

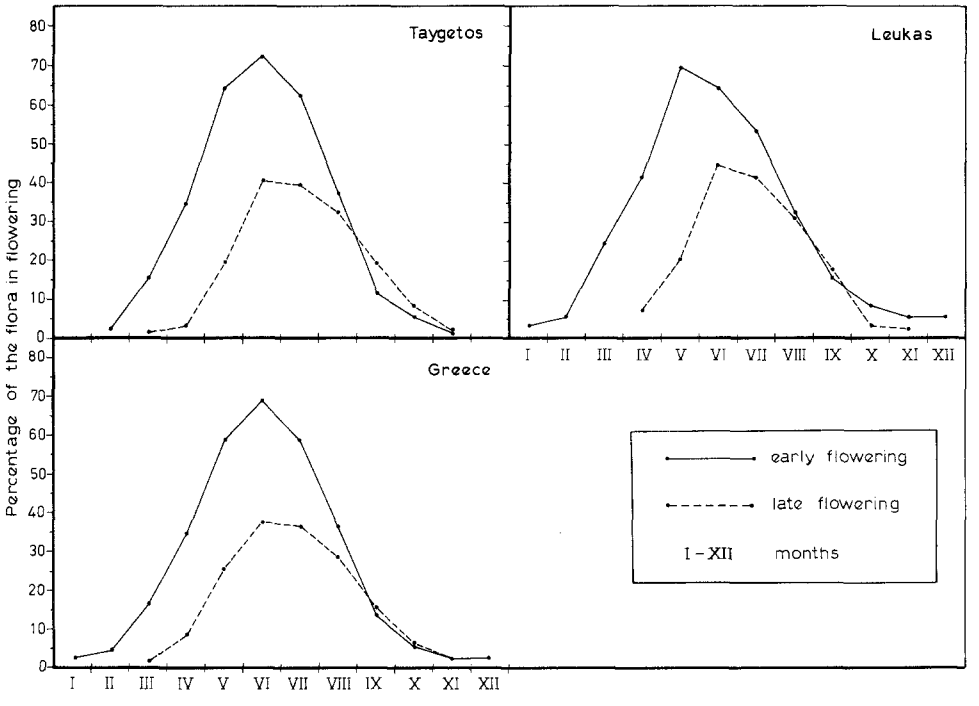

Fig. 1e.

Fig. 1. Curves of early (——) and late (---) flowering activity of the aromatic floras of 18 Greek regions (a–e) and curves for all regions together (e).

Stojanov & Jordanov (1938), Strid (1980), Yannitsaros (1969) and Zaganiaris (1934, 1938–1940). Also our papers (Voliotis, 1967, 1976, 1979).

It should be noted that these 170 species do not represent the entire aromatic Greek flora. Kriti, for example, has a great amount of aromatic plants, many of which are not included in the Appendix. Still, the island of Kriti has been excluded because it is much larger than the other study areas and hence difficult to compare. Both absolute numbers of aromatic species and percentage proportion, for all 18 regions were calculated.

The months of flowering, late as well as early flowering were then recorded. For each month and for each of the mentioned regions the number of flowering species was determined and also calculated as % of the entire Greek list (Table 1). Figure 1 presents the proportion of flowering species in % of the total number of aromatic species for each region.

The flower colour of all 170 species was noted as one of the following colours: green, white, yellow, red and violet according to the Flora Europaea

Table 2. Flower-colour phenological spectra in % of the regional totals.

	Falakron	Lailias	Cholomon	Voras	Vermion	*Olympos*	Ossa	Parnassos	Parnis	Taygetos	Athos	Sithonia	Pilion	Samothraki	Skiathos	Santorini	Kythira	Leukas	Greece
Violet	27	20	28	24	22	24	23	30	28	30	27	26	29	30	23	35	31	31	26
Red	18	12	17	17	16	20	13	24	20	15	15	17	12	10	13	27	17	19	16
Yellow	35	37	25	34	34	29	34	21	32	27	28	28	28	28	31	15	26	20	29
White	18	31	29	24	28	25	27	21	17	26	28	26	28	28	29	19	24	27	28
Green	2	–	1	1	–	2	3	4	3	2	2	3	3	4	4	4	2	3	1

Table 3. Matrix of Sørensen similarity values for all pairs of regions as to their aromatic flora.

