

THE CURRENT SPREAD OF INVASIVE NEOPHYTES OF GENUS *FALLOPIA* IN TOWN HLOHOVEC (SW SLOVAKIA) AFTER TEN YEARS

SÚČASNÉ ROZŠÍRENIE INVÁZNYCH NEOFYTOV RODU *FALLOPIA* V MESTE HLOHOVEC (JZ SLOVENSKO) PO DESIATICH ROKOCH

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Abstract

In this paper, we compare the current spread of invasive populations of neophytes, the genus *Fallopia* (*Polygonaceae*) in town Hlohovec (SW Slovakia) in intensively farmed agricultural landscape after ten years. *F. × bohemica* has been the most successfully spreading hybrid. In 2001, it had colonized the area of 1 520 m² on 54 localities and in 2011 by 120 % more (3 338 m², 63 localities). The total surface area occupied by *F. japonica* was small.

Keywords: agricultural landscape, invasive plant, mapping, *Fallopia*, management

Abstrakt

V práci porovnávame rozšírenie inváznych populácií neofytov rodu *Fallopia* (*Polygonaceae*) v meste Hlohovec (JZ Slovensko) v intenzívne obhospodarovanej poľnohospodárskej krajine po desiatich rokoch. Najúspešnejšie sa šíril hybrid *F. × bohemica*, ktorý v roku 2001 kolonizoval plochu 1 520 m² na 54 lokalitách a v roku 2011 o 120 % väčšiu (3 338 m², 63 lokalít). Druh *F. japonica* celkovo kolonizoval malú plochu.

Kľúčové slová: poľnohospodárska krajina, invázna rastlina, mapovanie, *Fallopia*, manažment

Detailed Abstract

F. japonica, *F. × bohemica* a *F. sachalinensis* patria k najvýznamnejším inváznym taxónom v poľnohospodárskej krajine Strednej Európy. Splanené populácie týchto rastlín sa šíria najmä v zastavanom území, ale môžu sa vyskytnúť aj na nezastavaných plochách. Tieto územia sú navzájom prepojené biokoridormi a preto je možný únik nielen burín, ale aj inváznych druhov rastlín do poľnohospodárskej krajiny. Vzhľadom k tomu, že rozšíreniu týchto rastlín nebola doposiaľ venovaná dostatočná pozornosť, cieľom našej práce bolo zistiť rozšírenie inváznych populácií rodu *Fallopia* (*Polygonaceae*) v zastavanom území mesta Hlohovec (JZ Slovensko) (7 454 m²) v intenzívne využívannej poľnohospodárskej krajine po desiatich rokoch. Ťažiskom práce bol vlastný terénny výskum, ktorý sme uskutočnili počas

vegetačného obdobia rokov 2001 a 2011, v mesiacoch máj až september s využitím metódy mapovania. Zaznamenali sme taxón, lokalitu, typ biotopu, priemernú hustotu jedincov, vybrané rastové parametre, percentuálny podiel regulovaných a neregulovaných populácií. Najúspešnejšie sa šíril hybrid *F. × bohemica*, ktorý v roku 2001 kolonizoval plochu 1 520 m² na 54 lokalitách a v roku 2011 o 120 % väčšiu (3 338 m², 63 lokalít). Veľkosť plôch po desiatich rokoch bola vysoko preukazne závislá od veľkosti plôch v prvom roku výskumu ako vyplýva z grafických korelácií ($r = 0,61$). Kríženec sa šíril najmä pozdĺž železničných (35 %) a cestných komunikácií (30 %) a v okolí protipovodňovej hrádze rieky Váh (20 %). Plocha porastov sa za jeden rok priemerne zväčšila od 20 do 35 % v závislosti od typu biotopu. Vzhľadom k úspešnosti hybridu, na obsadených lokalitách predpokladáme ďalšie šírenie. Neregulované populácie zaberali až 80 % z celkovej plochy obsadenej krížencom, preto je nevyhnutné vykonávať manažmentové opatrenia. Druh *F. japonica* tvoril malý počet populácií na malej ploche a ďalšie rozširovanie rastlín nebolo zistené.

