



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

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Ključne riječi:

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Synopsis

The paper contains results of research of flowering phenology and sex expression of flowers, inflorescences and single trees of *Acer tataricum* consecutively for 7 years on 15 marked trees in a local population (Grebice) near Nikšić. The flowers were morphologically falsely bisexual and functionally unisexual (male or female). The sex expression of the inflorescences is presented in the following seven flowering types of inflorescences: B type (♀ - ♂) – frequent; C type (♂_I - ♀ - ♂_{II}) – very frequent; D type (♂ - ♀) – very rare, E type (♂_I) very rare and G type (♂_I - ♂_{II}) – rare. Permanent protogyny was found in three trees, protandry in ten trees, while two trees had variable expression.

Sinopsis

PRILOG POZNAVANJU FENOLOGIJE CVJETANJA I POLNE EKSPRESIJE U ACER MONSPESSULANUM L. IZ CRNE GORE

U radu su dati rezultati istraživanja fenologije cvjetanja i polne ekspresije cvjetova, cvati i individualnih stabala *Acer tataricum* uzastopno tokom 7 godina na 15 markiranih stabala u jednoj lokalnoj populaciji (Grebice) blizu Nikšića. Cvjetovi su bili morfološki lažno dvopolni a funkcionalno jednopolni (muški ili ženski). Nađeni su sljedeći tipovi cvjetajućih cvati: B tip (♀ - ♂) – čest; C tip (♂_I - ♀ - ♂_{II}) – vrlo čest; D tip (♂ - ♀) – vrlo rijedak, E tip (♂_I) - vrlo rijedak i G tip (♂_I - ♂_{II}) – rijedak. Stalna protoginija je nađena kod 3 stabla a protandrija kod 10 stabala dok su 2 stabla imala promjenjivu ekspresiju

INTRODUCTION

Morphological and functional variations in the sexuality of *Acer* flowers were studied by a number of explorers. PAX (1886), monographer of *Acer* genus, said that flowers of *Acer tataricum* are andro-monoecious. POJARKOVA (1933), also monographer of *Acer* genus said that flowers of *A. tataricum* are male and bisexual. GUDESKI & DRENKOVSKI (1978) said that flowers of *A. tataricum* 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 flowers of *A. tataricum* are bisexual.

MATERIAL AND METHODS

Flowering phenology and sexual expression of flowers, inflorescences and trees of *Acer tataricum* were observed consecutively in period of 7 years on marked trees (15 trees) in a local population (GREBICE) near NIKŠIĆ. Sexuality of the flowers was determined on basis of their sexual organs functionality. During full anthesis of the flowers all flowers had normally developed stamens and non-well-developed pistils (rudimentary or abortive pistil) are considered to be male. Criteria for female flowers is incompetence for releasing pollen, and in case of releasing pollen such flowers are considered to be bisexual. Such the opinion is represented by a contemporary monographer of *Acer* genus 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 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, 1979).

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 very small rudimentary pistil with normally developed stamens (yellow with functional anthers on long filaments). The female flowers have 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). TRIPIĆ (2006) presents very similar results in *Acer obtusatum* and *A. campestre* and (TRIPIC, 2007, 2009) in *A. monspessulanum* and *A. platanoides*. It is observed, but rarely, that on some trees during the flowering, one or two almost normally developed female flowers, immediately before complete flowering, were transformed into functionally male flowers with illusory normal pistil with abortive ovary which is loose and pallid. Such flowers on first appearance look like bisexual, but in fact they are functionally unisexual male flowers. TRIPIĆ (2006, 2007, 2009) presents very similar results in *Acer campestre*, *A. monspessulanum* and *A. platanoides*. 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 occurred simultaneously flowering of one or two normally developed female flowers are vice versa. The phenomenon was observed on some specimens of *Acer campestre* (TRIPIC, 2006) and on some specimens of *A. platanoides* (TRIPIC, 2009). JONG (1976) presents the phenomenon on the specimen of *A. ginnala*. Otherwise, flowering of the male and female flowers on the same tree is divided in time intervals (except in these rare exceptions). It is dichogamy (male and female parts in same flower or different flowers on the same tree mature at different times).

Table 1: The phenophase of flowering in the observed population of *A. tataricum* L.

