Spread of common ragweed (*Ambrosia artemisiifolia* L.) on arable land in the Žitný ostrov

Rozšírenie ambrózie palinolistej (*Ambrosia artemisiifolia* L.) na ornej pôde Žitného ostrova

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Abstract

Common ragweed (*Ambrosia artemisiifolia*) is an invasive alien species indigenous to North America. Ragweed is a big threat to agriculture and has a serious impact on human health. The most important area with ragweed occurrence within Europe is Pannonian Plain in Central Europe. This research introduces for the first time the unique, direct broad-scale survey of *A. artemisiifolia* in relation to real-life occurrence and infestation in the field. To understand the distribution of ragweed in the territory the geospatial analysis was applied to create 2D map in ArcGIS environment. The field survey was undertaken during summer 2014 in the Žitný ostrov (Slovakia). The investigation revealed that spatial occurrence of *A. artemisiifolia* is not homogeneous and there is also striking territorial heterogeneity of infestation rate. Ragweed was observed at 80 (47.2%) out of 169 sites. The infestation of arable land (mostly stubbles) varied from weak infestation, 24 sites (1-30 plants*10 m^{-2}) to heavy infestation, 26 sites (>80 plants*10 m^{-2}). The research on associated plant communities was also carried out. Stubble field's vegetation was found to be highly species poor, on an average only 2.5 species*10 m^{-2}. Among 40 recorded species the most frequent (noticed at 25% sites) were *Datura stramonium*, *Chenopodium album*, and *Mercurialis annua*. This broad-scale survey provides an overview and useful information on considerations needed to make decisions about ragweed control and potential future expansion. The presented study offers also inventory of ragweed frequency over the large area.

Keywords: geosapatial analysis, infestation rate, segetal vegetation, spatial distribution, weeds

Abstrakt

Ambrózia palinolistá (*Ambrosia artemisiifolia*) je cudzí inázny druh, pôvodný v Severnej Amerike. Ambrózia je veľkou hrozbou pre poľnohospodárstvo a má tiež negatívny vplyv na ľudské zdravie. Najdôležitejšou oblasťou s výskytom ambrózie v Európe je Poddunajská rovina v Strednej Európe. Tento výskum prináša po prvýkrát unikátny, priamy a rozsiahly prieskum druhu *A. artemisiifolia* vo vzťahu ku skutočnému výskytu a zaburineniu v poľných podmienkach. K pochopeniu rozšírenia ambrózie na území bola použitá geopriestorová analýza s cieľom vytvoriť 2D mapu v prostredí ArcGIS. Prieskum bol uskutočnený na Žitnom ostrove v lete roku 2014. Výskum odhalil, že rozšírenie ambrózie nie je homogénne a je tam aj nápadná územná heterogenita. Ambrózia bola zaznamenaná na 80 (47.2%) zo 169 lokalít. Napadnutie ornej pôdy (hlavne strnísk) sa pohybovalo od slabého, na 24 lokalitách (1-30 rastlín*10 m^{-2}) až po obrovské, na 26 lokalitách (>80 rastlín*10 m^{-2}). Počas prieskumu sa súčasne realizovalo aj hodnotenie sprievodnej vegetácie. Vegetácia strnísk bola druhovo veľmi chudobná, v priemere iba 2.5 druhu*10 m^{-2}. Spomedzi 40 zaznamenaných druhov patrili k najčastejším (zaznamenaným na 25% lokalitách) *Datura stramonium*, *Chenopodium album* a *Mercurialis annua*. Tento plošne rozsiahly prieskum poskytuje celkový pohľad a užitočné informácie potrebné k rozhodnutiam dôležitým pre reguláciu ambrózie a o potenciále ďalšieho šírenia. Predkladaná štúdia katalogizuje aj výskyt ambrózie na veľkej ploche.

