



CONTRIBUTION TO THE KNOWLEDGE OF FLOWERING PHENOLOGY AND SEX EXPRESSION IN *Acer platanoides* L. FROM MONTENEGRO

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SYNOPSIS

Key words:

Flowering phenology,
sex expression,
Acer platanoides

The paper contains the results of research of flowering phenology and sex expression of flowers, inflorescences and single trees of *Acer platanoides* for five consecutive years on 13 marked trees in local population of the city park in Nikšić. The flowers were morphologically falsely bisexual and functionally unisexual (male or female). Male flowers had a very small, rudimentary pistil (unfunctional) with normally developed stamens, and female flowers had a normally developed pistil and unripe stamens. The following flowering types of inflorescences were recorded: B (♀ - ♂), C (♂ - ♀ - ♂), D (♂ - ♀), E (♂I), F (♂II), G (♂I - ♂II), H (♀ - ♂ - ♀) - the most frequent being the type C, and the rarest the types G and H.

SINOPSIS

Ključne riječi:

Fenologija cvjetanja,
polna ekspresija,
Acer platanoides

*PRILOG POZNAVANJU FENOLOGIJE CVJETANJA I POLNE
EKSPRESIJE U *Acer platanoides* L. IZ CRNE GORE*

U radu su dati rezultati istraživanja fenologije cvjetanja i polne ekspresije cvjetova, cvati i individualnih stabala *Acer platanoides* uzastopno tokom pet godina na 13 markiranih stabala u lokalnoj populaciji gradskog parka u Nikšiću. Cvjetovi su bili morfološki lažno dvopolni a funkcionalno jednopolni (muški ili ženski). Muški cvjetovi su imali vrlo mali, rudimentarni tučak (nefunkcionalan) sa normalno razvijenim prašnicima, a ženski cvjetovi su imali dobro razvijen tučak i nezrele prašnike. Nađeni su sljedeći cvjetajući tipovi cvati: B (♀ - ♂), C (♂ - ♀ - ♂), D (♂ - ♀), E (♂I), F (♂II), G (♂I - ♂II), H (♀ - ♂ - ♀), od kojih je najčešći C tip a najrjeđi G i H tip.

INTRODUCTION

Morphological and functional variations in the sexuality of *Acer* flowers were studied by many researchers. PAX (1885), a monographer of *Acer* genus, said that flowers of *Acer platanoides* are andro-monoecious. POJARKOVA (1949), also a monographer of *Acer* genus, said that flowers of *Acer platanoides* are male and falsely bisexual (maybe and bisexual). ZAMJATNIN (1958) said that flowers of *Acer platanoides* are with stamens and falsely bisexual (with pistils) on the same plant, but sometimes on single trees they are of only one or the other sex. JOVANOVIĆ (1973) reported that flowers of *Acer platanoides* on a single tree were with stamens and falsely bisexual (with pistils), sometimes on tree the flowers are only with stamens or only with pistils. GUDESKI & DRENKOVSKI (1978) said that flowers of *Acer platanoides* are functionally unisexual independently from development of sexual organs of the opposite sex (male flowers do not have pistil, and if there is pistil it is reduced and sterile and female flowers have well-developed stamens, but their anthers do not grow-up, half-anthers do not open and they produce sterile pollen). PALAMAREV (1979) reported that it is common for flowers of *Acer platanoides* to be unisexual.

MATERIAL AND METHODS

Flowering phenology and sexual expression of flowers, inflorescences and trees of *Acer platanoides* were observed on marked trees (13 trees) in local population of the city park in NIKŠIĆ consecutively in period of 5 years. Sexuality of the flowers was determined on basis of their sexual organs' functionality. During full anthesis of the flowers all of them had normally developed stamens and not well-developed pistils (rudimentary or abortive pistil) are considered to be male. Criteria for female flowers is their inability of releasing pollen, and in case of releasing pollen such flowers are considered to be bisexual. The criteria for a female flower will be its inability to release pollen. In case of pollen release, fertile or not, the flowers will be considered as bisexual. Such opinion is presented by a contemporary monographer of the genus *Acer* - JONG (1976). The sexual expression of the inflorescences is determined on basis of classification of inflorescences according to type of their flowering (WITTROCK, 1886; modified by CORRENS, 1928; taken from JONG, 1976) and numeral relationships between male and female flowers in the inflorescences is observed in a specimen of 30 randomly taken inflorescences for every individual tree and every specific year of observation. Phenophases: swelling of buds, opening of buds and flowering were determined according to recommendations (BEJDEMAN, 1974).

