

SEED MASS OF BIOGEOGRAPHICALLY DISTINCT POPULATIONS OF *Impatiens parviflora* DC.

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Abstract: Aim of the study was to compare seed mass data among and within populations of *Impatiens parviflora* located in Poland and Hungary. Seeds were collected from four and three distinct populations from Poland and Hungary, respectively. One of the Hungarian populations was sampled twice by distinguishing early and late seed sets, thus altogether eight seed samples were collected. From each sample five lots of 50 seeds were separated then measured with 0.01 mg accuracy. Data were statistically compared using standard univariate tests. Thousand seed mass of the studied small balsam populations ranged between 4.297 g and 7.279 g. Seed mass data were found to be similar for seven samples in the among population comparisons, but the eighth one, expressing the lightest seeds (collected at Vadálló rocks, Hungary) differed significantly from them. Grand mean of the four Polish populations was higher than grand mean of the Hungarian samples, 6.721 g and 5.968 g, respectively. Possible effect of seed mass on the colonization success of small balsam was discussed. Drought prevailing for some weeks seems to cause decrease on the seed mass of *I. parviflora*, but further studies are needed for satisfactory determination of this relationship.

Introduction

Small balsam (*Impatiens parviflora* DC.) is a native of stream and riversides, ravines, stony mountain slopes and moist, shady places in central Asia. Following cultivation in Botanical Garden at Geneva in 1831, it became an escape and widely naturalized in eastern, central and northern Europe including Britain (COOMBE 1956). In Hungary, it was first recorded in 1891 (BORBÁS 1891), and its recent distribution was summarised by CSISZÁR (2004). In Poland, it appeared few decades earlier, in the middle of 1850s and become one of the most invasive species of the country (TREPL 1984).

According to COOMBE (1956) European populations of small balsam show little genetic variability, but his statement concerns only for differences that have (infra specific) taxonomic significance. More recently KOMOSIŃSKA et al. (2006) made direct genetic investigations on two Polish populations and found them very similar. In spite of genetic uniformity, a high rate of morphological plasticity of small balsam was documented in several studies concerning size variability, regenerative capacity and other features (CSISZÁR 2006, CHMURA 2008, KLIMKO et al. 2009). Notwithstanding of its pronounced plasticity small balsam is known to be a weak competitor but germinates in a high rate and this is the major drive of its spread.

Seeds are generally considered as a conservative, less variable organ than any of the vegetative parts of a species (HARPER 1977). However, recent studies demonstrated that seed size vary among populations of a species in connection with extrinsic factors (e.g. elevation, latitude, habitat type, hoarding behaviour of rodents), although intrinsic

factors (mother plant size, leaf area, mean seed number per fruit, etc) might cause even larger variation (WULFF 1986, OBESO 1993, VAUGHTON and RAMSEY 1998, KOLLMANN and BAÑUELOS 2004, TAMURA and HAYASHI 2008, DENISIUK et al. 2009, GUO et al. 2010).

For *I. parviflora* seed mass records vary from 6.91 to 9 g for thousand seeds according to the database of Royal Botanic Gardens Kew (RBG 2008). Although Moravcová et al. (2010) reported on lighter seeds of *I. parviflora* (5.69 g) from Czech Republic, its seed mass variation still seems to be moderate comparing to several other species. A possible reason behind the relative uniformity of seed mass of *I. parviflora* could be related to the general uniformity of this species regarding several plant traits (what could have an ultimate connection with its relatively sudden spread as neophyte across Europe). An other reason could be the lack of critical amount of seed mass data published in the literature.

Aim of this study was to collect and compare further seed mass data from distinct populations of *I. parviflora* allocated in Hungary and Poland.

Materials and methods

Seed samples of *Impatiens parviflora* were collected at full-ripe stage, at three localities in Hungary and at four localities in Poland, during summer and autumn in 2011. At one of the Hungarian localities early seeds and late seeds were collected separate thus forming 4–4 seed samples from both countries (see Table 1).

