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Dedicated to Prof. dr. LJUDEVIT ILIJANIĆ on the occasion of his 70th birthday.

Phenodynamics of the most significant trees and shrub species in Arboretum Trsteno (Croatia)

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This paper presents an analysis of the phenodynamics of 60 taxa of trees and shrubs in Arboretum Trsteno (SE Adriatic coast, Croatia) in the period from February 1996 to February 1997. The plant geography spectrum has shown the predominance of South-East Asian species (31.7%) and the great share of spontaneous Mediterranean species (28.3%).

The length of the vegetation period for the observed species in 1996 ranged from 155 to 287 days. According to the summer and winter vegetation pause, two groups of species have been registered. The leafing-out phenological phase took place from April to May and showed differentiation into three time-groups.

It was noticed that the observed species gave feature to the matrix of vegetation only during the flowering period. Species were grouped according to flowering time into a few distinct seasonal aspects. On the basis of light-response and the length of day factor, three groups of plants might be distinguished: short-day, long-day and indifferent plants.

The phenodynamics of Arboretum is presented by a phenological activity index showing two annual peaks, the first occurring in May/June and the second in November/December.

Key words: phenology, vegetation period, flowering, seasonal variations, phenological activity, Arboretum Trsteno, Croatia.

Introduction

Phenological observations are especially concerned with surveys of spontaneous and anthropogenic ecosystems.(SCHNELLE 1955, LAUSI and PIGNATTI 1973, ILIJANIĆ et al. 1979, LINKOSALO et al. 1996) The majority of up-dated reports dealing with these topics have aimed at establishing the phenodynamics, the changes caused by pollution, and adaptation to a contaminated environent. (CICAK and ŠTEFANČIK 1993, CHRONOPOULOS et al. 1996, ŠTEFANČIK 1997).

The first phenological observations in Dubrovnik were done a hundred years ago, (NIKOLIĆ 1898) and were concerned mainly with spontaneous species. Thirty years ago, in Arboretum Trsteno a phenological garden, one of the comparative gardens in the International Phenological Gardens net, was established. Unfortunately it did not exist for a long time, and further, ordinary phenological observations have been done in the sphere of activity of the Agrometeorology Division of the Meteorological and Hydrological Service of the Republic of Croatia. The observations have taken into consideration defined autochthonous and allochthonous species.

In 1996/97 phenological observations were made in the framework of botanical research into the floristic composition of Arboretum Trsteno of the Croatian Academy of Sciences and Arts (Fig.1). The researched locality is situated in a non-polluted environment, far from the main road, free of air, ground and water pollution.

Arboretum Trsteno is a very interesting feature, not only because it is the only arboretum on the Adriatic coast and has very attractive scenery, but also because of its position in the littoral zone with a Mediterranean climate and its relatively unexplored collection of spontaneous Mediterranean and well acclimatized allochthonous species. This research was based upon the work and methods published by ILIJANIĆ et al.(1974).

The aim of this research was to find out: 1) the time course of all the phenophases of the main autochthonous and allochthonous trees and shrubs, 2) the start and duration of the vegetative season of the examined species for the

Fig. 1. Geographical position of Arboretum Trsteno

year 1996/97, 3) the phenological characteristics of the chosen species, 4) the phenodynamics of the park vegetation in Arboretum Trsteno.

Material and methods

The phenological research was done in Arboretum Trsteno on the site of the old historical garden (20 000 m^2), situated on the littoral slope 54–60 m above sea level, exposed to the south-south-west. The locality is characterized by balanced habitat factors, and is composed of a mix of spontaneous, subspontaneous and cultivated species. Half of the sixty species observed are deciduous and half evergreen. There are 43 allochthonous and 17 autochthonous species. Mature individuals that have for years reached the complete life cycle were observed. The key for choosing individuals of exotic species was their good adaptation to the new habitat in the Mediterranean climatic region.

