# Spread of common ragweed (*Ambrosia artemisiifolia* L.) on the Žitný Ostrov (Slovakia) and Szigetköz (Hungary) in 2015

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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. One of the most important areas 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 2015 in the Žitný ostrov (Slovakia) and Szigetköz (Hungary). Importance of ragweed survey in these two landscapes is not only because the agricultural significance, but is enhanced by the effect of its pollen on human health. The investigation revealed that spatial occurrence of* A. artemisiifolia *is not homogeneous and there is also striking territorial heterogeneity of infestation rate. In Žitný ostrov ragweed was observed at 143 (54,78%) out of 261 sites. In Szigetköz ragweed was observed at 50 (54,94%) out from 91 sites. This study offers inventory of ragweed frequency over the large area.*

***Keywords— real-life occurrence, spatial distribution, territorial heterogeneity, associated plant communities***

## I. 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 [35]. Ragweed is described as one of the most important invasive weed in Europe [19], [33] it is still expanding and modelling predict even the potential spread northward and uphill [11], [14]. 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 [9], [36], [38], [40], [43]. The cardinal negative effect of any invasion to native species is strong competition [32] and threat to biodiversity [42]. Ragweed acts as a strong competitor especially in the arable land [1] and colonies and dominates at disturbed habitats, where is no competition from native plants [47]. Common ragweed is a dominant weed in arable fields and in heavily infested regions of Europe causes substantial crop-yield losses. In Hungary, 700000 ha of farmland was heavily infested (extent of infestation 10 %<) in 2003 [4]. The most frequently infested crops within Central Europe are spring-sown crops like sunflower, corn, soybean and stubble fields [2], [21], [22], [51]. 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 per $m^2$ in Slovakia [53], sunflower yield in Hungary was decreased by 27% at density of two ragweed plants per $m^2$ [24] up to 33% at the density of 10 ragweed plants per $m^2$ [17]. The highly allergenic pollen of *A. artemisiifolia* means also considerable threat to public health, especially human respiratory system [39], [55]. The principal regions with *Ambrosia* occurrence in Slovakia are Žitný ostrov at the southwestern part of the country and south of Eastern Slovakia [56]. Common ragweed was first recorded within the scope of Europe in France in the 18th century [26] , while in Slovakia as late as 1949 [50]. This plant has no special demands for soil, however prefers moderately basic sandy and clays soils [45]. *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 [19], [20], [22], [25], [28], [29], [48],. On the other hand, while ragweed grows abundantly in certain habitats, other habitats are hardly populated [7]. In general many segetal plants in Central Europe are threatened by extinction [57] and increasing spread of common ragweed pose the threat e.g. to stubble-field weed community [23]. Many studies pointed out changes in segetal vegetation, disappearance of some species [12], [27], [44] and inappropriateness of habitats for natural enemies, birds and mammals [10].

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

## II. MATERIAL AND METHOD

### 2.1 Studied sites

Žitný ostrov and Szigetköz are island plains situated in Slovakia or Hungary at the Pannonian Plain "Fig.1" [37]. Žitný ostrov 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) and 15-30 kilometers wide and altitude varies from 105 to 129 m above the see level [58]. 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 [41].

The Szigetköz is situated in Western Hungary. It is bordered by Danube and its branches with a length of 52.5 km and an average width of 6-8 km. The territory has a size of 375 km$^2$ and elevation oscillates from 110 to 125 m above the see level [6]**.** In Szigetköz the number of sunshine hours per year range within 1900-2000 hours. The annual average air temperature reaches 10 °C, and annual precipitation totals stretches from 550 to 600 mm [52].

