Scientific Papers. Series B, Horticulture. Vol. LIX, 2015
Print ISSN 2285-5653, CD-ROM ISSN 2285-5661, Online ISSN 2286-1580, ISSN-L 2285-5653

CHARACTERISTICS OF INVASIVE TAXA OF *PARTHENOCISSUS* IN THE BUDA ARBORETUM, HUNGARY

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Abstract

There are 15 species in the genus of Parthenocissus (Krüssmann, 1989), some of them (Parthenocissus inserta, P. quinquefolia, P. tricuspidata) were used as hardy, decorative outdoor ornamental climbing shrubs in Hungary (Priszter, 1997; Tóth 2012). These invasive plants can spread spontaneously and cause ecological, maintenance problems in several gardens and public parks, among others in the Buda Arboretum, were different kind of characteristics of four Parthenocissus taxa were examined during two years (2012 and 2013). Biological features of reproduction (crop yield, seed viability, germination capacity), aptitude of spontaneous spreading (ground-space and number of plants, density of seedling under the mother plant) and maturation (coloration, shedding and soluble dry weight of fruits) were examined to determine their invasion capacity. P. tricuspidata produced the highest and P. inserta developed the lowest number of fruits. Seed viability was the largest in the case of P. quinquefolia (100%), and every taxon has got high capacity of germination (especially if the soft part of fruits – which usually contain germination inhibitors – was removed). The highest numbers of individuals were obtained on the case of P. quinquefolia (35 plants), this species covered 499 m^2 horizontal and 157 m^2 vertical area. The second was P. tricuspidata with 17 individuals, 158 m^2 horizontal and 2603 m^2 vertical area, followed after the other 2 species (P. inserta, P. tricuspidata 'Veitchii') with 143 and 32 m^2 ground-space covered by 17 and 4 plants. Fruits of P. tricuspidata 'Veitchii' were colored the earliest and fallen the latest (unlike P. inserta, which produce the latest fruit-colorization and the earliest shedding). There were not significant differences between soluble dry weight of every Parthenocissus fruits (6,3-7,6%).Taxa with more individuals and ranges were qualified as more invasive than the other ones with lower values. This qualification was directly proportional to the number of seedlings under the originally planted parents as well as the fruit quantity and the germinable of seeds, but not correlated with soluble dry weight and taste of fruits (in which there were not significantly differences between the taxa).

Key words: *invasive, Parthenocissus, Buda Arboretum.*

INTRODUCTION

Invasive species can spread aggressively in new habitats, and ecologically, economically damage native biomes (Mihályi and Botta-Dukát, 2004), probably thanks to the climate change and human impacts (Csiszár, 2012).

Not every introduced species can invade new areas; most of them are not dangerous for endemic floras or faunas (Mihályi and Botta-Dukát, 2004). At the same time; more and more researchers execute studies and publish results about invasive taxa. Nowadays, a special journal is available connected with invasive species: Biological Invasions (Dancza, 2012). Bulletins, regulations pertain to invasive plants were included in international environmental agreements and internal law (Genovise and Shine, 2007).

Parthenosissus (with 15 species) belonged to the *Vitaceae* family (Krüssmann, 1989). In Hungary, *Parthenocissus inserta, P. quinquefolia, P. tricuspidata* species and its cultivars were used as outdoor ornamental climbing shrubs (Priszter, 1997; Tóth, 2012). We can find them in the Buda Arboretum, where spontaneous invasion of *Parthenocissus* taxa often cause difficulties in horticultural works. There is no concrete data about introducing; perhaps these vines were firstly planted at the beginning of 19 century.

Parthenocissus quinquefolia is native to East part of North America. It is a strong climbing shrub with palmately compound leaves (which contains 5 leaflets), bifurcated tendrils and adhesive disks at the end of the tendrils. This species was come to Europe in 1887.

Parthenocissus inserta is very similar *to P. quinquefolia* (with the same origin and without disks). It was transferred to Europe in 1922.

Parthenocissus tricuspidata is originated in Japan, China and Korea. Juvenile leaves are 3-lobed, adult forms has trefoil ones. There are several varieties of this species, one of the most widespread and old-established, Japanese cultivar is 'Veitchii', a juvenile type (Krüssman, 1989).

The aim of our study was to examine invasion capacity of *Parthenocissus* taxa in the Buda Arboretum.