The observations began on February 23, 1996 and finished on February 23, 1997, with a frequency of 10 days. Partial phenophases were assessed according to a phenological scale (ILIJANIĆ et al. 1974):

+ winter stage (evergreen leaves)
0 stage without leaves (bud in winter stage)
1 growing leaf bud (outbreak bud)
2 half developed leaves
3 completely developed leaves
4 flower buds
5 flowers
6 growing fruits
7 ripe fruits
8 dissemination of fruits
9 changing colour of leaves
10 defoliation

A quantitative value of each phenophase is expressed by lower case letters : a, b, c, denoting the beginning (to 25% of the crown of the tree), the middle (more than 50% of the crown) and the end of the phenophase (100% of the crown). To make the results more explicit only the middle (b) of each phenophase has been presented in the tables. (Tab. 1, 3) As the beginning of the phenophase, the medium day was taken between the registered dates of the previous and the next phase.

Seasonal variations in the phenological activity of the species investigated were assessed by the phenological activity index (PAI) after DE LAMPE (1992). PAI was obtained by dividing the number of species in the same phenophase by the total number of observed species and could be assessed by months and seasons, which enables a complete review of the yearly course of phenological activity and seasonal variations to be made.

The interdependence between the seasonal development of plants and the annual course of meteorological factors has been known for a long time. As the observations were made during one year only, the relationships between pheno-

phases and meteorological factors were not the object of the research. Data on air temperature and precipitation were obtained from the nearest meteorological station, in Dubrovnik, about 25 km far from Trsteno (Fig. 2).

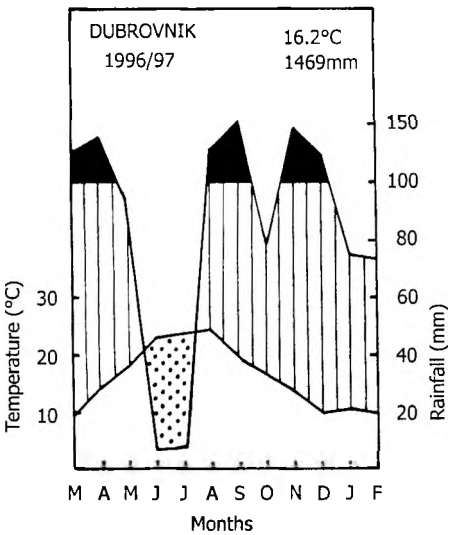

Fig. 2. Climatic diagram (after Walter) of Dubrovnik for the period from February 23, 1996 to February 23, 1997.

Results and discussion

Phenological observations of 60 taxa were made: 31 deciduous and 29 evergreen taxa. There were 8 deciduous and 9 evergreen spontaneous taxa, with 23 deciduous and 20 evergreen allochthonous taxa. Altogether they amount to 17 autochthonous and 43 allochthonous taxa (Tab. 1).

The phytogeographic spectrum of the species observed (Tab. 2) is significant not only for a review of the origin of plants but also, in comparison with each of the phenophases, for indicating the character of the particular species with respect to its climazonal origin, adaptability and attained acclimatization.

Three quarters of the observed species are of allochthonous origin, and species from South-East Asia are predominant, constituting 31.7% of the total. Very significant are species from North America, South America and from geographical regions around the Mediterranean, amounting to 6.7% each. The Mediterranean species predominant in Arboretum, account for 28.3% of the observed species.

Although not all the trees and shrub species of Arboretum were included in the observations, the choice of species observed, with insignificant aberration, represents a phytogeographical spectrum and a pheno-spectrum of the old central part of the plant collection of Arboretum Trsteno.

Tab. 1. Phenological data on 60 trees and shrub taxa in the time from February 23, 1996 to February 23, 1997 in Arboretum Trsteno. Dates are represented by four digits; the first two refer to days, the second two to months.