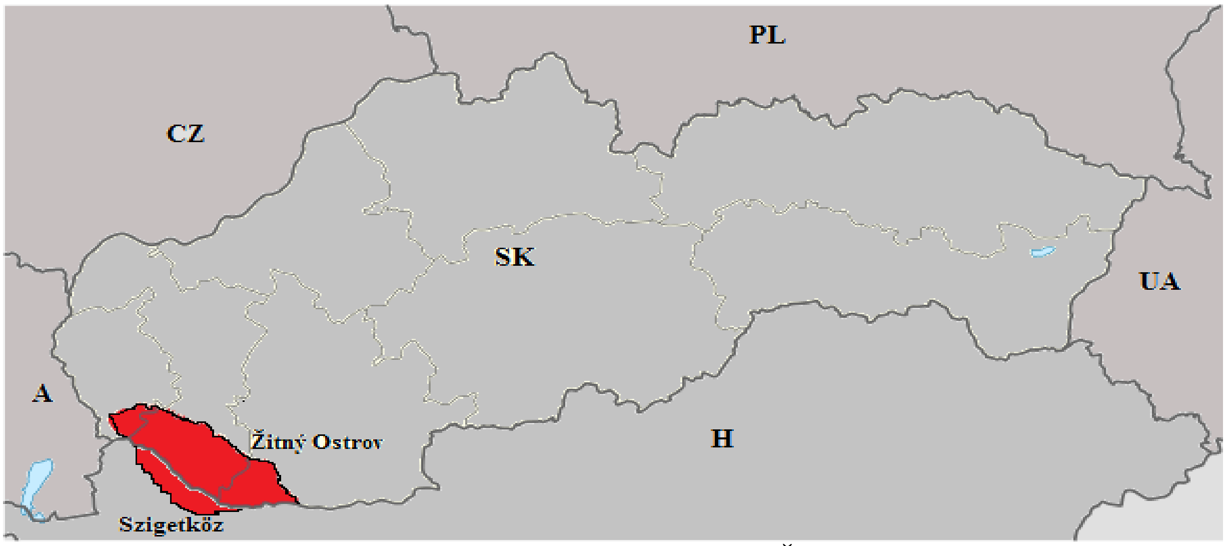


**FIGURE 1. THE MAP OF SLOVAKIA AND ADJACENT COUNTRIES; ŽITNÝ OSTROV AND SZIGETKÖZ ARE HIGHLIGHTED IN RED (MAP OF ŽITNÝ OSTROV IN SLOVAKIA 2014, MODIFIED BY ZS. DOMONKOS, 2015)**

### 2.2 The survey method

This research was based on 261 plots in Žitný ostrov (Slovakia) and 91 plots in Szigetköz (Hungary) of a standard size of 10 m$^2$ in 2015, from July 22 to October 5. The map of Žitný ostrov and Szigetköz 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 Szigetköz. The survey was focused on cereal stubble fields, however a few oil seed rape, peas and ensilage maize stubble 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 [34]. The 11-point scale was used for assessment of *Ambrosia* population density "Table 1". To record the spatial pattern of *Ambrosia* occurrence an on-board GPS (Garmin Oregon 650 navigation, Software version 4.50) was employed.

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 [31]. The natural status was modelled by using Spatial Analyst software additions, field measurements corresponding data series, as well as digitized table borders. An 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 unique gradient keys were made for data signal lines, which were used in the 2D graphing "Fig.2". Statistical analyzes were carried out using Statistica software (version 11; StatSoft, Inc. 1984-2012). For the accopmanying weed species analyse Shannon Wiener Diversity Index was used [8]. Hypothesis study was carried out to show that ragweed values "Table 1" measured in the Žitný ostrov and Szigetköz areas differ from each other (t-test) significantly [3] [13] [30]. This test was performed in all categories in pairs.

**TABLE 1**
**THE 11-POINT SCALE TO EVALUATE OCCURRENCE OF COMMON RAGWEED PER 10M2**

| Distribution rate | Number of *Ambrosia* plants per $10m^2$ | 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< | |

## III. RESULTS AND DISCUSSION

### 3.1 Rate of infestation

The detail investigation revealed that spatial occurrence of *A. artemisiifolia* in the Žitný ostrov and Szigetköz is not homogeneous, but there is also striking heterogeneity of infestation rate within the smaller areas "Fig.2" as it is proposed for Pannonian Plain by [7]. The common ragweed was observed at 143 (54.7%) out of 261 sites in Žitný ostrov. The weak infestation was recorded at the 24 (9.19%) sites, medium at 25 (9.5 %), strong at 24 (9.19%), and heavy infestation at 70 (26.8 %) sites. Average number of plants per infestation categories accounted for 12, 50, 74, and 146 plants per 10 $m^2$. The highest occurrence reached 340 ragweed plants per plot at Mad or 310 plants per plot at Čalovec. 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.