MATERIALS AND METHODS

Experiments were carried out in the Buda Arboretum of Corvinus University Budapest during 2012-2013. Separation of *P. quinquefolia* and *P. inserta* individuals was unambiguous but in the case of *P. tricuspidata* only grafted, older plants or seedlings with more intensive autumn-coloration were registered as cultivar 'Veitchii'. The other ones (non-grafted or less colourful seedlings) were recorded as the original species named *P. tricuspidata*. There were 3 main groups of the examinations according to the reproductive capacity, spreading and fruit maturation.

1. Examination of reproductive capacity

Yield, seed viability and germination were investigated.

To determine of <u>yield</u> (with a scale division from 1 to 5), fruits number/1 m^2 area of mother plant was estimated. The values of scale were: 1=0-20 fruits/m^2, 2=20-40 fruits/m^2, 3=40-60 fruits/m^2, 4=60-80 fruits/m^2, 5=80-100 fruits/m^2.

20-20 seeds were randomly collected from every taxon (before assessing of germination) and after peeling of the seed coat, <u>rate of viable/unviable seeds</u> was determined visually.

For examining <u>germination</u>, in 2012 (October) 20-20 seeds were gathered again from all taxon. As stratification, 10-10/10-10 seeds with/without pulp were sown into trays filled with sand. Furthermore, every trays were recessed and covered by Raschel net and leaf-litter (stratification procedure was placed in outdoor). After stratification, all seeds were transferred to chernozem soil with lime deposit in 2013 (April). Irrigation and examinations were done weekly. The last time of monitoring was at 3rd May (2013), after it every seedling were eliminated.

2. Examination of spreading

During examination of spontaneous spreading of *Parthenocissus* taxa in the Buda Arboretum, monitoring of occurrence, measuring of covered areas and determining of density of seedlings (under their mother plant) were done.

In the case of <u>monitoring of occurrence</u>, originally planted (usually elder) specimens were marked by the help of the map of the arboretum. After this, the other (e.g. newly hatched, young, spontaneously appeared) plants were counted and registered. Results of this monitoring were recorded on the map (with colourful spots), and all plant were photographed. Horticultural works (e.g. weeding, wood-cutting) and constantly varying stock made our research more difficulties were. Some specimen (which was registered in 2012) was resected in 2013.

During measuring of covered areas, plants were measured horizontally and vertically (with a metric rod) so thus their covered areas were calculated. In addition, age of plants was appreciated (if precise data were not found about it).

To determine <u>density of seedlings</u>, we used a 1 x 1 m sized frame (which was placed under the chosen mother plants), and all seedlings were counted within. Counting was repeated 3 fold (namely 3 different part under the mothers). Total number of seedling was calculated by the following formula:

Total number of seedling=total covered area of seedlings (m^2) x (seedling number/m^2).

3. Examination of fruit maturation

Coloration, dropping, taste and soluble dry weight of fruits were examined.

Monitoring (and photographing) of fruit coloration and dropping was done weekly, from 24th August 2012 to 14th December 2012. Results were illustrated on Figure 4.

In order to ascertain bird's choice (i.e. which *Parthenocissus* produce the best fruit for birds), soluble dry weight of collected fruit was determined in the laboratory of Department of Applied Chemistry (Faculty of Food Science, Corvinus University Budapest) in 2013 (November). For measuring, PAL-1 (Atago Corporation, Tokyo, Japan) portable digital refractometer was used. Soluble dry weight (%) is current for defining sucrose contents of solutions (Fodor, 1971; Kovács, 2012). During the examination, 2 g fruits (from all taxa) and equal quantity (Milli-Q 18.2 MΩcm) distilled water (DV) was measured by Precisa 40MS-200A analytical balance. After it, fruits (mixed with DV) fractured and homogenised in braying mortar. Finally, filter-liquor was separated from the homogenous suspension, and 3 drops were used for refractometric analyses.

In 2013 (autumn) we degusted the fruits, and tastes (sweet, bitter, acidic) were recorded with a scale range from 1 to 5 (Table 3). Range 1 was: the less sweet or bitter or acidic, range 5 was: the sweetest or bitterest or the most acidic.

RESULTS AND DISCUSSIONS

1. Examination of reproductive capacity

Results were shown on Table 1. *Parthenocissus tricuspidata* produced the highest and *P. inserta* the lowest number of fruits. It is an important factor, because plants with higher yield commonly produce more seedlings. Moreover, birds (which are often take part in spreading plants) often prefer plants taxa with more fruits or seeds.

In 2012, rate of viable seed was the highest (100%) in the case of *P. quinquefolia* (in 2012), and 20 % of *P. tricuspidata* 'Veitchii' seeds were unviable. Next year, all (100%) seeds of *P. inserta* and *P. quinquefolia* was viable, and 90% in the case of the others (*P. tricuspidata* and *P. tricuspidata* 'Veitchii'). Not only higher yield, but producing more viable seeds is important for successful spreading.