Kľúčové slová: buriny, geopriestorová analýza, priestorové rozšírenie, stupeň napadnutia, segetálna vegetácia

Introduction

Common ragweed, *Ambrosia artemisiifolia* (Asteraceae) is an annual, monoecious herb, native to North America. All aspects of its biology and ecology were described in detail by Essl et al. (2015). The species has been introduced and naturalized in many countries worldwide (Makra et al., 2015). Ragweed is described as one of the most important invasive weed in Europe (Guillemin and Chauvel, 2011; Kazinczi and Novák, 2014), it is still expanding and modelling predict even the potential spread northward and uphill (Chapman et al., 2014; Essl et al., 2015). The most important areas with ragweed occurrence within Europe are Pannonian Plain in Central Europe (especially Hungary and some parts of Slovakia, Serbia, Croatia, Slovenia, and Romania), Rhone-Alpes region in France, Ukraine, southern European Russia and Po River valley in Italy (Makra et al., 2005; Csontos et al., 2010; Prank et al., 2013; Thibaudon et al., 2014; CABI, 2015). The cardinal negative effect of any invasion to native species is strong competition (Levine et al., 2004) and threat to biodiversity (Zisenis, 2015). Ragweed acts as a strong competitor especially in the arable land (Fenesi et al., 2014) and colonises and dominates at disturbed habitats, where is no competition from native plants (Gentili et al., 2015). Common ragweed is a dominant weed in arable fields and in heavily infested regions of Europe causes substantial crop-yield losses. In Hungary, 700,000 ha of farmland was heavily infested (extent of infestation >10%) in 2003 (Tóth et al., 2004). The most frequently infested crops

within Central Europe are spring-sown crops like sunflower, corn, soy bean and stubble fields (Týr et al., 2009; Kovács, 2010; Pinke et al., 2012, 2013). For example, *A. artemisiifolia* decreased grain yield of corn by 19.5% and above ground corn biomass by 18.5% at density of 5 ragweed plants*m^{-2} in Slovakia (Vereš et al., 2011), sunflower yield in Hungary was decreased by 27% at density of two ragweed plants*m^{-2} (Béres, 1985) up to 33% at the density of 10 ragweed plants*m^{-2} (Kazinczi et al., 2007). The highly allergenic pollen of *A. artemisiifolia* means also considerable threat to public health, especially human respiratory system (Smith et al., 2013; Bordas-Le Floch et al., 2015). The principal regions with *Ambrosia* occurrence in Slovakia are Žitný ostrov (or Csallóköz in Hugarian) at the southwestern part of the country and south of Eastern Slovakia (Jehlík, 1998). Common ragweed was first recorded within the scope of Europe in France in the 18th century (Bullock et al., 2012) while in Slovakia as late as 1949 (Makovcová et al., 1998). This plant has no special demands for soil, however prefers moderately basic sandy and clays soils (Reisinger, 1992). *Ambrosia* grows in dry fields and pastures, vineyards, waste grounds, along rivers, canals, bird feeding places, roads and railways. Heavy infestation occurs around agricultural and industrial objects and forms dense populations especially in agricultural land within lowlands (Pál, 2004; Pinke et al., 2011; Medvecká et al., 2012; Pinke et al., 2013; Kazinczi and Novák, 2014; Májeková and Zaliberová, 2014; Milakovic et al., 2014). On the other hand, while ragweed grows abundantly in certain habitats, other habitats are hardly populated (Skjøth et al., 2010). The most invasive weeds, e.g. *Abutilon theophrasti* or *Cyperus esculentus*, are showing intensive distribution, whereas *A. artemisiifolia* and *Solanum carolinense* showed the widely dispersed distribution (Watanabe et al., 2002). In general many segetal plants in Central Europe are threatened by extinction (Kropáč, 2006) and increasing spread of common ragweed pose the threat e.g. to stubble-field weed community (Pinke and Pál, 2009).

The present study offers insight into the pattern of *A. artemisiifolia* occurrence within the farming landscape of Žitný ostrov (in Slovakia). Geospatial analysis to create 2D map in ArcGIS environment was used, which helps to understand the abundance and distribution of ragweed in the territory. The main aim was to know particularly what is the spatial spread of *A. artemisiifolia* throughout the most intensive managed agricultural land and which are the most important accompanying plant species of ragweed in the field.