In Szigetköz the ragweed occurrence was recorded at 50 (54,94 %) out of 91 sites. Weak infestation was recorded at 27 (29,67%), medium infestation at 12 (13,18 %), strong infestation at 6 (6,59%) and heavy infestation at 5 (5,49%) sites. Average number of ragweed plants per infestation categories, 12, 46, 66 and 127 plants per 10 $m^2$, resemblance the situation in Žitný ostrov**.** Highest number of ragweed occurrence was observed in Dunaszeg 201 plants and Ásványráró 118 plants per plot.

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 herbaria data and floristic literature [5], [15], [49] or pollen monitoring [7], [16], [20] only Pinke et al, 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 [19]. 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 and in the middle part of Szigetköz "Fig 2". The frequent growing of sunflower, maize and sugar beet in the crop rotation within these territories might be one of the main reasons. Especially sunflower growing may result in the high ragweed abundance [20], greater accumulation of ragweed seeds and more complicated chemical control due to the botanical similarity [18]. Besides, the smaller size of fields in the central and eastern part of Žitný ostrov in comparison with western part could be added 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 [10], [21], [46]. An investigation indicates that the ragweed abundance is significantly higher at the field margins than in the centre [20].

### 3.2 Accompanying species

In the summer 2015 the research on associated plant communities was also carried out over all study sites. In Žitný ostrov was recorded 60 accompanying weed species. Most frequent species in Žitný ostrov were *Chenopodium album* 46.74%, *Mercurialis annua* 34.48%, *Polygonum aviculare* 30.27%, *Cirsium arvense* 25.67%, *Datura stramonium* 24.14%, *Echinochloa crus-galli* 19.16%, *Setaria pumila* 16.48% and *Chenopodium hybridum* 14.56%, *Abutilon theophrasti* 14.18%, *Capsella bursa-pastoris* 13.79% were recorded on surveyed sites. Recorded 60 associated weed species belong to 24 botanic families. Highest infestation weeds from Poaceae 17.34%, Asteraceae 17.09%, Chenopodiaceae 13.64%, Polygonaceae 9.76%, Euphorbiacea 8.00%, Solanaceae 7.07%, Malvaceae 4.04%, Amaranthaceae 3.20%, Brassicaceae 3.11%, Caryophyllaceae 3.03% were recorded. Accompanying species survey held in Szigetöz relealed that the most frequent species during 2015 were *Chenopodium album* 63.74%, *Mercurialis annua* 39.56%, *Cirsium arvense* 31.87%, *Echinochloa crus-galli* 30.77%, *Setaria viridis* 30.77%, *Chenopodium hybridum* 25.27%, *Panicum miliaceum* 19.78%, *Polygonum aviculare* 17.58%, *Amaranthus retroflexus* 16.48 %, *Datura stramonium* 16.48 %. Recorded 59 species belong to 22 botanic families, the most abundant, analogous to Žitný ostrov, were Poaceae 19.24%, Chenopodiaceae 17.34%, Asteraceae 14.80%, Euphorbiacea 8.67%, Amaranthaceae 5.50%, Polygonaceae 5.50%, Solanaceae 4.44%, Convolvulaceae 3.81%, Lamiaceae 3.81% and Brassicaceae 3.38%.