DECIDUOUS SPECIES	Phenophases								
	1b	2b	3b	4b	5b	7b	8b	9b	10b
Autochthonous sp.									
Carpinus orientalis Mill.	2703 – 0704	1704 – 2104	2604 – 0205	2204 – 3004	1005 – 1505	0208 – 2008	0709 – 2009	1511 – 2111	2811 – 0212
Cornus mas L.	2703 – 0204	1804 – 2204	1105 – 1705	1612 – 2812	0303 – 1403	1507 – 2307	0108 – 0808	2211 – 3011	1812 – 2612
Cotinus coggygria Scop.	2503 – 3103	2304 – 3004	1605 – 2505	2204 – 0205	1405 – 2605	0407 – 1407	0210 – 1410	1410 – 2810	2011 – 3011
Fraxinus ornus L.	0603 – 2003	2004 – 2704	1005 – 1605	2603 – 1004	2604 – 0805	1809 – 0410	0611 – 1211	2411 – 3011	0212 – 1212
Ficus carica L.	2002 – 0203	1004 – 2204	2804 – 0805	0805 – 3005	0406 – 2006	2707 – 1609	–	1611 – 2611	2811 – 0312
Punica granatum L.	1603 – 0104	1204 – 1804	0205 – 1605	1406 – 0807	2006 – 1407	0610 – 1610	1011 – 0112	0811 – 1411	2011 – 3011
Quercus pubescens Willd.	2703 – 0204	1704 – 2604	0605 – 2005	1404 – 2004	2504 – 0205	1010 – 2610	1011 – 2511	1612 – 2512	3012 – 1001
Vitis vinifera L.	2503 – 0104	0405 – 1205	1805 – 2605	0405 – 1705	0206 – 1806	2808 – 0609	–	1610 – 2410	1710 – 1611
Allochthonous sp.									
Broussonetia papyrifera (L.) Vent.	1204 – 2004	0305 – 0805	2005 – 3105	2404 – 0205	1805 – 2605	–	–	2810 – 0211	1811 – 2511
Calycanthus occidentalis Hook. et Arn	2802 – 2003	0804 – 1304	2604 – 1005	2204 – 0505	3005 – 1606	1207 – 1807	2307 – 0108	1809 – 2809	1010 – 1610
Cercis siliquastrum L.	1004 – 2204	0805 – 1305	1805 – 2705	2603 – 0104	2004 – 2904	2207 – 2907	1809 – 2809	1011 – 1611	1811 – 2311
Chimonanthus praecox (L.) Link	2602 – 0603	0504 – 1004	1804 – 2904	2309 – 0410	1212 – 2612	0107 – 0807	2307 – 2907	2211 – 1112	2412 – 3012
Diospyros virginiana L.	2703 – 0204	2104 – 2604	1205 – 1905	0905 – 1805	2705 – 0406	2811 – 1412	1812 – 2612	1510 – 2610	0611 – 1411
Eleagnus umbellata var. parvifolia Sch	0603 – 1803	0204 – 1504	2004 – 2504	2803 – 0304	2404 – 0805	1208 – 0509	1809 – 2509	2511 – 0811	1012 – 2412
Erythrina crista – galli L.	1804 – 2404	0805 – 1405	2005 – 2805	1005 – 1605	0506 – 2006	–	–	0511 – 1111	1111 – 1411
				2007 – 2407	0608 – 1408	–	–		
				0809 – 1709	2809 – 0310	–	–		
Firmiana simplex (L.) W.F.Wight	1104 – 2404	1005 – 1505	2605 – 0206	–	–	–	–	0611 – 1411	2011 – 2611
Hibiscus syriacus L.	2003 – 1104	3004 – 0405	1105 – 1605	2605 – 1006	0607 – 0809	0809 – 1609	0110 – 0810	2110 – 2910	0811 – 1411
Liriodendron tulipifera L.	0804 – 1204	3004 – 0805	1905 –2605	2804 – 1205	2605 – 0806	1911 – 0312	1212 – 2812	0811 – 2011	2011 – 2911
Melia azedarach L.	1204 – 2404	0905 – 1605	2005 – 2605	3004 – 1405	2605 – 0606	1811 – 3011	1504 – 0205	1410 – 2410	0511 – 1211
Paulownia tomentosa (Thunb.)Steud.	1604 – 2404	1205 – 2205	2605 – 0606	2011 – 1012	0405 – 2005	1811 – 2711	1012 – 2212	2010 – 2810	1011 – 2311
Periploca graeca L.	1503 – 2903	1504 – 2104	0205 – 1405	1004 – 2004	1305 – 2505	2211 – 1612	2801 – 1502	1012 – 1812	2912 – 0601