Viable seeds germinated fast and well in the case of every *Parthenocissus* taxa. Although there were not significant differences between the groups, germination ratio was higher if pulp (which probably contained inhibitors) was removed from fruits.

Table 1. Values of reproductive capacity of *Parthenocissus* species and cultivars (Buda Arboretum, 2012)

Taxon	Yield (estimated values)	Seed viability (%)	Germination capacity of seeds (with pulp) (pcs/20pcs)	Germination capacity of seeds (without pulp) (pcs/20pcs)	Endurance of fruits (days)	Seedling number under their mother plant (pcs)
P. inserta	3	100	11	12	56	5
P. quinquefolia	4	100	10	15	63	10
P. tricuspidata	5	90	14	18	70	20
P. tric. 'Veitchii'	4	90	12	14	77	10

2. Examination of spreading

a) Spreading in the Buda Arboretum

As we can see on Figure 3, every *Parthenocissus* taxa widespread all part of the Buda Arboretum and numerous seedlings were found mainly on the wall of the buildings, on the retaining walls, on the surface of larger rocks and on the fences.

In the bottom part of the arboretum, mostly *P. quinquefolia* and *P. tricuspidata* plants were found. In particular, the latter species grown on the wall of buildings, on the other hand, *P. quinquefolia* mainly crept up the trees, shrubs or the retaining walls (but sometimes grown horizontally on the grass).

P. tricuspidata 'Veitchii', *P. inserta* and *P. quinquefolia* covered large areas in the upper part of the arboretum. For example *P. tricuspidata* 'Veitchii' mainly grown on the building 'E' (Figure 1),

Figure 1. *Parthenocissus tricuspidata* 'Veitchii' on building 'E' (Buda Arboretum) (photo: Végh, 2012)

P. quinquefolia preferred fence near Ménesi Street (Figure 2), and on the grass, trees and shrubs mainly *P. inserta* plants were found.

Figure 2. Information board and fence was covered by *Parthenocissus quinquefolia* (Buda Arboretum) (photo: Végh, 2012)

Taxa with larger areas (and longer spread distances) have higher capacity of invasion. However, if spread distances of (invasive) mother plants were increased, the new plants (seedlings) were not always their offsprings.

The number and composition of invasive plants is continuously change due to the reserving works in the Buda Arboretum. Some cases, new plants were not found at the next occasion (probably these plants were weeded out).

Even so, all plants were registered on the map. By the way, some specimens of *Parthenocissus* can develop new shoots next year in the case of unsuccesful weeding.