RESULTS AND DISCUSSION

All analysed trees were monoecious plants. The male and female flowers are both placed on the same inflorescence. The male flowers have a very small rudimentary pistil with normally developed stamens (yellow with functional anthers on long filaments). The female flowers have a normally developed pistil and unripe stamens (the anthers are green, hard and unfunctional and filaments are very short). We find similar results with GUDESKI & DRENKOVSKI (1978). TRIPIC (2006) presented very similar results for *Acer obtusatum* and *Acer campestre*. We have not established the results reported by JOVANOVIĆ (1973) that flowers on single trees of *Acer platanoides* are sometimes only with stamens or only with pistils. It is observed, but rarely, that on some trees during the flowering immediately before the completion of flowering, one or two almost normally developed female flowers, transformed into functionally male flowers with an illusory normal pistil and an abortive loose and pallid ovary. Such flowers on the first sight look like bisexual ones, but in fact, they are functionally unisexual male flowers. TRIPIC (2007) presented very similar results for *Acer monspessulanum*. On these flowers the stamens are developed normally on trees later on. Very rarely observed on two trees during the stage of male flowers flowering, it was noticed that on tree and also sometimes on same inflorescences there were simultaneously flowerings of one or two normally developed female flowers and vice versa. Otherwise, flowering of male and female flowers on the same tree is divided into time intervals (except for these rare exceptions). The phenophase of buds swelling in observed local population of *Acer platanoides* took place from 10th February to 15th March and lasted for 17 - 45 days depending on weather conditions, and especially temperature (Table 1 and Graph 1).

The phenophase of buds opening started from 10th to 29th March depending also of weather conditions and especially the temperature (Table 1 and Graph 1). The opening of a single bud lasted 1 - 8 days depending of tree, weather conditions and especially temperature.

Table 1. The phenophases: swelling and opening of buds in the observed population of *Acer platanoides* L. (Nikšić)

Year	Swelling of buds		Opening of buds	
	start	massive	start	massive
2001	10 Feb – 26 Mar	16Mar – 30 Mar	20 Mar – 31 Mar	27 Mar – . Apr
2002	15 Feb – 12 Mar	8 Mar – 21 Mar	10 Mar – 21 Mar	18 Mar – 2 Apr
2003	2 Mar – 29 Mar	25 Mar – 7 Apr	29 Mar – 10 Apr	2 Apr – 16 Apr
2004	25. 2. – 18 Mar	17 Mar - 2 Apr	28 Mar – 3 Apr	1 Apr – 8 Apr
2005	15 Mar - 1 Apr	30 Mar – 8 Apr	24 Mar – 10 Apr	7 Apr – 17 Apr

The beginning of flowering in local population varies from 13th March to 5th April, and the end of flowering varies from 29th April to 5th May (Table 2 and Graph 2).

Table 2. The phenophase of flowering in the observed population of *Acer platanoides* L.

Year	Flowering of the individual trees			Flowering of the population		
	start	massive	the end	start	massive	the end
2001	24Mar – 3 Apr	27 Mar – 8 Apr	9 Apr – 30 Apr	24 Mar	29 Mar - 12 Apr	30 Apr
2002	13Mar – 26Mar	19 Mar – 12 Apr	9 Apr – 30 Apr	13 Mar	22 Mar - 14 Apr	30 Apr
2003	2 Apr – 14 Apr	5 Apr – 16 Apr	19 Apr – 29 Apr	2 Apr	12 Apr - 25 Apr	29 Apr
2004	30 Mar – 5 Apr	1 Apr – 9 Apr	16 Apr – 5May	30 Mar	4 Apr - 17 Apr	5 May
2005	5 Apr – 14 Apr	9 Apr – 12 Apr	19 Apr – 2 May	5 Apr	12 Apr - 18 Apr	2 May

The observed trees flowered abundantly or enough abundantly 2 - 4 years consecutively and afterwards 1 - 2 years they flowered poorly or very poorly (with a little or very little inflorescences on tree).