	Falakron	Lailias	Cholomon	Voras	Vermion	Olympos	Ossa	Parnassos	Parnis	Taygetos	Athos	Sithonia	Pilion	Samothraki	Skiathos	Santorini	Kythira	Leukas
Falakron	1.00	0.55	0.56	0.62	0.52	0.66	0.56	0.44	0.41	0.44	0.51	0.46	0.45	0.42	0.37	0.17	0.20	0.32
Lailias	0.55	1.00	0.52	0.54	0.44	0.42	0.53	0.39	0.20	0.35	0.39	0.34	0.30	0.29	0.24	0.00	0.08	0.17
Cholomon	0.56	0.52	1.00	0.61	0.57	0.70	0.68	0.49	0.48	0.59	0.65	0.65	0.63	0.57	0.50	0.22	0.34	0.52
Voras	0.62	0.54	0.61	1.00	0.61	0.71	0.59	0.50	0.40	0.51	0.58	0.45	0.46	0.39	0.28	0.15	0.20	0.29
Vermion	0.52	0.44	0.57	0.61	1.00	0.59	0.58	0.38	0.37	0.45	0.55	0.46	0.50	0.36	0.30	0.13	0.19	0.29
Olympos	0.66	0.42	0.70	0.71	0.59	1.00	0.70	0.59	0.56	0.61	0.71	0.59	0.64	0.55	0.38	0.17	0.30	0.46
Ossa	0.56	0.53	0.68	0.59	0.58	0.70	1.00	0.52	0.55	0.60	0.68	0.57	0.70	0.53	0.50	0.19	0.40	0.49
Parnasos	0.44	0.39	0.49	0.50	0.38	0.59	0.52	1.00	0.51	0.51	0.52	0.40	0.51	0.40	0.40	0.20	0.21	0.36
Parnis	0.41	0.20	0.48	0.40	0.37	0.56	0.55	0.51	1.00	0.59	0.60	0.62	0.61	0.55	0.57	0.15	0.56	0.63
Taygetos	0.44	0.35	0.59	0.51	0.45	0.61	0.60	0.51	0.59	1.00	0.71	0.67	0.60	0.57	0.55	0.39	0.47	0.60
Athos	0.51	0.39	0.65	0.58	0.55	0.71	0.68	0.52	0.60	0.71	1.00	0.72	0.68	0.58	0.56	0.32	0.48	0.58
Sithonia	0.46	0.34	0.65	0.45	0.46	0.59	0.57	0.40	0.62	0.67	0.72	1.00	0.67	0.70	0.63	0.37	0.53	0.68
Pilion	0.45	0.30	0.63	0.46	0.50	0.64	0.70	0.51	0.61	0.60	0.68	0.67	1.00	0.63	0.67	0.35	0.54	0.55
Samothraki	0.42	0.29	0.57	0.39	0.36	0.55	0.53	0.40	0.55	0.57	0.58	0.70	0.63	1.00	0.63	0.36	0.49	0.62
Skiathos	0.37	0.24	0.50	0.28	0.30	0.38	0.50	0.40	0.57	0.55	0.56	0.63	0.67	0.63	1.00	0.43	0.62	0.62
Santorini	0.17	0.00	0.22	0.15	0.13	0.17	0.19	0.20	0.15	0.39	0.32	0.37	0.35	0.36	0.43	1.00	0.56	0.40
Kythira	0.20	0.08	0.34	0.20	0.19	0.30	0.40	0.21	0.56	0.47	0.48	0.53	0.54	0.49	0.62	0.56	1.00	0.61
Leukas	0.32	0.17	0.52	0.29	0.29	0.46	0.49	0.36	0.63	0.60	0.58	0.68	0.55	0.62	0.62	0.40	0.61	1.00

(Tutin *et al.*, 1964–1980) and to Polunin & Haxley (1965). Spectra of flower colours as % of the regional totals are presented in Table 2.

Finally the similarity coefficient of Sørensen (1948) was applied in order to calculate the similarity of any pair of regions regarding their aromatic flora. See Table 3.

Results

In the study area the Athos peninsula comes first with 105 aromatic taxa, followed by the massifs of Olympos with 103 and Taygetos with 97, meaning 62, 61 and 58% of the total respectively. On the other hand the volcanic island Santorini has only 26 aromatics, or 15%. The richness of the three mountainous areas is caused by the variety of habitats, ranging from sea level to alpine, and with varying substrates.

The curves for early and late flowering are rather similar. Still some groups can be distinguished: the northern Greek regions are very similar as are the Ionian island Leukas and the Aegean Skiathos, both around the 39° meridian. The peaks in the flowering curves for continental Greece and the N Aegean islands fall in June, whereas the southern sites have the peak in May. Most areas show a markedly symmetric curve.

White and yellow colours together make up more than 50% for most of the areas, but the extreme Santorini has only 34%. Similarity values range between 0.72 for Athos and the nearby Sithonia peninsula (this because of proximity and close ecological similarity) and 0.32 between Athos and Santorini, mainly due to the low number of species in the latter area.

The absolute minimum is zero, meaning that two areas do not share one single aromatic species. This is the case with Lailias and Santorini, which indeed show the largest possible contrast:

Lailias	Santorini
mainland	island
mountainous	lowland
silicate	vulcanic substrate
northern elements	not se

Discussion

The flowering period in Greece is short in comparison with that in central and northern Europe. It lasts only some weeks usually in May (Diamantopoulos & Margaris, 1981). However, in the mountainous north the flowering period lasts some weeks longer and the optimum is in June. The curve for the aromatic plants has its optimum in June as well.