Introduction

Invasive plants are defined as non-native species that spontaneously spread and displace native species from their natural biotopes and reduce the biodiversity (the Act No. 543/2002 on Nature and Landscape Protection). The valid list of invasive plant species in Slovakia is presented in the regulation No. 24/2003 and No. 173/2011, which was amended on the 15th June 2011 by two other species [*Helianthus tuberosus* L. (Jerusalem artichokes) and *Ambrosia artemisiifolia* L. (Common ragweed)]. Three taxons of the genus *Fallopia* in Slovakia belong to the invasive plant species, which have to be eliminated, according to the law. Successfully spreading species in Slovakia are *F. japonica* (Japanese knotweed), *F. sachalinensis* (Giant knotweed) and their hybrid *F. × bohemica*.

This paper presents the results of spread of invasive plant populations, genus *Fallopia* in urban area town Hlohovec (SW Slovakia) after ten years, evaluation of the selected population-biological characteristics and performance of the plant management. Release of invasive plant species from urban area into undeveloped area is possible, can threaten biodiversity and causes farmers and policy holders the cost of removing. With this study, we want to help to reconstruct the expansion of selected invasive neophytes on a local level, because there is a lack of detailed studies based on plants-mapping on the chosen location.

Material and Methods

Species *F. japonica* [(Houtt.) Ronse Decraene] and *F. sachalinensis* [(F. Schmidt) Ronse Decraene] were introduced to Europe from eastern Asia as an ornamental plant in the middle of the 19th century and very quickly began to invade (Bailey, Wisskirchen, 2006). Parental species, as well as their cross *F. × bohemica* [(Chrtěk et Chrtková) J. P. Bailey] belong to the plants with clonal growth (Bailey, Wisskirchen, 2006; Barney, et al., 2006; Pyšek, 2009).

The first data about the occurrence of *F. japonica* in Slovakia came from the 1920s and 1930s (Eliáš, 2004). *F. japonica* is a perennial, dioecious plant. The stems are 1.5m to 3.5m high, straight, at the top branched, often arcuate, hollow. The base of

lower leaves is truncate, apex acuminate, and undersides entirely glabrous. They form an extensive root system, richly branched, reaching up to a width of 15m to 20 m from the parent plant and a depth of 2m to 3m (Cvachová, et al., 2002; Bailey, Wisskirchen, 2006; Barney, et al., 2006; Vinogradova, Majorov, Chorun, 2010).

Hybrid *F. × bohemica* was previously confused with the parental species *F. japonica*, not only in Slovakia (Eliáš, Fehér, Končeková, 1999), but also in many other countries such as central Russia (Majorov, 2002) and USA (Shaw, Seiger, 2002). It was found for the first time in 1982 near town Náchod in the Czech Republic and described as *Reynoutria × bohemica* (Chrtěk, Chrtková, 1983). All plants have got morphologically androgynous flowers, but functionally unisexual flowers predominate. The fruit is black to black-brown coloured triangular achene. Base of lower leaves is weakly to moderately cordate at base, apex acuminate, and undersides of larger leaver with numerous short stout hairs (Cvachová, et al., 2002).

Hlohovec is located in south-western Slovakia in the Trnava Self-Governing Region. It stretches in a dell between the southern part of mountain range Považský Inovec and a part of the Nitra hill range. River Váh and its alluvium separate it from the Trnava hills. The area of the cadastre is 6 412 ha. The urban area is 7 454 m². The number of inhabitants is 22 396. The altitude of the town square is 156 m. It belongs to the hot and dry climate zone, with mild winters. A common soil type is brown luvisol, locally luvisol from loess and near the river fluvisol (Atlas krajiny SR, 2002).