Material and method

Ecological conditions of the studied area

Žitný ostrov is situated in Slovakia at the Pannonian Plain (Figure 1). It is the largest river island in Europe with area of 1885 km^2 and it is bordered by river Danube southern and by the Danube branch (named Little Danube) northerly. The island is 84 kilometers long (from city Bratislava to city Komárno), 15-30 kilometers wide and altitude varies from 105 to 129 m above the see level (Tibor et al., 2002). Žitný ostrov belongs in warm regions of Slovakia with 50 or more summer days annually in average. The mean annual air temperature ranges from 9 °C to 10 °C and the mean

January air temperature is -2 °C. The area is very dry with the mean annual precipitation totals from 500 to 550 mm. The mean annual sum of global radiation range from 1200 to ≥1300 kWh*m^{-2} (Zaťko, 2002).

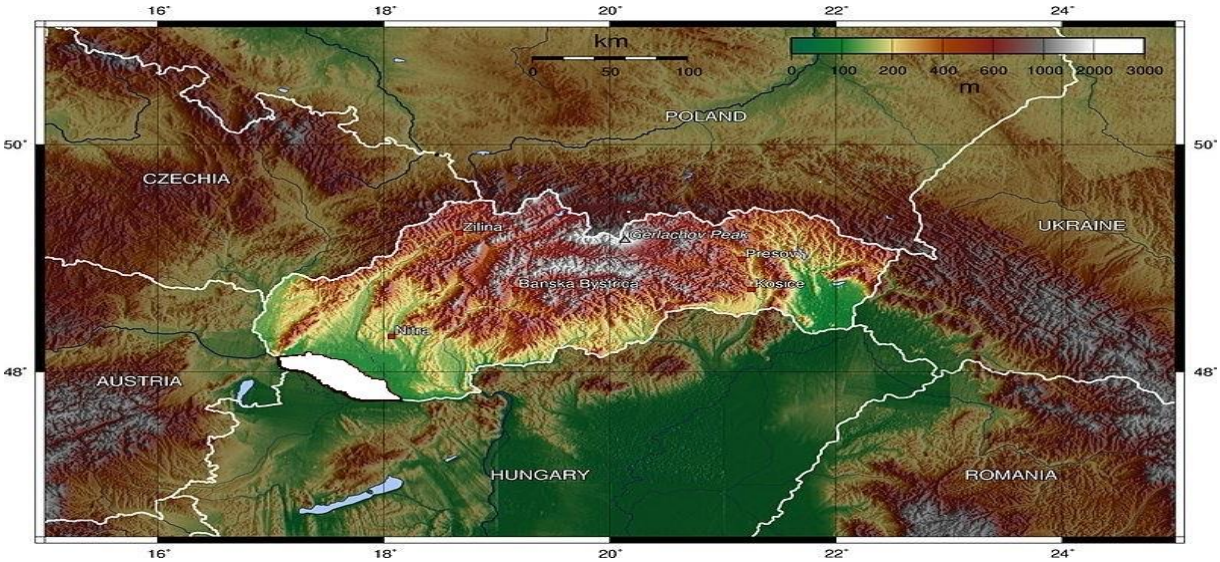

Figure 1. Physical map of Slovakia and border countries; Žitný ostrov is highlighted in white (Vidiani, 2011; modified by Z. Domonkos, 2015)

Obrázok 1. Mapa Slovenska a okolitých krajín; Žitný ostrov je zvýraznený na bielo (Vidiani, 2011; upravené, Z. Domonkos, 2015)

Agronomical characteristics

Žitný ostrov features the agricultural landscape with the longest vegetation period in Slovakia and with the mildest winter. It is an area with prevailing share of arable land (Mládek, 2002). The most frequent crops are maize (*Zea mays*), winter wheat (*Triticum aestivum*), spring barley (*Hordeum vulgare*) and sunflower *(Helianthus annuus*). The natural boundaries of Žitný ostrov do not trace administrative borders. The largest district of the region is Dunajská Streda. The main crops grown in this district are shown in Table 1.

The survey method

This research was based on 169 plots of a standard size of 10 m^2 from 28 July to 13 September 2014. The map of Žitný ostrov was overlaid with a 25 km^2 grid. Within the grid cells study plots were selected in a random design in order to include the variation of Žitný ostrov and the full range of stubble fields. The survey was focused on cereal stubble fields, however a few oil seed rape stubbles, sugarbeet, lucerne and sunflower fields were taken as well. The sampling sites were usually (if it was possible) located where weed vegetation was well developed and *A. artemisiifolia* and associated vegetation were recorded and counted. Associated vegetation was verified according to Hunyadi et al. (2011). The 11-point scale was used for assessment of *Ambrosia* population density (Table 2). To record the spatial pattern of

Ambrosia occurrence an on-board GPS (Sygic navigation, version 13.4.1) was employed.