Year	Flowering of the individual trees			Flowering of the observed population		
	start	mass	the end	start	mass	the end
1998	14 – 19 May	16 May- 5 June	2 – 8 June	14 May	19 May–3 June	8 June
1999	10– 21 May	13 May–3 June	28 May–6 June	10 May	17 May–1 June	6 June
2000	6 – 14 May	9 May – 1 June	28 May – June	6 May	Not mass	4 June
2001	5 – 18 May	8 – 31 May	26 May–3 June	5 May	15 – 28 May	3 June
2002	3 – 15 May	7 – 29 May	17 May–2 June	3 May	11 – 30 May	2 June
2003	7 – 13 May	10 – 26 May	22 May-10 Jun.	7 May	12– 24 May	10 June
2004	8 – 18 May	11 May– 7June	4 – 12 June	8 May	17 May–5 June	12 June

The beginning of flowering in local population varies from 3 May to 14 May, and the end of flowering varies from 1 June to 12 June (Table 1 and Graph 1).

The observed trees flowered abundantly or enough abundantly 2 - 4 years consecutively and afterwards 1 - 2 years they flowered badly or very badly (with a little or very little of inflorescences on tree). The flowering of the single tree lasted from 13 to 31 days while the flowering of entire population lasted from 26 to 36 days, and that depends of weather conditions, especially the temperature (Graph 1). All protandrous trees (Graph 1; Fig. 1) always had two series of male flowers and one series of female flowers (♂ - ♀ - ♂) while protogynous trees (Fig. 2) had mostly one series of male flowers and one series of female flowers (♀ - ♂). One protogynous

tree had during only one year (Graph 1, tree 11, 2004) two series of female flowers and two series of male flowers ($\text{♀} - \text{♂} - \text{♀} - \text{♂}$). TRIPIC (2006) presents very similar results for *Acer campestre* while *A. obtusatum* mostly had only one series of male flowers and one series of female flowers. Total number of flowers on single inflorescence varies from 7 to 153 (the male flowers in amount from 5 to 144 and the female flowers in amount from 0 to 21 flowers). The inflorescences with only male flowers were relatively rare and the inflorescences with only female flowers were not found.



Figure 1: *Acer tataricum*: Protandrous flowering specimen. Photo: Tripić R.



Figure 2: *Acer tataricum*: Protogynous flowering specimen. Photo: Tripić R.

Table 2: The duration of flowering in the observed population of *A. tataricum* L. (in days).

Year	The observed individual tree			The observed population	
	first series of male (♂) flowers on a tree	female (♀) flowers on a tree	second series of male (♂) flowers on a tree	all flowers on a tree	all observed trees
1998	4 - 13	3 - 6	2 - 8	17 - 22	26
1999	3 - 16	3 - 6	3 - 9	15 - 24	28
2000	2 - 18	3 - 6	4 - 12	15 - 26	30
2001	6 - 19	3 - 6	3 - 11	15 - 23	30
2002	6 - 16	4 - 7	3 - 9	13 - 27	31
2003	3 - 12	3 - 6	1 - 8	14 - 21	26
2004	4 - 21	4 - 7	3 - 10	20 - 31	36

All male flowers of individual trees flowered at least 7 days and at most 24 days, and female flowering at least 3 days and at most 7 days. It is determined that phenophases of flowering of male flowers at all observed trees were significantly longer than phenophases of flowering of female flowers (Table 2, Graph 1). The annual flowering rhythm between observed trees was significantly different.

Quantitative relationship of the male and female flowers on single inflorescence were 50.0 - 100 % of the male flowers, and also on single trees there were 78.0 - 94.1 % of the male flowers (Table 4.).

Permanent protogyny was found on three trees and protandry was found on ten trees (Graph 1). One tree (Graph 1, the tree 1) had protogyny for five years consecutively, afterwards it had protandry for one year. Other tree (Graph 1, the tree 14) had protandry for three years consecutively, afterwards it had protogyny for one year - the following year, and again it had protandry for the three consecutive years (Graph 1). TRIPIĆ (2000, 2009) in *Acer platanoides* presents similar results and in *A. campestre* (TRIPIĆ, 2006) while in *A. obtusatum* and *A. monspessulanum* all protogynous trees have always had protogyny and all protandrous trees have always had protandry during all years of observation (TRIPIĆ, 2006, 2007)

The sex expression of the inflorescences shown at the following five flowering types of inflorescences: B type (♀ - ♂) – frequent; C type (♂_I - ♀ - ♂_{II}) – very frequent; D type (♂ - ♀) – very rare, E type (♂_I) very rare and G type (♂_I - ♂_{II}) – rare.