The crux of this work is the field research performed during the period May-September 2001 and 2011, using the mapping method. We recorded taxon, location and type of biotope according to Ružičková et al. (Ružičková, et al., 1996). We measured the size of vegetation area (m²) and the height of the highest stems (m). Every shoot with leaves or with side branches and inflorescence was considered as an individual (ramet, i-individual). We found out the average density of individuals (low 1-15 i.m⁻², medium 16-30 i.m⁻², high 31 and more i.m⁻²) with the method of counting individuals, always on a 1x1m square inside the population in order to avoid the edge effect. Evaluation of ramet density was realized in June, when the number of individuals is highest. We determined the percentage of areas with non-regulated populations, in which the plants have been not removed and regulated ones, where the management measures were performed regularly. The nomenclature of species in communities is referred according to Marhold and Hindák (Marhold, Hindák, 1998).

Results and discussion

The first record of the collection of *F. japonica* in the form of herbarium sheet in Hlohovec comes from 1966 from the park on the Dilongova street (Ješko, Vavro, 1966; Feráková, Ješko, 1969). The hybrid *F. × bohemica* was the most represented from all invasive neophytes of *Fallopia* species in Hlohovec surroundings, *F. japonica* occurred with much lower intensity. In the Czech Republic and Slovakia, the hybrid spreads much faster than parental species (Eliáš, Fehér, Končeková, 1999; Halmová, Fehér, 2009). The occurrence of *F. sachalinensis* was not recorded.

Spread of *Fallopia × bohemica* in urban area in Hlohovec

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During the first year of research, it has been registered 54 localities in Hlohovec on the area of approximately 1 520 m². At the recent spreading, the area colonized by the hybrid increased by 120 % (3 338 m², 63 localities). In 2001, it spread successfully on already occupied sites, especially along the rail (35 %) and road (30 %) communications and along dykes of the river Váh (20 %). The surface occupation of different biotope types according to Ružičková et al. (Ružičková, et al., 1996) is documented fig.1.

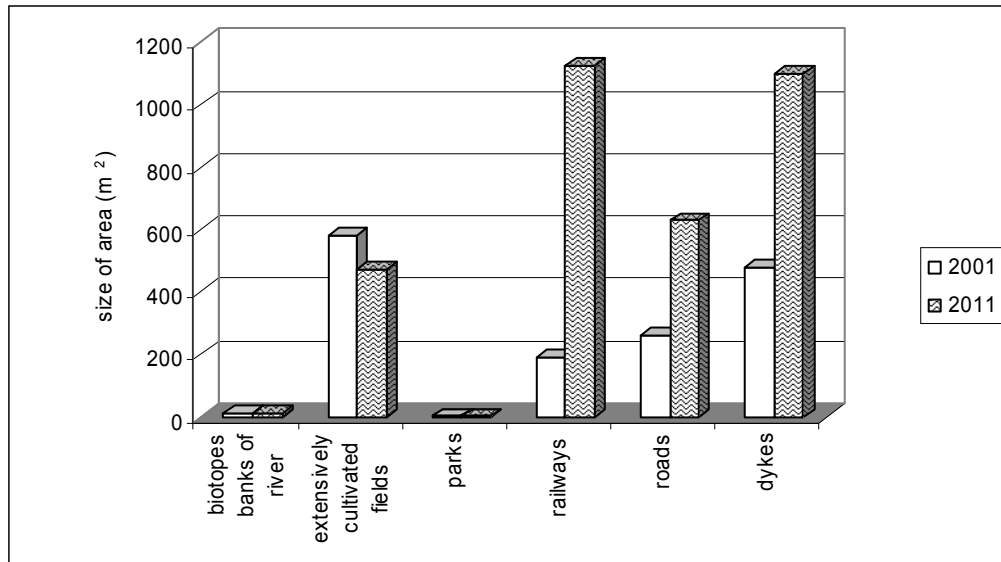


Figure 1. Area representation of *Fallopia* × *bohemica* according to biotope types
Obrázok 1. Plošné zastúpenie *Fallopia* × *bohemica* podľa typov biotopov