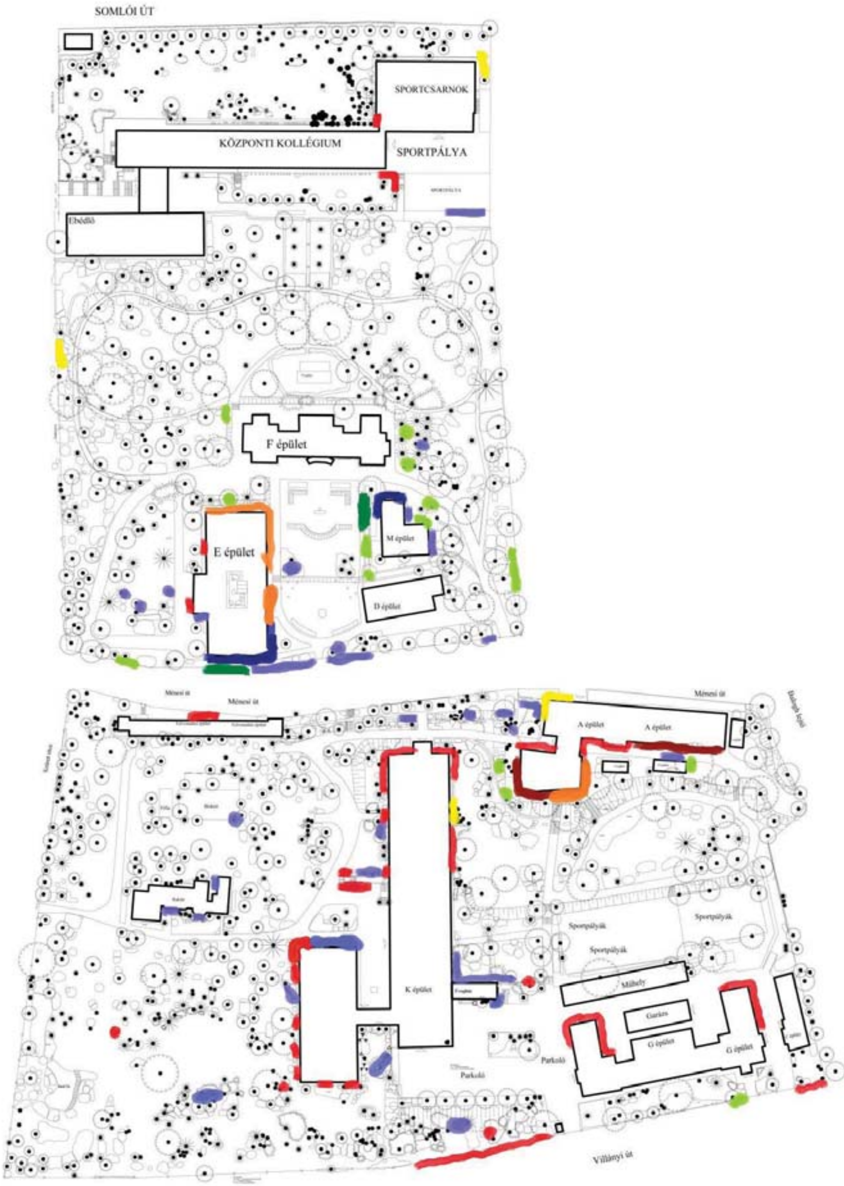

Figure 3. Spread of *Parthenocissus* genus in the Buda Arboretum (2013)
(map: Schmidt and Czigány, 2013)

Colour codes:
P. quinquefolia: dark blue=original plantation, pale blue=spontaneous occurrence
P. inserta: dark green= original plantation, pale green= spontaneous occurrence
P. tricuspidata: dark purple= original plantation, red= spontaneous occurrence
P. tricuspidata 'Veitchii': orange= original plantation, yellow= spontaneous ccurrence

b) The number of individuals, sizes of covered areas

The number of individuals and sizes of covered areas were shown on Table 2.

Most plants (35: 6 elder and 29 young) were found in the case of *Parthenocissus quinquefolia*. This species mainly grown vertically (499 m^2) and the size of horizontal area was 157 m^2. The largest specimen covered almost 140 m^2 on a wall

17 *Parthenocissus inserta* plant was registered, mostly youngs (15) and only 2 elder. The largest *P. inserta* had almost 48 m^2 covered area on the wall (and the smallest: less than 5 m^2). Considering the whole arboretum, this species covered nearly 143 m^2 on horizontal spaces and vertically overgrown 219 m^2 on the walls.

23 specimens were found in the case of *Parthenocissus tricuspidata*. But this species had got the largest vertical covered area, approximately 2603 m^2 (Table 2), and the largest plants grown vertically almost 1248 m^2 and horizontally 52 m2 (all plants: 158 m^2).

Only 4 *P. tricuspidata* 'Veitchii' were in the arboretum (most of them originally planted). The total size of their horizontal spaces was 346 m^2, and 32 m^2 regarding vertical areas.

Summarizing, *P. quinquefolia*, covered the largest areas, and spread more aggressively than the other taxa (probably due to the adhesive disks on the strong tendrils which are absolutely suitable for climbing everywhere). On the other hand, *P. tricuspidata* and especially its cultivar named 'Veitchii' was the weakest invader, because these plants easily damaged by hard frost (Schmidt and Tóth, 2012) and only spread on the building/retaining walls, sometimes on the bark of wide tree trunks.

Table 2. The number of individuals and size of covered area of *Parthenocissus* taxa (Buda Arboretum)

Taxa	No of individuals (pcs)		Horizontal (ground) space (m^2)	Vertical space (m^2)
	Original	Total		
Parthenocissus inserta	1	17	219	143
Parthenocissus quinquefolia	2	35	499	159
Parthenocissus tricuspidata	1	17	2603	158
Parthenocissus tricuspidata 'Veitchii'	2	4	346	32
Total:	**6**	**73**	Average: 916	**490**

3. Examination of fruit maturation

a) Coloration of fruits

P. tricuspidata 'Veitchii' fruits gained their mature colour firstly, and the last were *P. inserta* and *P. quinquefolia* (figure 4). Fruit endurance (from the beginning of coloration till the end of dropping) was the longest on individuals of *P. tricuspidata* 'Veitchii' and the shortest in the case *P. inserta*.