Collected seed samples were kept in paper bags under room temperature conditions to the date of measurements. During storage weight of seeds were monitored till the moment when it is stabled then five-five 50-seed lots were formed from each sample and their weight measured with ‘Sartorius’ analytical balance at 0.01 mg accuracy.

Seed mass data were statistically compared using ANOVA followed by Tukey-Kramer multiple comparisons test. Grand means of the seed masses for Hungarian and Polish populations were compared by using Student *t*-test. Normality of data and homogeneity of variance were analyzed by Shapiro-Wilk and Levene test, respectively. Differences between means at probability lower than 0.05 ($p < 0.05$) were considered significant (INSTAT 2003, R DEVELOPMENT CORE TEAM 2011).

Results

Average seed mass and its standard deviation determined for each sample are shown in Table 2 and Figure 1. The lightest seed mass was found in the Hungarian population at Vadálló rocks (H1), whereas the most heavy seeds characterized the Polish population (P3) collected in the Beskid Żywiecki Mts. Grand mean seed mass of the four Hungarian samples were also lighter than the corresponding value for Polish populations (5.9682 g and 6.7207 g, respectively), and the difference was significant ($t = -2.0451$, $P = 0.04846$).

Results of the statistical comparisons among the eight samples are summarized in Figure 1. Mean seed mass differences were not significant in any combinations among seven samples. However, seeds collected at the Vadálló rocks in Hungary (H1) differed significantly from all of the samples originated from Poland and also from further two samples collected in Hungary. The H1 population had the smallest seed mass value anyway.

Table 1. Basic parameters of the study sites where seed samples of *Impatiens parviflora* were collected. H1-4: samples collected in Hungary; P1-4: samples collected in Poland

1. táblázat Az *Impatiens parviflora* magtétélek gyűjtési helyeinek alapadatai

H1-4: Magyarországon gyűjtött minták; P1-4: Lengyelországban gyűjtött minták

Code	Geographic name of locality; and vegetation type	GPS co-ordinates	Size of sampled population	Nr of individuals harvested	Sampling date
H1	Vadálló rocks, Visegrádi Mts, Hungary; beech, lime and hornbeam forest; <i>Mercuriali-Tiliatum</i>	N 47° 44' 22'' E 18° 54' 50'' 480 m a.s.l.	10000	300	24. Aug. 2011.
H2	Rumi forest at river Rába, Hungary; managed oak-ash-elm floodplain forest	N 47° 06' 41'' E 16° 50' 45'' 170 m a.s.l.	10000	300	02. Sep. 2011.
H3	Kis-Sváb Hill, Budai Mts, Hungary; road side vegetation	N 47° 30' 12'' E 19° 00' 47'' 220 m a.s.l.	1000	200	22. Jul.- 03. Aug. 2011. early seeds
H4	Kis-Sváb Hill, Budai Mts, Hungary; road side vegetation	N 47° 30' 12'' E 19° 00' 47'' 220 m a.s.l.	1000	200	05-31. Aug. 2011. late seeds
P1	Katowice, Poland; managed forest with <i>Pinus sylvestris</i>	N 50° 12' 8.31'' E 18° 57' 26.13'' 237 m a.s.l.	1000	300	04-05. Sep. 2011
P2	„Bukowica” nature reserve near Wygierzów, Poland; beech forest <i>Dentario glandulosae</i> <i>Fagetum</i>	N 50° 4' 45.81'' E 19° 24' 59.48'' 310 m a.s.l.	10000	200	18. Sep. 2011
P3	Soblówka near Ujsoły, in the Beskid Żywiecki Mts., Poland; spruce forest	N 49° 26' 13.6'' E 19° 08' 33.7'' 660 m a.s.l.	1000	200	20. Sep. 2011
P4	„Skala Kmity” nature reserve, Zabierzów near Kraków, Poland; oak-hornbeam forest <i>Tilio-Carpinetum</i>	N 50° 06' 13.24'' E 19° 49' 8.06'' 237 m a.s.l.	10000	200	18. Sep. 2011

Standard deviation of seed mass within populations ranged from 0.2152 to 1.5180 (for H2 and P1, respectively) with an average of 0.8213. Standard deviation of seed mass among populations (based on the 8 values of sample means) was 0.9133, however it dropped to 0.4178 when the extreme low data of the population at Vadálló rocks was excluded.