The flowering of a single tree lasted from 11 to 41 days while the flowering of entire population lasted from 28 to 49 days, and that depends of temperature (Table 3 and Graph 2). All protandrous trees (Graph 2) always had at least two series of male flowers and one series of female flowers (♂ - ♀ - ♂) while protogynous trees (Graph 2) had mostly one series of male flowers and one series of female flowers (♀ - ♂). TRIPIC (2006) presented very similar results for *Acer campestre* while *Acer obtusatum* mostly had only one series of male flowers and one series of female flowers. Total number of flowers on single inflorescence varies from 10 to 84 (the male flowers in amount from 2 to 57 and the female flowers in amount from 0 to 37 flowers). The inflorescences with only male flowers were relatively rare and the inflorescences with only female flowers were not found.

Table 3. The duration of flowering in the observed population of *Acer platanoides* L. (in days).

Year	The observed individual tree				The observed population
	first series of male flowers	female flowers	second series of male flowers	all flowers	all observed trees
2001	4 - 25	3 - 10	3 - 8	17 - 32	38
2002	4 - 25	4 - 8	6 - 17	25 - 41	49
2003	6 - 15	3 - 9	2 - 11	15 - 26	29
2004	1 - 16	3 - 6	3 - 16	16 - 35	38
2005	3 - 14	2 - 6	2 - 11	11 - 22	28

Quantitative relationship of the male and female flowers on single inflorescence was 7.1 - 100 % of the male flowers, and also on single trees 48.7- 87.0% of the male flowers (Table 5.).

Table 4. Level of flowering (number of flowers on a tree) of individual trees of *Acer monspessulanum* L. during the year

Year	Total number of trees N	Level of flowering					
		non-flowering	very low	low	medium	high	very high
2001	13	-	-	1	1	4	7
2002	13	-	1	1	2	6	3
2003	13	-	1	-	2	6	4
2004	13	-	-	1	2	4	6
2005	13	-	2	2	1	4	4