The comparison of the obtained data on the surface representation of *F. × bohemica* along railroads showed that during the first year of research, the observed plants colonized an area of 188 m² and ten years later the area six times larger (1 124 m²) (Fig. 1). Annually hybrid colonized an area of average 94 m² on railway stands. We assume that the spread of stem fragments or underground parts was positively affected by the wind caused by passing trains. It is known that the plants have high regeneration ability. The regeneration of roots or stems of the hybrid is higher than the one of parental species (Bímová, Mandák, Kašparová, 2004). 90 % of *F. japonica* individuals germinated from 0.08 m root cuttings (Sásik, Eliáš jun., 2006).

The spread of *F. × bohemica* was also caused by road transport in Hlohovec. The area of localities spreading along the roads has risen by up to 141 % over the decade. It has been found a significant increase of the area along the dyke – by 131 % (Fig. 1). On this site, in two large populations, the plants died in the middle of polycormon (central die-back). The main purpose of death of *F. × bohemica* ramets is not the interspecific or intraspecific competition, but the growth of underground organs (Adachi, Terashima, Takahashi, 1996).

The hybrid spreads best through water, because the swimming roots or stem fragments have no barriers on the way and can easily colonize new biotopes (Cvachová, Gojdičová, 2003). Even though, there was only one population on the banks of the river Váh on the left side, between the road and the rail bridge. In the

last five years, mainly the invasive species *Helianthus tuberosus* has spread along the river Váh. The significance of water flows is variable for different types of invasive plants found other authors (Eliáš, Fehér, Končeková, 1999; Fehér, 2001; Halmová, Fehér, 2009). It is less significant for the species of the genus *Fallopia*, which corresponds well with our results. In the Moscow area, the species occur mainly on river banks, in the European part of Russia on ruderal sites (Vinogradova, Majorov, Chorun, 2010). In Belgium, *F. × bohemica* spreads in cities (70 %), along roads and rivers. The overgrowth area increased within a year by more than 30 % (Tiébré, et al., 2008). Similarly, in Hlohovec, the overgrowth area increased by 20 to 35 % within a year, depending on the type of biotope (Fig. 1).

Water managers regularly cut the plants of *F. × bohemica*, at least three times during the growing season on the river Váh. The plants have been not removed and the size of the area has not even changed after the decade (12 m²). Mechanical removing alone is not effective. Regular monthly cutting of plants reduces the spread of the vegetation, but does not eliminate it (Barney, et al., 2006). The field survey shows that the greatest danger comes from unregulated populations of *F. × bohemica* (Table 1), which has already begun to behave invasively. The same centres of the occurrence state also in 2001-2003 in Hlohovec (Pauková, 2008; Pauková, Kotrla, Prčík, 2008).

Table 1. Observed population-biological characteristics of the largest unregulated populations of *Fallopia × bohemica*

Tabuľka 1. Sledované populačno-biologické charakteristiky najväčších neregulovaných populácií *Fallopia × bohemica*

Biotope	Area (m ²)		population density (i.m ⁻²)		height of shoots (m)	biocoenosis
	2001	2011	2001	2011	2011	
Years						2011
A610000 Dykes						
behind dykes (part Peter)	60	161	high	high	3,8	monocoenosis
behind dykes (part Peter)	80	180	high	medium	3,7	polycoenosis
behind dykes (part Peter)	51	147	high	high	3,5	monocoenosis
behind dykes (part Peter)	139	312	high	medium	3,8	monocoenosis
A510000 Railways						
Železničná street	27	307	medium	high	3,6	monocoenosis
Železničná street	42	505	medium	high	3,7	monocoenosis
A520000 Roads						
Mierova street (firm Bekaert)	-	169	-	high	3,9	monocoenosis

Figure 2 shows that the number of larger populations (especially over 150 m²) increased within the observed years what indicates a successful local spreading of *F. × bohemica*.