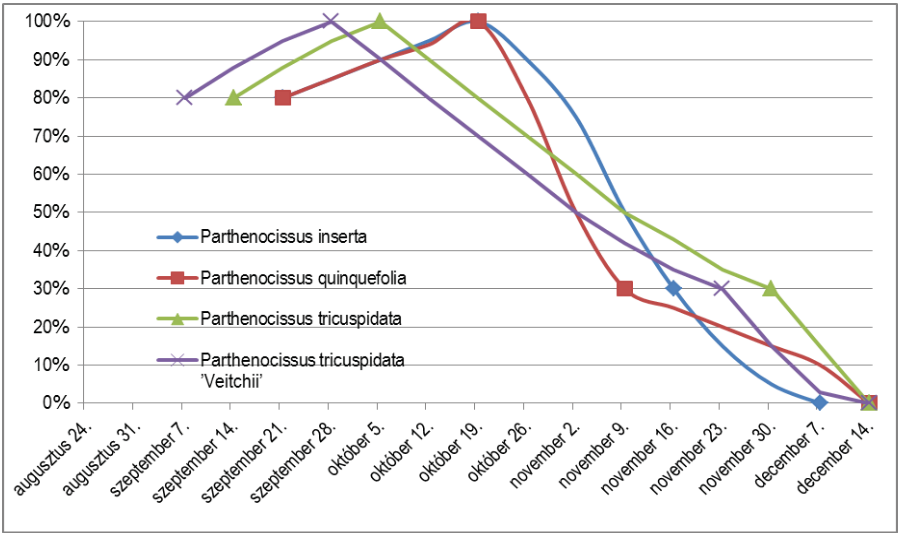

Figure 4. Coloration and dropping time of *Parthenocissus* fruits in the Buda Arboretum (2012)
(80%= beginning of fruit coloration, 100%= total coloration,
30%= beginning of fruit dropping, 0%= end of fruit dropping)

b) Soluble dry weight and taste of fruits

Soluble dry weight of *Parthenocissus* fruits were almost equal with fairly low variations (7,6-6,3%) (Figure 5).

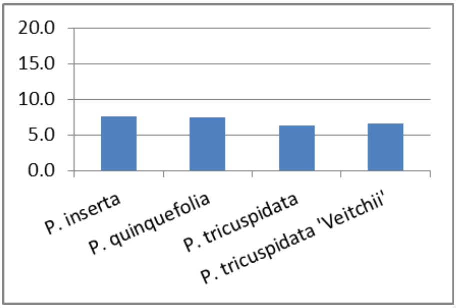

Figure 5. Soluble dry weight of fruits of *Parthenocissus* taxa in the Buda Arboretum (2013)

Not significantly higher values were obtained in the case of *P. inserta, P. quinquefolia*, and the other 2 taxa produce fruits with slightly lower dry weight. Also, there were not significant differences between the tastes of fruits of every taxon of *Parthenocissus*. (Table 3).

Table 3. Taste of fruits of *Parthenocissus* taxa (Buda Arboretum, 2013)

Taxa	Taste of fruits		
	Sweet	Bitter	Acidic
P. inserta	2	3	1
P. quinquefolia	3	2	1
P. tricuspidata	3	2	1
P. tricuspidata 'Veitchii'	2	2	1

Note: range 5=the sweetest or bitterest or the most acidic, range 1=the less sweet or bitter or acidic

Birds usually help for spreading *Parthenocissus* fruits and seeds; however, some species/cultivars of this genus were proved to be more aggressive than the others. Probably soluble dry weight and taste of fruit could affect the capacity of spreading, although statistically differences were not detected between them.

CONCLUSIONS

Invasion characteristics of four kinds of *Parthenocissus* (3 species and 1 cultivar) were examined during 2012 and 2013 in the Buda Arboretum. The highest number of individuals (with the largest ground area) were found in the case of *Parthenocissus quinquefolia*, followed by *Parthenocissus tricuspidata* (17 plant, covered 158 m^2 horizontal and 2603 m^2 vertical area) and *Parthenocissus inserta*, *Parthenocissus tricuspidata* 'Veitchii' (17 and 4 plant with 143 m^2 and 32 m^2 ground place). Taxa with more individuals and larger covered area were pronounced as more invasive than the others with less number of plants and overlaid area. Positive correlation was detected between the invasion capacity and the number of seedling, fruits and germination capacity of seeds. Nevertheless, there were not significant differences between *Parthenocissus* taxa in according to the soluble dry weight and taste of fruits.

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MISCELLANEOUS

EX·TERRA·AVRVM