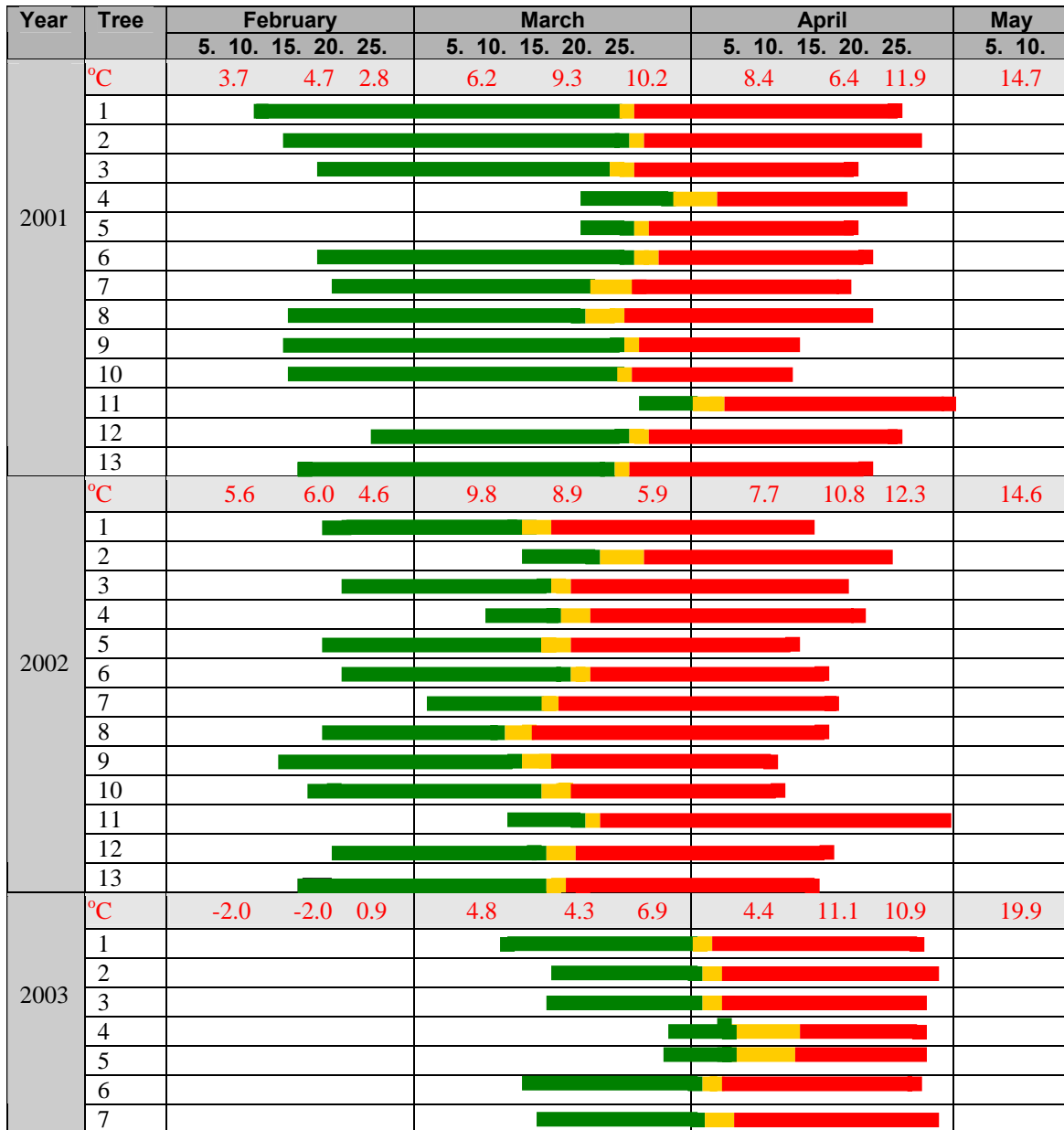
Permanent protogyny was found on two trees and protandry was found on nine trees. One tree (the tree 10) had protogyny in three consecutive years, afterwards it had a very short protandry in one year (it lasted only one day and it was only in one inflorescence), and it had a protogyny again in the following year. Other tree (the tree 6) had protandry one year afterwards it had a very short protogyny in the following year (it lasted two days and it was only in five inflorescences) and it had a protandry three years consecutively (Graph 1. and Graph 2.). TRIPIC (2000) presented similar results for *Acer platanoides* but other trees (trees: 3, 5, 9, 11, 12 and 13). The sex expression of the inflorescences occurred at next seven flowering types of inflorescences: B ($\text{♀} - \text{♂}$), C ($\text{♂} - \text{♀} - \text{♂}$), D ($\text{♂} - \text{♀}$), E (♂ I), F (♂ II), G (♂ I - ♂ II), H ($\text{♀} - \text{♂} - \text{♀}$). The most frequent is C type the rarest being G and H types. The observed protandrous trees always had C type of flowering inflorescence and with this type majority of the trees also had some other type i.e.: C+B; C+D; C+B+D; C+B+E; C+B+H; C+D+E+G

The observed protogynous trees always had B type of flowering inflorescence and with this type they sometimes also had some other type i.e.: B+D; B+F; B+H (Table 6).

Table 5. Frequency of number of flowers in individual inflorescences of the observed trees of *Acer platanoides* L.