It is known that the number of therophytes decreases towards the peninsulas bordering the Mediterranean Basin at higher latitudes, whereas the hemicryptophytes increase (Voliotis, 1977). This coincides with lower temperatures, higher altitudes and, towards the west, especially the Pindus region, a higher precipitation (Voliotis, 1973). We think that the observed symmetry in flowering curves for the aromatics can be explained by a sort of compensation: the therophytes being replaced by the aromatics with a broader and more varied spectrum. Shift towards the left of the maximum in the flowering curves for the islands can be explained by the low number of aromatic therophytes in comparison with the whole aromatic flora, whereas the number of therophytes as a whole is large.

There is some implication of our findings regarding pollinating insects. Three factors influence visual stimuli for insects: reflection of ultraviolet radiation, brightness and colour combination, in multicoloured flowers. Bees, for instance are unable to identify red, but on the other hand they do recognize ultraviolet and moreover yellow between 650–530 $\mu\mu$ azure blue between 470–400 $\mu\mu$ and white. In fact bees visit many red flowers too, because they reflect ultraviolet.

The high percentage of white and yellow flowers becomes understandable in view of the fact that most Greek aromatic plants are entomogamic. From the colour spectrum it appears that the percentage of violet and ultraviolet flowers increases, together with a decrease in the percentage of yellow and white flowers. These differences are connected with differences in intensity of sunlight, percentage of ultraviolet radiation and with biogeographical relations of the pollinating insects.

Appendix

List of Greek aromatic plants used in this study

Abies borisii-regis
A. cephallonica
Aceras anthropophorum
Achillea clavennae
A. erba-rotta ssp. olympica
A. millefolium
Acinos alpinus
A. arvensis
A. rotundifolius
A. suaveolens
Angelica sylvestris
Anthemis arvensis
A. cotula
Anthoxanthum odoratum
Anthriscus cerefolium
Arctium lappa
Artemisia absinthium
A. vulgaris
Asparagus acutifolius
A. verticillatus
Atractylis gummifera
Betula pendula
Bifora radians
Bupleurum fruticosum
Calamintha nepeta
C. grandiflora
Carlina acaulis
Centranthus ruber
Cephalanthera damasonium
Ceratonia siliqua
Cercis siliquastrum
Chaerophyllum aromaticum
Chamomilla recutita
Cistus incanus
C. monspeliensis
C. parviflorus
C. salvifolius
Clematis flammula
C. vitalba
Convallaria majalis
Cotinus coggygria
Crithmum maritimum
Cruciata laevipes
Cyperus rotundus
Dactylorhiza maculata
Daphne mezereum
Dictamnus albus
Epipactis atrorubens
Eryngium campestre
Filipendula ulmaria
Foeniculum vulgare
Fraxinus ornus
Galium odoratum
G. verum
Geranium macrorrhizum
Geum urbanum
Gymnadenia conopsea
Helichrysum italicum
Heracleum sphondylium
Humulus lupulus
Ilex aquifolium
Jasminum fruticans
J. humile
Juniperus communis
J. oxycedrus
J. phoenicea
Laurus nobilis
Lavandula angustifolia
L. stoechas
Lilium albanicum
L. candidum
Listera ovata
Lonicera caprifolium
L. etrusca
L. implexa
L. periclymenum
Lythrum salicaria
Melilotus officinalis
Melissa officinalis
Melittis melissophyllum
Mentha aquatica
M. longifolia
M. pulegium
Micromeria cremnophila
M. cristata
M. graeca
M. juliana
M. nervosa
Myrtus communis
Narcissus papyraceus
N. poëticus
N. serotinus
N. tazetta
Nepeta cataria
Nerium oleander
Nigella damascena
Nigritella nigra ssp. nigra
Opopanax chironium
O. hispidus
Orchis coriophora ssp. fragrans
O. pallens
O. purpurea
O. simia
O. ustulata
Origanum heracleoticum
O. onites
O. scabrum
O. vulgare
Orobanche caryophyllacea
O. gracilis
Osyris alba
Pancratium maritimum
Periploca graeca
Petasites hybridus
Pinus halepensis
P. sylvestris
Pistacia lentiscus
P. terebinthus
Polygonatum odoratum
Populus nigra
Primula veris ssp. columnae
P. vulgaris
Prunus mahaleb
P. spinosa
Pulicaria odora
Rhus coriaria
Rosa canina
Rosmarinus officinalis
Salvia amplexicaulis
S. argentea
S. candidissima
S. eichlerana
S. glutinosa
S. officinalis
S. pomifera
S. pratensis
S. ringens
S. sclarea
S. triloba
S. verbenaca
S. verticillata
S. virgata
S. viridis
Sambucus ebulus
S. nigra
Satureja athoa
S. montana
S. parnassica
S. thymbra
Scilla autumnalis
Spartium junceum
Styrax officinalis
Syringa vulgaris
Tanacetum parthenium
T. vulgare
Teucrium chamaedrys
T. polium
Thymbra spicata
Thymus capitatus
Th. ocheus
Tilia cordata
T. platyphyllos
T. tomentosa
Trifolium nigrescens
T. repens
Verbena officinalis
Vinca minor
Viola alba
V. odorata
Vitex agnus-castus

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