Table 3: Level of flowering (number of flowers on a tree) of individual trees of *A. tataricum* L. during a year

Year	Total number of trees N	Level of flowering					
		non-flowering	very low	low	medium	high	hery high
1998	15	2	-	-	3	7	3
1999	15	3	1	-	5	4	2
2000	15	1	4	1	7	2	-
2001	15	-	-	-	4	6	5
2002	15	-	-	-	4	7	4
2003	15	1	-	-	9	4	1
2004	15	-	-	-	3	7	5

On the single trees the following flowering types of inflorescences were observed: only C type; mixed types: B+C, B+E, B+C+E, B+C+E+G, C+B, C+D, C+G, C+B+G, C+D+G (Table 5).

JONG (1976) presents for *Acer tataricum* that one specimen produced only B flowering type and other specimen produced inflorescences of C type, occasionally mixed with type D, while HAAS (1933) according to the quotation of JONG (1976) for *A. tataricum* presents only specimens with B and specimens with D flowering type.

Table 4: Frequency of number of the flowers in the individual inflorescences of the observed trees of *Acer tataricum* L.

Tree	Year	Male flowers		Female flowers		All flowers in an inflorescence		% of male flowers in an inflorescence	% of male flowers on a tree
		min.	max.	min.	max.	min.	max.		
1	2000	21	85	0	9	22	88	76.5 – 100	91.4
	2004	17	96	0	12	19	102	78.3 – 100	92.1
2	2000	13	76	1	10	14	82	66.7 – 100	88.2
	2004	7	61	0	8	10	66	65.2 – 100	88.8
3	2000	12	87	0	15	14	97	80.0 – 100	89.0
	2004	16	82	1	14	21	96	71.7 – 97.1	85.7
4	2000	34	111	1	19	39	129	83.8 – 97.9	89.6
	2004	5	62	2	13	7	70	69.4 – 93.8	84.8
5	2000	23	76	4	15	27	88	70.6 – 90.7	83.1
	2004	10	48	1	16	15	56	50.0 – 95.7	78.0
6	2000	17	56	0	16	17	63	68.1 – 100	82.3
	2004	14	54	4	17	21	66	64.3 – 88.9	78.9
7	2000	10	55	0	9	14	63	76.4 – 100	89.8
	2004	7	42	0	8	11	47	70.8 – 100	86.4
8	2000	27	73	4	18	31	84	71.0 – 90.7	81.1
	2004	24	71	2	18	29	82	69.3 – 94.6	82.4
9	2000	13	74	1	14	17	81	74.8 – 97.5	86.9
	2004	14	70	0	15	20	78	71.7 – 100	84.6
10	2000	-	-	-	-	-	-	-	-
	2004	14	63	1	12	17	69	70.5 – 96.2	83.9
11	2000	16	69	0	13	19	76	70.6 – 100	84.9
	2004	14	66	0	16	18	77	68.9 – 94.3	82.1
12	2000	13	144	0	19	18	153	85.9 – 100	94.1
	2004	15	139	0	16	20	148	81.7 – 100	92.9
13	2000	12	97	1	21	19	111	65.0 – 94.5	80.6
	2004	10	52	0	18	17	65	50.0 – 100	78.4
14	2000	20	107	2	16	26	117	75.4 – 97.2	86.6
	2004	17	88	3	18	21	100	68.0 – 90.9	80.3
15	2000	15	98	1	15	22	106	67.9 – 100	85.1
	2004	16	104	1	16	23	113	70.0 – 90.0	83.3

The protandrous trees mass-produced C type, rarely B type and G type, and very rarely D type. The protogynous trees mass-produced B type and very rarely E type and C type (Table 5).

Table 5. The sex expression of the observed individual trees of *Acer tataricum* L.

Year	Total number of trees N	Flowering types of individual trees									
		B+C	B+E	B+C+E	B+C+E+G	C	C+B	C+D	C+G	C+B+G	C+D+G
2000	14	-	2	1	-	4	2	1	2	2	-
2004	15	1	1	1	1	6	1	-	1	2	1

CONCLUSION

Morphologically, the flowers were falsely bisexual and functionally unisexual. Male flowers have small rudimentary pistil and well-developed stamens (long filaments and yellow functional anthers), and female flowers have well-developed pistil and immature 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 the flowers in individual inflorescence varies from 10 to 84 (male flowers 2 to 57 and female flowers 0 to 37). Quantitative relationship of the male and female flowers on single inflorescence was 50.0 - 100 % of the male flowers, and also on single trees there is 78.0 - 94.1 % of the male flowers. The flowering types of inflorescence that was found: B type (♀ - ♂) – frequent; C type (♂_I - ♀ - ♂_{II}) – very frequent; D type (♂ - ♀) – very rare, E type (♂_I) very rare and G type (♂_I - ♂_{II}) – rare. On the single trees the following flowering types of inflorescences were observed: only C type; mixed types: B+C, B+E, B+C+E, B+C+E+G, C+B, C+D, C+G, C+B+G, C+D+G (Table 5).