Table 1. The main crops grown in the district of Dunajská Streda (Statistical Office, 2013)

Tabuľka 1. Hlavné plodiny pestované v okrese Dunajská Streda (Štatistický úrad, 2013)

Number	Crop	Area (ha)
1.	Maize	25,405
2.	Winter wheat	18,871
3.	Spring barley	6,620
4.	Fodder crops	5,913
5.	Sunflower	4,673
6.	Sugarbeet	475

For the geospatial analysis the ESRI (Environmental Systems Research Institute, 380 New York Street, Redlands, CA 92373-8100, USA), ArcGIS ArcView 10.1, ArcGIS Spatial Analyst, and the ArcGIS 2D Analyst were applied (Tamás et al., 2006). The natural status was modeled by using Spatial Analyst software additions, field measurements corresponding data series, as well as digitized table borders. Additional information about the status field from the scale models and the models produced by different sets of data produced by juxtaposition were obtained. For the model production the IDW (Inverse Distance Weighted) interpolation method was used. An attention was paid to the 5 categories of infestation, and other five points were included in the interpolation, the grid size is determined by 3 m. In the interest of informative representation we made unique gradient keys for data signal lines, which were used in the 2D graphing (Figure 2).

Results and discussion

The detail investigation revealed that spatial occurrence of *A. artemisiifolia* in the Žitný ostrov is not homogeneous, but there is also striking territorial heterogeneity of infestation rate (Figure 2) as it is proposed for Pannonian Plain by (Skjøth et al., 2010). The common ragweed was observed at 80 (47.2%) out of 169 sites.

The infestation category of arable land (mostly stubble fields) varied from weak to heavy infestation (Table 2). The weak infestation was recorded at the 23 (28.75%) sites, medium at 15 (18.75%), strong at 16 (20%), and heavy infestation at 26 (32.5%) sites. Average number of plants per infestation categories accounted for 13,

42, 70, and 157 plants*m^{-2}. The highest occurrence reached 400 ragweed plants per plot at Okoličná na Ostrove or 220 plants per plot at Boheľov. The majority of locations without the presence of ragweed were recorded in the western part of Žitný ostrov (close to the city Bratislava). Nevertheless, the sites without common ragweed were irregularly recorded also in all other areas.

Table 2. The 11-point scale to evaluate occurrence of common ragweed plants*m^{-2}

Tabuľka 2. Jedenásť bodová stupnica hodnotenia výskytu rastlín ambrózie palinolistej*m^{-2}

Distribution rate	Number of plants*m^{-2}	Category of infestation
0	0	1 - no infestation
1	1-10	2 - weak infestation
2	11-20	
3	21-30	
4	31-40	3 - medium infestation
5	41-50	
6	51-60	
7	61-70	4 - strong infestation
8	71-80	
9	81-90	5 - heavy infestation
10	>91	

Interestingly, while some sites are heavily infested (e.g. Orechová Potôň Lúky 1), other very closely situated habitats are completely free of ragweed (Orechová Potôň Lúky 3). These data point to distinct heterogeneity also on-site.

To the author's knowledge, this research introduces for the first time the unique, direct broad-scale survey of *A. artemisiifolia* in relation to real-life occurrence and

dominancy in the field. There are otherwise several accounts on the distribution of ragweed. However, these are mostly indirect studies based exclusivelly on herbarium data and floristic literature (Chauvel et al., 2006; Essl et al., 2009; Richter et al., 2013) or pollen monitoring (Skjøth et al., 2010; Karrer et al., 2015), only Pinke et al. (2011) surveyed 243 arable ragweed infested fields. In Hungary, as a result of extensive data collection a comprehensive study about integrated methods of suppressing ragweed appeared (Kazinczi and Novak, 2014). The highest ragweed densities as well as the highest levels of invasion in agricultural land are found in the central and eastern part of Žitný Ostrov (Figure 2). The frequent growing of sunflower, maize and sugar beet in a crop rotation within this territory might be one of the main reasons. Especially sunflower growing may result in the high ragweed abundance (Pinke et al., 2011), greater accumulation of ragweed seeds and more complicated chemical control due to the botanical similarity (Kazinczi et al., 2008). Besides, the smaller size of fields in the central and eastern part of Žitný ostrov in comparison with western part could be the other reason of ragweed spreading. Field margins are usually less properly managed, herbicides less efficiently applied, crop growth is usually lower, and environmental influence on plant diversity higher (Wilson and Aebischer, 1995; Pinke et al., 2012; Seifert et al., 2015). Investigations indicate that the ragweed abundance is significantly higher at the field margins than in the centre (Pinke et al., 2011).