Table 2. Thousand-seed mass records (in grams) of geographically distinct *Impatiens parviflora* populations collected in Hungarian (H1-4) and Polish (P1-4) localities. R1-5= indicate replicates collected from the same population; S.D.= standard deviation

2. táblázat A földrajzilag elkülönülő *Impatiens parviflora* populációk ezermagtömeg adatai (grammokban kifejezve). H1-4= Magyarországon gyűjtött, illetve P1-4= Lengyelországban gyűjtött magtétélek. R1-5= az azonos magtétélekből (populációkból) származó ismétléseket jelöli. S.D.= standard eltérés

	H1	H2	H3	H4	P1	P2	P3	P4
R1	3.636	6.700	8.160	5.554	7.532	6.784	7.652	6.922
R2	3.488	6.928	4.720	5.698	8.924	7.054	8.280	6.606
R3	4.998	7.142	7.352	6.242	6.724	6.124	7.706	6.846
R4	4.840	6.582	7.836	5.362	5.322	6.008	7.058	6.212
R5	4.522	6.826	5.726	7.052	5.392	5.472	5.698	6.098
Average	4.2968	6.8356	6.7588	5.9816	6.7788	6.2884	7.2788	6.5368
S.D.	0.6943	0.2152	1.4747	0.6820	1.5180	0.6332	0.9839	0.3697

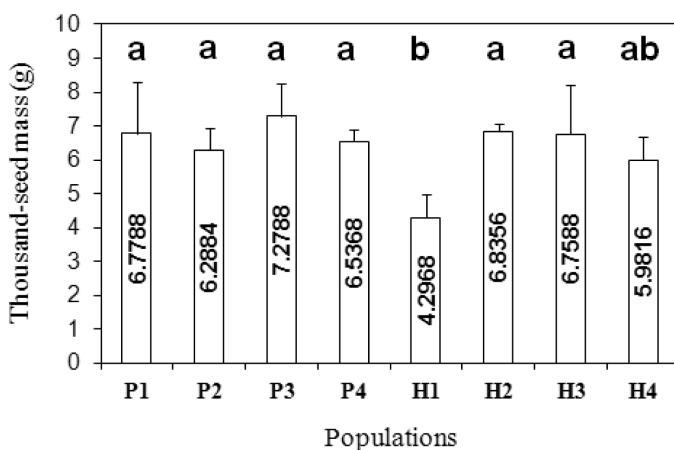


Figure 1. Average thousand-seed mass records of geographically distinct *Impatiens parviflora* populations from Hungary (H1-4) and Poland (P1-4). Bars and sections indicate means and standard deviation. The same letters above bars means that values do not differ at $p < 0.05$

I. ábra Átlagos ezermagtömeg értékek a földrajzilag elkülönülő, Magyarországról (H1-4), illetve Lengyelországból (P1-4) származó *Impatiens parviflora* allományokra vonatkozóan. Az átlagokat mutató oszlopok tetejére helyezett szakaszok a megfelelő S.D. értékeket jelzik. Az oszlopok felett álló eltérő betűk a szignifikánsan elkülönülő mintákra utalnak $p < 0,05$ hibahatár mellett

Discussion

Seed mass data of seven samples studied in this work fell within the range of published data for *I. parviflora*. Seed mass of 4.2968 g obtained for the population at Vadálló rocks is the lowest record yet published for small balsam. This population is relatively young,

originated from an introduction at the end of the third quarter of the last century, and was characterized by severe self thinning during dry summer periods (CSONTOS 1984, 1986a).

Apart from one Hungarian sample, seed mass data of *I. parviflora* were similar in statistical sense and it corresponds with relative stability of seed traits in general, as discussed by HARPER (1977). More pronounced differences were found regarding vegetative organs, number of flowers and number of seeds of *I. parviflora* in a study carried out on Polish populations (CHMURA 2008). However, the somewhat larger grand mean of the Polish samples is noteworthy and might be a sign of more suitable environmental conditions for *I. parviflora* in Poland than in Hungary. Since reproduction of small balsam, an annual herb, can rely on seeds only, larger seed mass in Poland might also be related to its wider distribution and more pronounced invasive behaviour in Poland. Indeed, TREPL (1984) found that very small seeds of *I. parviflora* showed limited germination rate compared to medium and large sized seeds.