Tab. 1. – continued

DECIDUOUS SPECIES	Phenophases								
	1b	2b	3b	4b	5b	7b	8b	9b	10b
Philadelphus coronarius L.	2703 – 0204	2004 – 0205	2505 – 3005	0205 – 1205	0406 – 1006	0607 – 1607	0508 – 1208	2110 – 2910	1011 – 2411
Poncirus trifoliata (L.) Raf.	1004 – 1504	0405 – 1805	2405 – 2905	2003 – 3003	2004 – 2604	1410 – 2210	2011 – 1512	0411 – 1011	1611 – 2011
Sophora davidii Kom.	2503 – 0204	1604 – 2604	0105 – 1005	1804 – 2604	2005 – 2905	1008 – 2308	0710 – 1411	1810 – 2910	0211 – 0811
Syringa vulgaris L.	2803 – 0204	1204 – 1604	2104 – 2604	0904 – 1304	2404 – 0305	0108 – 1208	2408 – 0309	0411 – 1211	1611 – 2411
Tamarix africana Poir.	2603 – 0204	2804 – 0405	2605 – 0406	0203 – 1803	1004 – 2204	1806 – 2406	2007 – 0408	2111 – 3011	1612 – 2212
Wisteria sinensis (Sims) Sweet	0804 – 1204	3004 – 0805	1605 – 2405	1403 – 2003	2004 – 0205 2406 – 1207	–	–	0811 – 1611	1911 – 2611
* *Bougainvillea glabra* Choisy	1403 – 1604	0405 – 1105	1805 – 2605	1505 – 2011	1006 – 1511	–	–	–	0602 – 1003
* *Boug. glabra* Choisy 'Sanderiana'	1004 – 2504	0205 – 1205	2805 – 0506	2705 – 2907	0607 – 2008	–	–	–	2712 – 0601
* *Lantana camara* L.	1004 – 2204	0405 – 1005	1405 – 1905	2805 – 1510	2506 – 2010	–	–	–	2712 – 2001
* *Rosa banksiae* Ait.	0804 – 1404	1005 – 1705	2405 – 2905	0203 – 1403	0205 – 2305	–	–	–	0601 – 2001

* Evergreen species but deciduous in Trsteno

EVERGREEN SPECIES	Phenophases						
	1b	2b	3b	4b	5b	7b	8b
Autochthonous sp.							
Arbutus unedo L.	1804 – 2504	1105 – 1805	2805 – 0606	0508 – 1108	1212 – 2812	2011 – 3011	2412 – 3012
Coridothymus capitatus (L.) Rch.f.	2501 – 0802	2102 – 2702	1404 – 2804	0306 – 0906	0607 – 1207	1608 – 2508	0209 – 0609
Laurus nobilis L.	0504 – 1004	3004 – 1205	2605 – 0206	2406 – 1007	2903 – 1004	0909 – 2009	1412 – 1001
Lonicera implexa Ait.	1601 – 2701	0602 – 1802	0904 – 1504	2404 – 3004	2805 – 1006	1207 – 1807	2607 – 0108
Myrtus communis L.	1104 – 2004	0605 – 1405	2005 – 2605	2805 – 0406	0607 – 2007	0711 – 2011	1201 – 2601
Nerium oleander L.	1604 – 2204	0205 – 0805	1405 – 2005	1605 – 2805	2506 – 0108	1612 – 2812	1001 – 2001
Rosmarinus officinalis L.	1203 – 1903	1004 – 2004	1805 – 3105	0801 – 2401	0203 – 0804	–	–
	2008 – 0109	0809 – 2009	1210 – 1610	2208 – 0309	1809 – 1210	–	–
Teucrium fruticans L.	3003 – 1004	1604 – 2204	2804 – 0405	2911 – 2203	0504 – 0605	1606 – 2706	2007 – 0108
	2008 – 0109	1009 – 2309	1010 – 2010				