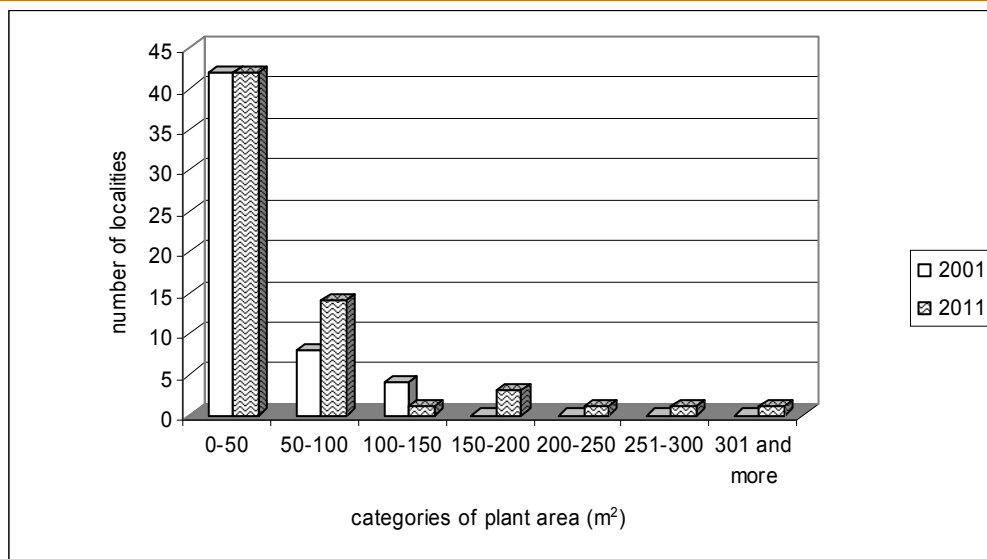


Figure 2. Frequency of *Fallopia* × *bohemica* localities depending on the size of the overgrowth area

Obrázok 2. Početnosť lokalít *Fallopia* × *bohemica* v závislosti od veľkosti plochy porastov

In 2001, the hybrid formed mainly monocenoses (69 % of localities), but ten years later was their proportion only one-third (35 %). We think, this is because of increase of the vegetation surface and gradual displacing of other species of the undergrowth (sub-canopy), but also through the periodical regulation on the extensively cultivated fields, which created approximately 40 % of the total localities occupied by *F.* × *bohemica*. In other phytocenoses, the most frequently occurring species were *Elytrigia repens* L. Desv., *Urtica dioica* L., *Convolvulus arvensis* L., *Capsella bursa pastoris* (L.) Medik., *Trifolium pratense* L., *Taraxacum* sect. *Ruderalia* Kirschner, H.Øllg. & Štěpánek and others.

The obtained results concerning the size of *F.* × *bohemica* areas show that their size in 2011 was highly significantly dependent ($r = 0.605$, $P < 0.01$) on the size of the areas in 2001, and the trend has a linear character (Fig. 3). This means that the size of the overgrowth areas in 2001 had a statistically significant effect on the size of the areas in 2011 on the selected level of significance.