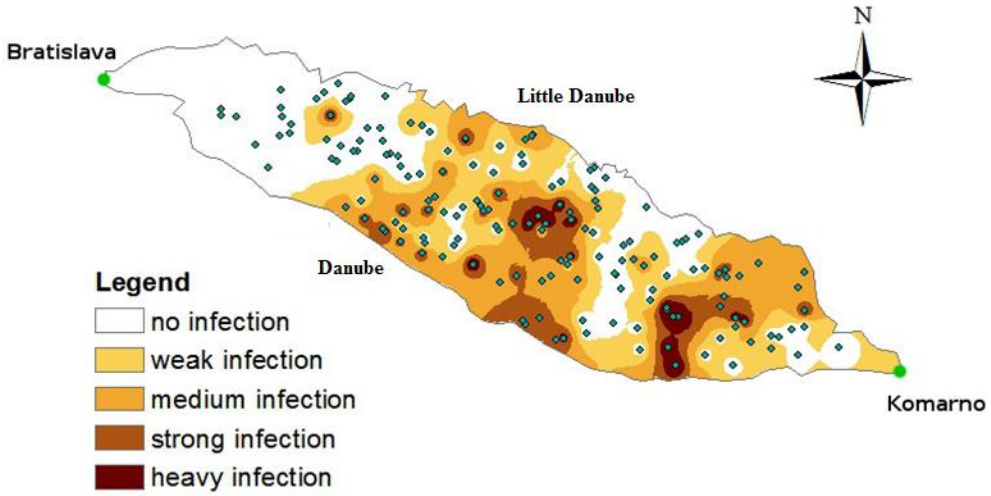

Figure 2. Spatial variations of common ragweed occurrence and infestation rate in the Žitný ostrov; the map is based on the categories of infestation. Small square points symbolize particular plots.

Obrázok 2. Priestorová variabilita výskytu ambrózie a stupňa napadnutia na Žitnom ostrove; mapa je založená na kategóriách napadnutia. Malé štvorcové body predstavujú jednotlivé miesta hodnotenia.

In the summer 2014 the research on associated plant communities was also carried out over all study sites. The most common associated plants belong to segetal vegetation (class Stellarietea) (Kropáč, 2006). Stubble field's vegetation was found to be highly species poor, on an average only 2.5 species*m^{-2}, what is in accordance with Meyer et al. (2013) and Seifert et al. (2015). The list of all 40 recorded species is similar as described by Essl et al. (2015). Most frequent species, *Datura stramonium*, *Chenopodium album*, and *Mercurialis annua* were recorded at 25% sites. Other common species, *Setaria viridis*, *Cirsium arvense, Echinochloa crus-galli*, *Amaranthus retroflexus*, *Panicum miliaceum*, and *Solanum nigrum* occurred on 19.5%, 14%, 12%, 11%, 10%, and 10% plots respectively. Many studies pointed out changes in segetal vegetation, disappearance of some species (e.g. Holub and Procházka, 2000; Pyšek, 2001; Ruprecht, 2005), and inappropriateness of habitats for natural enemies, birds and mammals (Seifert et al., 2015). These communities are drastically influenced by new intensive agronomical systems (Kropáč, 2006) and Pinke and Pál (2009) consider the increasing of ragweed spread either as one of the reasons.

Conclusiouns

The procedure presented here could be used for preparing occurrence inventories of common ragweed regardless of pollen data availability. Therefore, further studies might be made involving also surrounding regions. The geospatial analysis enables not only clearly understand to frequency and dominancy of ragweed in the territories, but it offers also useful data to forecast potential *Ambrosia* spreading. This approach could make possible to navigate successful management programs and match the farmers needs better than models which are based on even if well-established pollen networks.

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