Tab. 1. – continued

EVERGREEN SPECIES	Phenophases						
	1b	2b	3b	4b	5b	7b	8b
Viburnum tinus L.	2803 – 0804	2104 – 2604	3004 – 0505	2009 – 1010	2702 – 1603	1011 – 2511	1001 – 2401
Allochthonous sp.							
Acacia dealbata Link	2303 – 0104	2404 – 0805	0605 – 2005	2607 – 0808	2401 – 1002	1406 – 2406	0607 – 2007
Acacia retinodes Schlechtend.	3003 – 1004	1804 – 2404	0205 – 1505	0405 – 1505	0806 – 2206	–	–
	0808 – 1608	2508 – 0109	0609 – 1009	1008 – 2208	1208 – 2009	–	–
Buxus balearica Lam.	0804 – 1204	2604 – 0205	1205 – 1805	1609 – 2909	2004 – 2604	0307 – 1507	2108 – 2808
Buxus sempervirens L.	2603 – 0204	2104 – 2704	0605 – 1205	0210 – 1410	0803 – 1603	1806 – 2906	1007 – 1807
Cinnamomum camphora L. Sieb.	1802 – 0503	0804 – 1504	2604 – 0605	3003 – 1204	1205 – 1805	1910 – 2610	1011 – 2211
Citrus sinensis (L.) Pers.	1004 – 2004	3004 – 1005	1905 – 3005	2004 – 0205	1005 – 2405	2511 – 0812	–
Citrus aurantium L.	1804 – 2504	3004 – 0805	1605 – 2505	2304 – 2804	1005 – 2605	0812 – 2012	0807 – 2007
Citrus medica L.	1204 – 2404	2904 – 0605	1105 – 2005	1804 – 3004	1405 – 2805	2011 – 0412	–
Eriobotrya japonica (Thunb.) Lindl.	1608 – 2608	0409 – 1009	2109 – 2609	0809 – 1609	1510 – 0611	2405 – 3005	–
Jasminum mesnyi Hance	3003 – 1204	2004 – 2904	1105 – 1805	2911 – 2412	0304 – 0605	–	–
Jasminum officinale L.	1604 – 2404	3004 – 0505	1005 – 1605	2205 – 3105	2006 – 1010	–	–
Ligustrum lucidum Ait.	1904 – 2404	0805 – 1505	2305 – 3005	1206 – 2406	1407 – 2507	0811 – 2211	2601 – 2602
Magnolia grandiflora L.	3003 – 1004	0105 – 1205	2505 – 3005	2205 – 3105	1806 – 0307	2010 – 2910	0711 – 2211
Persea indica Spreng.	0804 – 2104	0705 – 1505	0506 – 2006	0203 – 2808	0205 – 1405	–	–
Pittosporum tobira (Thunb.) Ait.	0602 – 1602	2803 – 1004	0205 – 2005	2603 – 0504	1804 – 0505	2811 – 1012	0612 – 1812
Rhaphiolepis umbellata (Thunb.) Mak.	1003 – 2203	0905 – 1605	2505 – 0406	1503 – 0704	0905 – 1805	0711 – 2211	1012 – 2812
Rosa rubiginosa L. 'Semperflorens'	1403 – 2103	2903 – 0804	2104 – 3004	2002 – 2603	0804 – 1505	1006 – 1207	2806 – 3007
				1808 – 1012	1809 – 2311	2010 – 0511	1011 – 2811
Schinus molle L.	2004 – 2604	0606 – 1206	1806 – 2406	2906 – 0307	0608 – 2809	–	–
Tecomaria capensis (Thunb.) Spach	0704 – 1204	2004 – 2504	0205 – 2305	0609 – 1609	1410 – 2211	–	–
Trachelospermum jasminoides (Lindl.) Lem.	0903 – 81603	1404 – 2104	0405 – 1405	1704 – 2604	1205 – 2605	–	–

Tab. 2. Phytogeographical spectrum of species observed in Arboretum Trsteno.

Area of origine	Number of sp.	%
South - East Asia	19	31.7
Mediterranean	17	28.3
North America	4	6.7
South America	4	6.7
South Europe, Mediterranean, West Asia, North Africa	4	6.7
West Asia	2	3.3
Middle Asia	2	3.3
Himalaya	2	3.3
Australia	2	3.3
Middle America	1	1.7
South Africa	1	1.7
Balearic Islands,	1	1.7
Canarian Islands, Madeira, Azores	1	1.7

In the year 1996 the length of the vegetation period for the observed deciduous species (Tab. 3) was assessed by the number of the days from phase 3b to phase 9b (ILIJANIĆ et al. 1974). Spontaneous species stand out as the group with the longest vegetation season and *Quercus pubescens* as the species with the longest vegetation period, of 234 days.