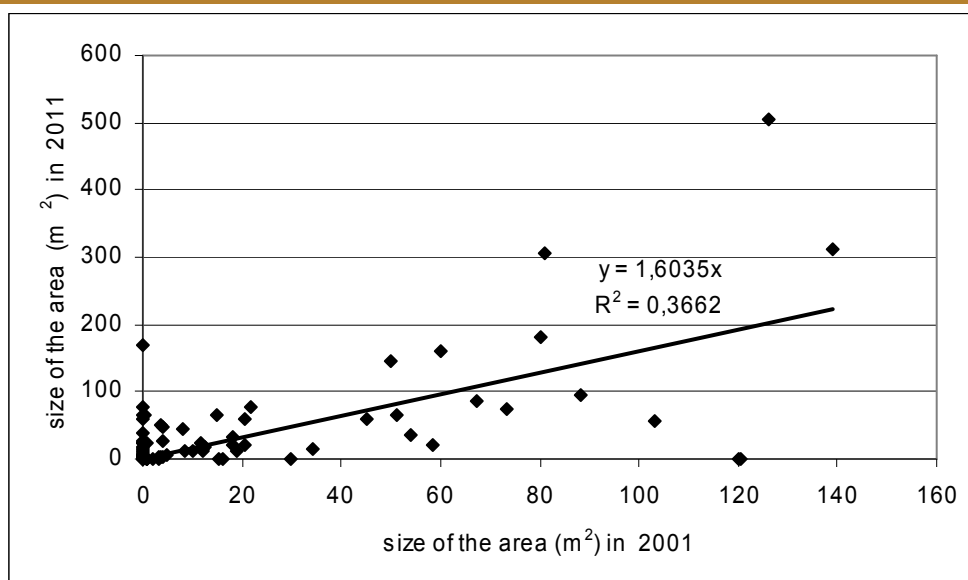


Figure 3. Linear dependence of the *Fallopia × bohemica* areas
 Obrázok 3. Lineárna závislosť veľkosti plôch *Fallopia × bohemica*

The assessment of the population density of ramets showed that during the first year of our research, 50 % of the populations were characterized by a high density of individuals (31 and more i.m⁻²) and ten years later, by a medium density (16-30 i.m⁻²). Differences in the density of individuals can be explained by an intraspecific competition of ramets and by an impact of climatic conditions.

The removal of *F. × bohemica* plants in Hlohovec was carried out on 55 % of the total number of localities, in the so-called regulated populations. However, in area terms, it is only a relatively small area (671 m²), what represents 20 % of the total area colonized by hybrid. In July 2011, the average height of the plants in regulated populations ranged from 0.2 to 1 meter. The plants were regularly cut three times during the growing season. Number of unregulated populations in Hlohovec represented 45 % of the total populations colonized by hybrid. The average height of plants in summer 2011 ranged from 3.5 to 4 meters. We conclude that the area of unregulated populations occupied up to 80 % (2 668 m²) of the total area occupied by hybrid, therefore it is urgent to propose any regulatory management and to implement regularly management measures, which improve the present state.

Other authors referred that the hybrid *F. × bohemica* spreads in western Slovakia (Trnava and its surroundings, Nitra and its surroundings, upper Požítavie) (Eliáš, Fehér, Končeková, 1999; Fehér, 2001; Pauková, 2008; Pauková, Kotrla, Prčík, 2008), in central Slovakia (Zvolen and its surroundings, Žiar nad Hronom, Banská Štiavnica) (Eliáš, 2004; Sásik, Eliáš jun., 2006), but also in eastern Slovakia (High Tatras, in surroundings of Košice and in the area of Tokaj) (Eliáš, 2004).

Spread of *Fallopia japonica* in urban area in Hlohovec

In the studied town, the species formed, during the first year, three, later only two connected monodominant populations on a biotope of extensively cultivated fields, specifically in the garden behind a supermarket on the Pod beranom street. The mechanical removal methods reduced the overgrowth area from 49 m² to 35 m².

During our field research in July 2011, the plants were not cut but kept for ornamental purposes, together with other bushes and trees on the site.

Conclusions

F. × bohemica was the most successfully spreading hybrid in town Hlohovec in Slovakia. In 2001, it had colonized the area of 1 520 m² and in 2011 by 120 % more (3 338 m²). The size of the areas in 2011 was highly significantly dependent ($r = 0.605$, $P < 0.01$) on the size of the areas in 2001, and the trend has a linear character. The hybrid has spread mainly along the railways (35 %), roads (30 %) and along the dykes of the river Váh (20 %). The overgrowth area had increased in one year from 20 to 35 % depending on the type of biotope. Due to the success of *F. × bohemica* on already occupied sites, we expect its further spreading. Unregulated populations occupied 80 % of the total areas occupied by hybrid. Therefore, it is necessary to carry out management measures. The hybrid *F. japonica* has formed a small number of populations and the further spread of the plants has been not found.

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