Tree	Year	Male flowers		Female flowers		All flowers in an inflorescence		% of male(♂) flowers in an inflorescence	% of ♂ flowers on tree
		min.	max.	min.	max.	min.	max.		
1	2001	9	47	0	18	16	50	42.5 – 100.0	87.0
	2002	8	43	3	26	18	51	32.0 – 92.3	62.1
	2004	6	46	1	16	16	53	37.5 – 97.3	83.2
2	2001	12	45	4	13	18	51	56.0 – 89.4	80.6
	2002	12	43	3	10	19	50	72.4 – 89.6	84.7
	2004	11	36	5	12	16	48	68.8 – 86.8	78.2
3	2001	14	43	0	21	16	54	56.4 – 100.0	77.4
	2002	10	37	3	23	16	53	42.9 – 87.0	66.5
	2004	12	40	5	24	17	57	54.7 – 72.9	68.5
4	2001	16	45	6	29	29	63	37.2 – 78.9	64.2
	2002	16	39	8	37	32	60	33.9 – 75.0	57.8
	2004	17	42	6	31	35	73	33.3 – 86.1	59.6
5	2001	9	48	7	30	20	72	45.0 – 78.4	64.7
	2002	19	54	6	24	27	76	61.9 – 86.7	76.9
	2004	17	53	7	28	24	81	60.0 – 76.5	66.1
6	2001	8	24	6	26	16	48	40.0 – 63.6	48.7
	2002	7	27	6	27	16	52	42.9 – 77.4	61.3
	2004	8	26	7	19	19	47	38.1 – 74.1	56.1
7	2001	8	36	4	34	13	66	30.8 – 70.0	52.3
	2002	14	53	6	24	23	70	51.4 – 77.1	66.2
	2004	9	33	4	27	13	60	53.9 – 69.2	59.5
8	2001	11	46	0	25	16	59	46.3 – 100.0	70.1
	2002	8	43	4	29	16	63	35.7 – 83.3	58.5
	2004	9	39	2	18	15	51	52.9 – 86.7	68.9
9	2001	11	42	4	33	18	76	37.1 – 69.0	56.8
	2002	17	54	6	31	25	80	59.0 – 81.6	70.5
	2004	15	51	5	34	20	74	43.4 – 79.1	61.4
10	2001	9	35	3	18	14	49	60.9 – 83.3	73.7
	2002	8	32	2	17	12	42	57.9 – 100.0	77.5
	2004	9	29	1	17	10	39	56.4 – 90.0	71.8
11	2001	6	55	1	27	11	72	43.6 – 89.1	69.2
	2002	2	57	2	32	12	84	7.1 – 83.3	64.1
	2004	8	57	5	32	16	79	47.9 – 82.8	70.2
12	2001	13	48	4	24	19	66	57.4 – 77.0	66.7
	2002	16	39	3	21	21	59	57.9 – 81.5	70.6
	2004	12	38	4	19	16	55	55.8 – 78.0	64.6
13	2001	7	46	5	29	23	68	25.0 – 78.4	58.6
	2002	9	54	3	35	17	79	22.2 – 81.8	68.8
	2004	12	51	6	27	20	75	50.0 – 76.8	66.6