In Trsteno, some evergreen allochthonous species (Tab. 3) with phytogeographical origins from warmer and subtropical regions developed a deciduous rest of vegetation during 2–4 months in the late-winter and early-spring period, because of inadequate climatic conditions in this period of the year. This deciduous rest occurs suddenly and by force of low temperatures about 0 °C and a very severe and cold north wind that causes defoliation. Leafing-out about the middle of the spring is a period of renewal and regeneration from winter injuries.

Autochthonous evergreen species cease their intensive vegetation during the summer rest according to the dynamics of climatic factors of the Mediterranean region. One little group of allochthonous species shows the same vegetation rest during the summer (*Acacia dealbata, Buxus balearica, Buxus sempervirens, Eriobotrya japonica, Jasminum nudiflorum, Rosa rubiginosa 'Semperflorens', Tecomaria capensis*). The majority of allochthonous evergreen species have developed or retained the winter vegetation rest of the regions of their phytogeographical origin. (*Cinnamomum camphora, Citrus aurantium, Citrus medica, Citrus sinensis, Jasminum officinale, Ligustrum lucidum, Magnolia grandiflora, Persea indica, Pittosporum tobira, Rhaphiolepis umbellata, Schinus molle, Trachelospermum jasminoides*).

The dynamics of beginning of the leafing-out phenophase (phase 3b) of the observed deciduous species takes place in April and May and shows differentiation into three groups. All the autochthonous species have the leafing-out phenophase condensed into about the middle of the April, whereas the allochthonous species have it dispersed into the whole time course of the phenophase. Among them, particular attention is attracted by the group of early species and the late group that proves its thermophilic character (*Firmiana simplex, Paulo-*

Tab. 3. The length of the vegetational season (VS) for some deciduous species in Arboretum Trsteno

Species / Origine	3b	9b	VS in days
Quercus pubescens (Mediterranean)	0605	2512	234
Eleagnus umbellata var. parvifolia (Himalaya)	2004	0812	233
Periploca graeca (Mediterranean)	0205	1812	231
Ficus carica (Mediterranean)	2804	2611	213
Carpinus orientalis (South Europe, Mediterran.)	2604	2111	210
Chimonanthus praecox (China, Japan)	1804	1112	208
Syringa vulgaris (West Asia)	2104	1211	206
Fraxinus ornus (South Europe, Mediterranean)	1005	3011	204
Cornus mas (Europe)	1105	3011	203
Diospyros virginiana (North America)	1205	2611	199
Punica granatum (Mediterranean)	0205	1411	197
Tamarix africana (W. Mediterranean, N. Africa)	2605	3011	188
Wisteria sinensis (China)	1605	1611	184
Cercis siliquastrum (S. Europe, W. Asia)	1805	1611	183
Sophora davidii (China)	0105	2910	182
Firmiana simplex (China)	2605	1411	177
Erythrina crista– galli (South America)	2005	1111	176
Hibiscus syriacus (China, Japan)	1105	2910	171
Poncirus trifoliata (China)	2405	1011	170
Calycanthus occidentalis (North America)	2604	1010	168
Broussonetia papyrifera (China, Japan)	2005	0211	167
Cotinus coggygria (South Europe)	1605	2810	165
Vitis vinifera (cult.sp.)	1805	2410	160
Melia azedarach (Middle Asia)	2005	2410	158
Philadelphus coronarius (West Asia)	2505	2910	157
Liriodendron tulipifera (North America)	1905	2011	155
Paulownia tomentosa (China)	2605	2810	155
Evergreen species – deciduous in Trsteno:			
Bougainvillea glabra (South America)	1805	1003	297
Lantana camara (Trop. America)	1405	2001	252
Rosa banksiae (China)	2405	2001	242
Bougainvillea glabra 'Sanderiana' (S. America)	2805	0601	223

wnia tomentosa, Tamarix africana, Broussonetia papyrifera, Erythrina crista-galli, Melia azedarach, Philadelphus coronarius). The leafing-out temperature ranged from 11.5 °C to 18.0 °C.