For the studied *I. parviflora* stands, standard deviation of seed mass among populations exceeded the average value of within population deviation. However, with the exclusion of the extreme low mean seed mass data of the population at the Vadálló rocks among population standard deviation of seed mass dropped considerably and in this case it became smaller than within population standard deviation. Considering studies on other species, in case of *Plathymenia reticulata* seed mass differed in a greater extent within populations than between populations (GOULART et al. 2006), but results concerning *Primula elatior* showed opposite trend (JACQUEMYN et al. 2001).

The unique behavior of the small balsam population at Vadálló rocks needs some further remarks. Weeks preceding seed collection were extreme dry in the Vadálló rocks region, precipitation in August was only 30–40% of the 30-years average (calculated for years 1971–2000; data from Hungarian Meteorological Service). For *I. glandulifera*, negative correlation between **seed mass and the heat sum over the period of seed maturation** was already reported (WILLIS and HULME 2004). Thus, shortage of water could also have an effect on seed size of small balsam, in the given season. Seed size dependence on draught was supported by the results obtained for early and late samples of the Kis-Sváb Hill population with the latter sample (collected in August) being lighter. It could also be possible that small seed size is a constant character of the population at Vadálló rocks, which lies rather isolated in a hilly country stand of hardwood forest (see site description in CSONTOS 1986b), and has limited connection with other *I. parviflora* populations that are found at much lower altitude along the banks of the river Danube. Variation of small balsam's seed mass would worth for studying through some consecutive years in the light of meteorological data.

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MAGTÖMEG VIZSGÁLATOK AZ *Impatiens parviflora* DC. KÜLÖNBÖZŐ
NÖVÉNYFÖLDRAJZI RÉGIÓKBAN ÉLŐ POPULÁCIÓIBAN

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Kulcsszavak: inváziós fajok, populációk összevetése, magtömeg, kisvirágú nebáncsvirág

Összefoglalás: Jelen dolgozat célja az *Impatiens parviflora* lengyelországi és magyarországi populációiból származó magtömeg adatok összehasonlító statisztikai elemzése. A vizsgált faj magvait négy lengyelországi és három magyarországi populációból gyűjtöttük be 2011. július és szeptember között. Az egyik magyarországi populációból két alkalommal is gyűjtöttünk – megkülönböztetve a korai és a késői magtermést – s így összesen nyolc magtételhez jutottunk. Minden egyes magtételből 5 db 50 magos mintát különítettünk el, majd azokat le-mértük 0,01 mg pontosságú digitális gyorsmérlegben. A kapott magtömeg adatokat általánosan elterjedt, egyvál-tozós statisztikai tesztekkel elemeztük. A vizsgált kisvirágú nebáncsvirág populációk ezermagtömegei 4,297 g és 7,279 g között változtak. A magtömeg adatok hét magtétel esetében, a populációk közötti összehasonlításban statisztikai értelemben nem különböztek, azonban a nyolcadik (a Vadálló-köveknél gyűjtött) minta magtöme-ge szignifikánsan eltért a többitől és a legkisebb ezermagtömegűnek bizonyult. A négy lengyel populációból származó magtétel ezermagtömegeinek nagytárgya (6.721 g) meghaladta a magyarországi magtételek esetében kapott nagytárgyat (5.968 g). Az eltérés lehetséges okai, és a magtömeg vélhető összefüggése a faj kolonizációs sikerével megvitatásra kerültek. Végül, arra utaló adatokat is kaptunk, hogy a termésérési időszakban bekö-vetkező néhány hetes aszály korlátozza az *Impatiens parviflora* magtermelését és kisebb ezermagtömeget eredményezhet, de az összefüggés pontosabb meghatározásához további vizsgálatok szükségesek.