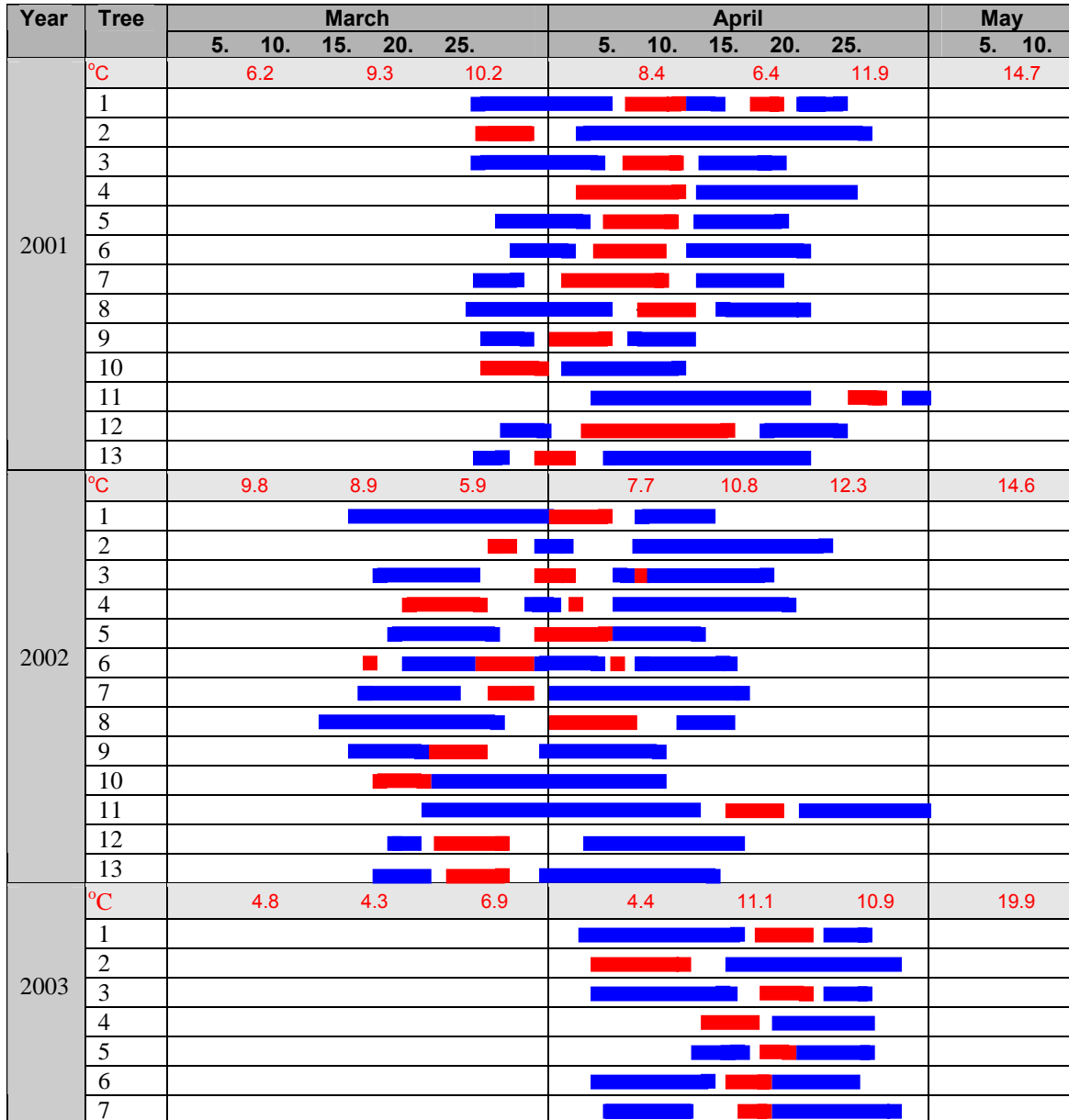
Graph 1. The phenophases: swelling, opening and flowering of buds of individual *Acer platanoides* L. trees