The flowering phenophase is the most significant and the most attractive phenological trait in Arboretum and is dominant the whole year round. Differences in the timing of the start of the flowering phenophase and differences in its seasonal intensity closely correspond to the seasonal changes of the climate. As in Trsteno the meteorological observations were interrupted by the war (1991) there is a break in continuity of observations. There are no relevant data to compare with the seasonal variations in the phenological activities. Therefore, the seasonal variations of the light period and the course of the flowering phenophase have been considered. In maintenance of its life cycles every plant is sub-

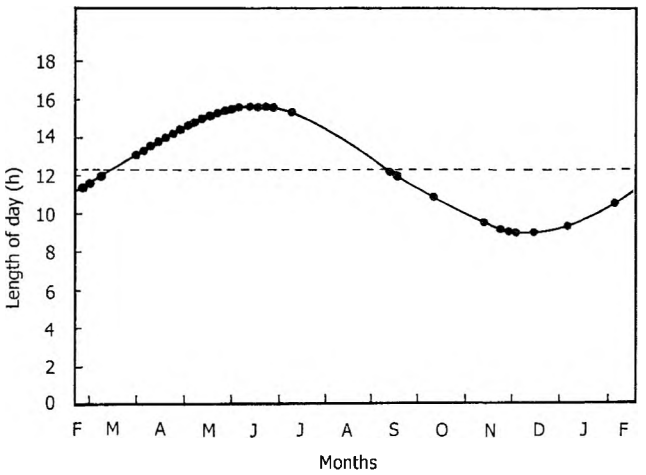

Fig. 3. Interrelationships between the length of day and the beginning of the flowering phenophase of the species observed in Arboretum Trsteno.

Tab. 4. List of long-day, short-day and indifferent species in Arboretum Trsteno.

Long-day species:		Short-day species:
Broussonetia papyrifera (L) Vent.	*Magnolia grandiflora* L.	*Acacia dealbata* Link
Cercis siliquastrum L.	*Melia azedarach* L.	*Arbutus unedo* L.
Cinnamomum camphora L. Sieb.	*Paulownia tomentosa* (Thunb.) Steud.	*Chimonanthus praecox* (L.) Link.
Citrus aurantium L.	*Persea indica* Spreng	*Cornus mas* L.
Citrus medica L.	*Pittosporum tobira* (Thunb.) Ait.	*Eriobotrya japonica* (Thunb) Lindl.
Citrus sinensis (L.) Pers.	*Poncirus trifoliata* (L.) Raf.	*Jasminum mesnyi* Hance
Coridothymus capitatus (L.) Rch. f.	*Rhaphiolepis umbellata* (Thunb.) Mak.	*Tecomaria capensis* (Thunb.) Spach
Diospyros virginiana L.	*Rosa banksiae* Ait.	
Eleagnus umbellata var parvifolia Sch.	*Schinus molle* L.	Indifferent species:
Erythrina crista-galli L.	*Sophora davidii* Kom.	*Acacia retinodes* Schlechtend.
Hibiscus syriacus L.	*Tamarix africana* Poir.	*Bougainvillea glabra* Choisy
Jasminum officinale L.	*Trachelospermum jasminoides* Lem.	*Bougainvillea glabra* Choisy 'Sanderiana'
Ligustrum lucidum Ait.	*Wisteria sinensis* (Sims) Sweet	*Lantana camara* L.
Liriodendron tulipifera L.		*Rosa rubiginosa* L. 'Semperflorens'

jected to the factor of length of day during the growing season as well as to other climatic and soil conditions. If its distribution depends upon successful seed production, its limits of distribution must depend largely upon those conditions of summer-day length favourable to successful flowering and the production of fertile seed (BROWN-BLANQUET 1965). Species differ among themselves by the sensitivity and intensity of their response to the daily duration of light.

According to different types of photoperiodism in consideration of flowering phenophase, the species investigated could be differentiated into short-day plants, long-day plants and plants not sensitive to photoperiods (Fig. 3). All this is clearly visible throughout the very attractive seasonal aspects that alternate in the course of annual cycle. This periodism underlying the main impression given by Arboretum is not conditioned exclusively by the complex of climatic factors,

as is the case with surrounding spontaneous Mediterranean vegetation, but is also the authentic reflection of the diverse floristic composition of the autochthonous and allochthonous species (Tab. 4).