Permanent protogyny was found on three trees and protandry was found on ten trees while two trees had changeable of expression.

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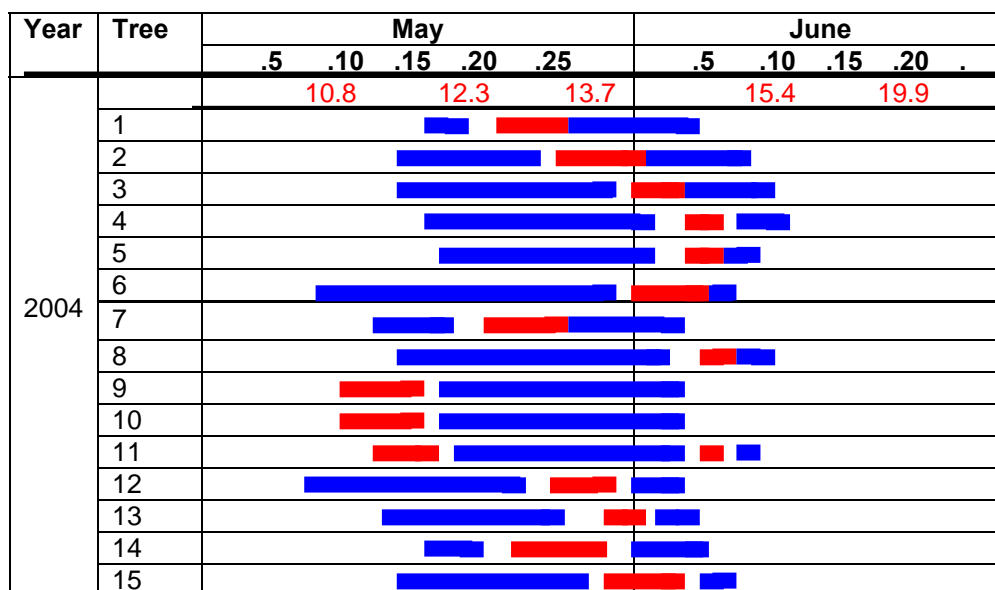
Graph 1: The phenophase of the flowering of the observed individual trees of *Acer tataricum* L

Year	Tree	May					June				
		.5	.10	.15	.20	.25	.5	.10	.15	.20	.
1998				13.3	14.4	14.2		20.1		15.9	
	1	Not flowered									
	2										
	3										
	4										
	5										
	6										
	7										
	8										
	9										
	10										
	11	Not flowered									
	12										
	13										
	14										
15											
1999				14.9	15.8	16.8		21.1		19.5	
	1										
	2										
	3										
	4										
	5										
	6										
	7										
	8										
	9										
	10	Not flowered									
	11										
	12										
	13	Not flowered									
	14										
15	Not flowered										
2000				14.5	17.1	17.4		20.3		21.1	
	1										
	2										
	3										
	4										
	5										
	6										
	7										
	8										
	9										
	10	Not flowered									
	11										
	12										
	13										
	14										
15											

Graph 1. continued

Year	Tree	May				June				
		.5	.10	.15	.20	.25	.5	.10	.15	.20
2001				14.7	14.4	18.6	15.6	18.5		
	1									
	2									
	3									
	4									
	5									
	6									
	7									
	8									
	9									
	10									
	11									
	12									
	13									
	14									
15										
2002				14.6	15.8	15.0	15.9	21.8		
	1									
	2									
	3									
	4									
	5									
	6									
	7									
	8									
	9									
	10									
	11									
	12									
	13									
	14									
15										
2003				19.9	17.8	17.4	19.7	23.4		
	1									
	2									
	3									
	4									
	5									
	6									
	7									
	8									
	9									
	10									
	11									
	12									
	13									
	14									
15										

Graph 1. continued



Legend: ■ - phenophase of the flowering of the male flowers
■ - phenophase of the flowering of the female flowers