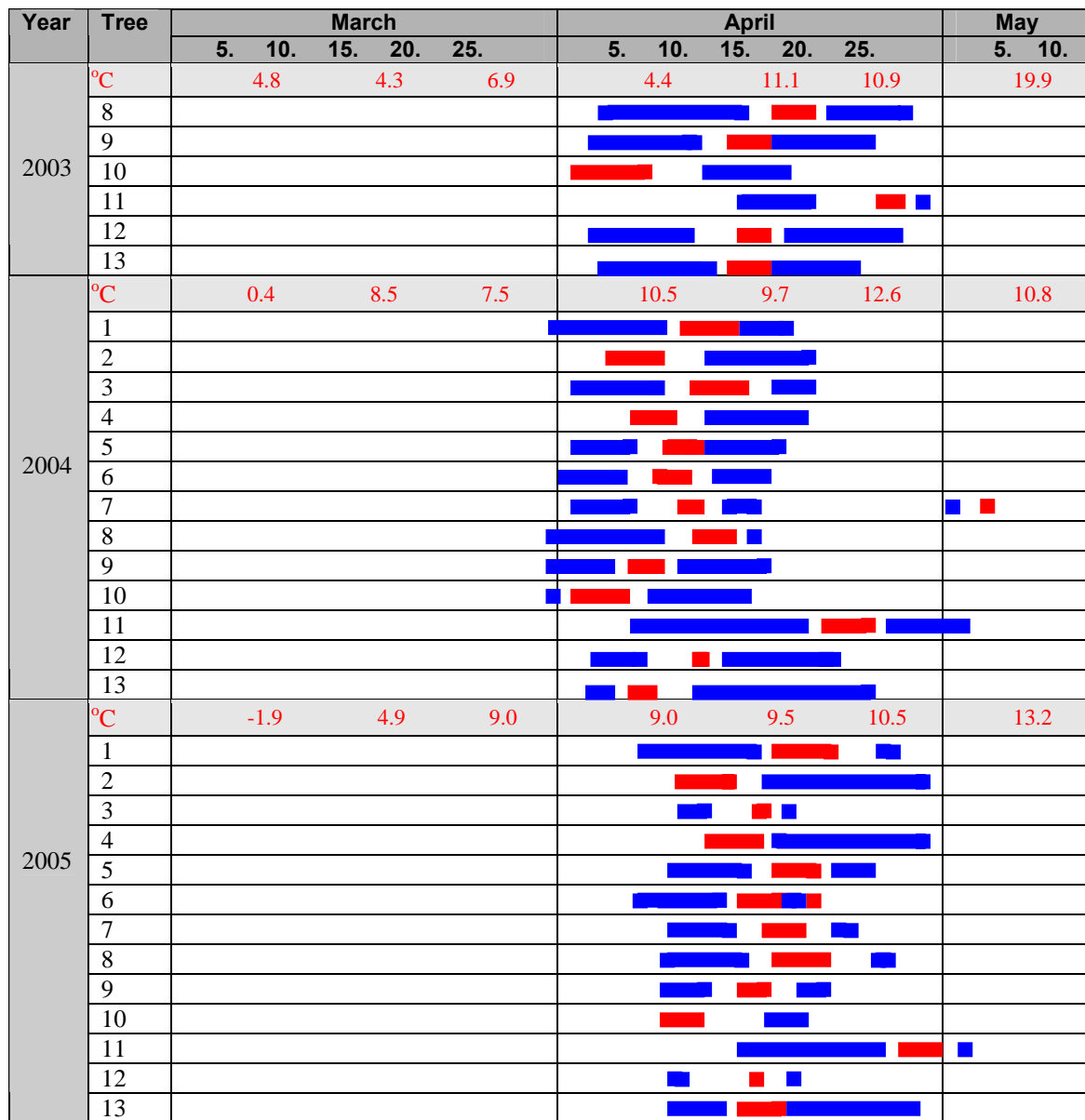




Graph 1.
 Legend: ■ - phenophase of the swelling of the buds;
■ - phenophase of the opening of the buds;
■ - phenophase of the flowering.

Graph 2. The phenophase of the flowering of the observed individual trees of *Acer platanoides* L.





Graph 2.

Legend:

- - phenophase of the flowering of male flowers
- - phenophase of the flowering of female flowers

Table 6. The sex expression of the observed individual trees of *Acer platanoides* L.

Year	Total number of trees	Flowering types of individual trees										
		B	C	B+D	B+F	B+H	C+B	C+D	C+B+D	C+B+E	C+B+H	C+D+E+G
2001	13	2	-	-	1	-	-	8	1	-	-	1
2002	13	2	-	-	1	-	3	4	2	1	-	-
2003	13	-	-	-	1	2	-	5	3	1	-	1
2004	13	2	3	1	-	-	1	6	-	-	-	-
2005	13	1	-	-	1	1	2	5	1	1	1	-

CONCLUSION

The flowers were morphologically falsely bisexual and functionally unisexual. Male flowers have a small rudimentary pistil and well-developed stamens (long filaments and yellow functional anthers), and female flowers have a well-developed pistil and imature stamens (green, hard and non-functional anthers on very short filaments). Phenophase of flowering in observed population begins in different time and lasts 28 - 49 days, and on individual tree 11 - 41 days, depending on weather (especially temperature), number of flowering trees and volume of flowering of each tree. Total number of flowers in individual inflorescence varies from 10 to 84 (male flowers 2 - 57 and female flowers 0 - 37). Quantitative relationship of male and female flowers on single inflorescence is 7.1 - 100 % of male flowers, and also on single trees there is 48.7 - 87.0 % of male flowers. The flowering types of inflorescence that was found: B (♀ - ♂), C (♂ - ♀ - ♂), D (♂ - ♀), E (♂I), F (♂II), G (♂I - ♂II), H (♀ - ♂ - ♀). The most frequent is C type while the rarest are G and H types. Permanent protandry is established on nine trees and permanent protogyny is established on two trees. One tree had protandry in one year and it had protogyny in four years whereas the other tree had protogyny in one year and protandry in four years.

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