Flowering takes place in successive phases and every season has its different and characteristic aspects according to the composition and the percentage of flowering species. Peculiarity of species composition in Arboretum is reflected in the permanent flowering course of the year (Fig. 4). There is no well defined division among the seasonal aspects, because some species have the flowering phenophase prolonged through two or three seasons of the year, and two species even through all four seasons.

Species	**Share**
Spring flowering	53.5%
Spring-summer flowering	6.8%
Spring-summer-autumn flowering	5.0%
Summer flowering	10.2%
Summer-autumn flowering	1.7%
Autumn flowering	5.0%
Winter flowering	6.8%
Winter-spring flowering	6.8%
Year round flowering	3.4%

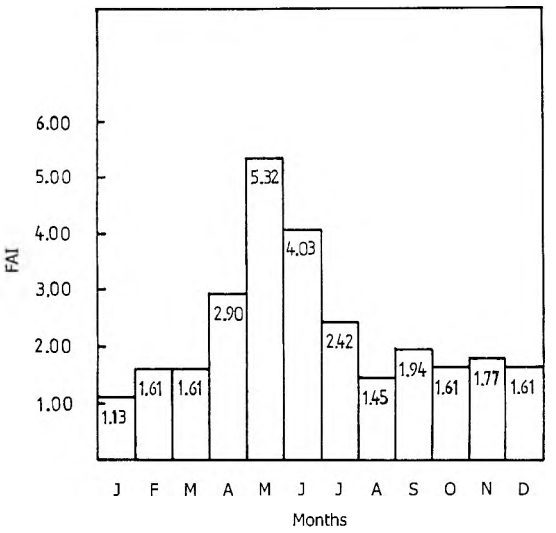

Fig. 4. Annual variations in the flowering activity index (FAI) for 1996 in Arboretum Trsteno.

For the main phenological events, one, two or three phenophase intensity peaks were observed during the year. For the leafing-out phenophase, only one peak, in May, for the flowering phenophase the main peak in May, the second in September and the third in December, for the fruiting phenophase the main peak

in August and second in November, for the change of colour of leaves phenophase only one peak in the transition period September/November.

Studies of plant phenology recognize seasonality at different levels of organisation including ecosystem, community and population level (BULLOCK and SOLIS-MEGALLANES 1990). The community level is generally analysed by using synthetic descriptors such as the number of species or the percentage of individuals showing a particular phenological trait.

In order to assess the phenodynamics of the specific floristic structure of Arboretum Trsteno the same approach as for the community level was used in this paper. Seasonal variations in the phenological activity throughout the annual cycle were shown by global index (PAI) including phenophases from 2 to 10. This is illustrated by a line graph (Fig. 5) where two peaks were identified. The first peak shows a high phenological activity in the May/June transition period, and second peak a somewhat higher activity in the November/December transition period.

Floristically, Arboretum is not a natural community, its species composition being anthropegenic, and its phenodynamics is the reflection of the genetic properties of individuals as well as the effect of climatic factors of the region.

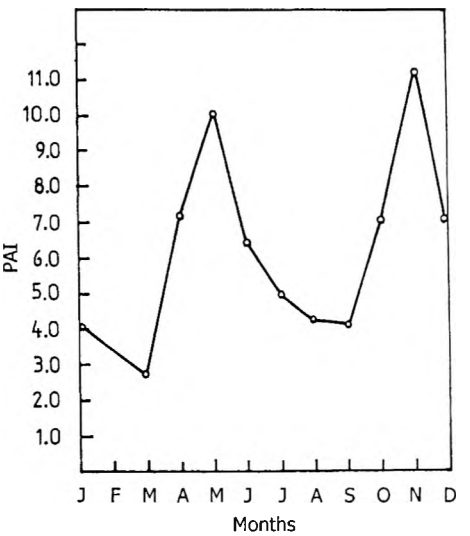

Fig. 5. Annual course of the phenophase activity index (PAI). (Phenophases 2–10 included)

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