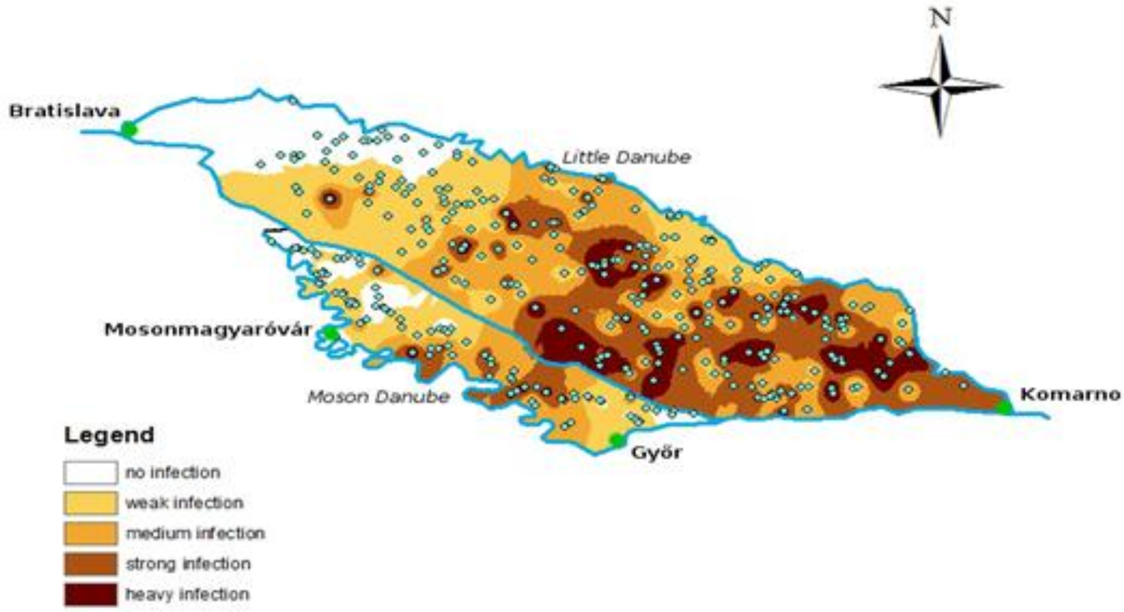


**FIGURE 2. SPATIAL VARIATIONS OF COMMON RAGWEED OCCURRENCE AND INFESTATION RATE IN THE ŽITNÝ OSTROV AND SZIGETKÖZ. THE MAP IS BASED ON THE CATEGORIES OF INFESTATION. SMALL SQUARE POINTS SYMBOLIZE PARTICULAR PLOTS.**

### 3.3 Comparison of surveyed areas

**TABLE 2**
**HYPOTHESIS ANALYSES BETWEEN THE CATEGORY VALUES OF ŽITNÝ OSTROV AND SZIGETKÖZ**

| | T-test for Independent Samples, Note:Variables were treated as indepented samples | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Group 1 vs Group 2 | Mean Group 1 | Mean Group 2 | t-value | df | p | Valid N Group 1 | Valid N Group 2 | Std.Dev Group 1 | Std.Dev Group 2 | F-ratio Variances | p.Variances |
| Žitný Ostrov 2. vs. Szigetköz 2. | 12,25 | 12,41 | -0,0725 | 49 | 0,9425 | 24 | 27 | 7,83 | 7,66 | 1,0444 | 0,9088 |
| Žitný Ostrov 3. vs. Szigetköz 3. | 49,52 | 45,83 | 0,9859 | 35 | 0,3309 | 25 | 12 | 10,55 | 10,86 | 1,0603 | 0,8597 |
| Žitný Ostrov 4. vs. Szigetköz 4. | 74,28 | 66,5 | 3,4574 | 29 | 0,0017 | 25 | 6 | 4,41 | 6,98 | 2,5026 | 0,1169 |
| Žitný Ostrov 5. vs. Szigetköz 5. | 145,89 | 127 | 0,7181 | 73 | 0,475 | 70 | 5 | 57,17 | 50,24 | 1,2949 | 0,9061 |

Only category number 4 (strong infestation) that there was a significant difference between the two fields of data in case of a high prevalence data "Table 2". First it was assumed (as null hypothesis) that the standard deviation of the two variables is equal, and as an alternative hypothesis, that they are different with 95 % probability. The F-test proved that there are no significant differences between the standard deviation of the variables ($p=0.1169$; $p>0.05$). Knowing this it was assumed (as null hypothesis) that the means do not significantly differ from each other, either, with 95 % probability. The result of t-test was that the null hypothesis is fault in this case ($p=0.0017$; $p<0.05$), i.e. the difference of Žitný ostrov 4 category and Szigetköz 4 category average values is significant, and the difference of 4. category can statistically be justified on the Žitný ostrov and Szigetköz "Fig.3".

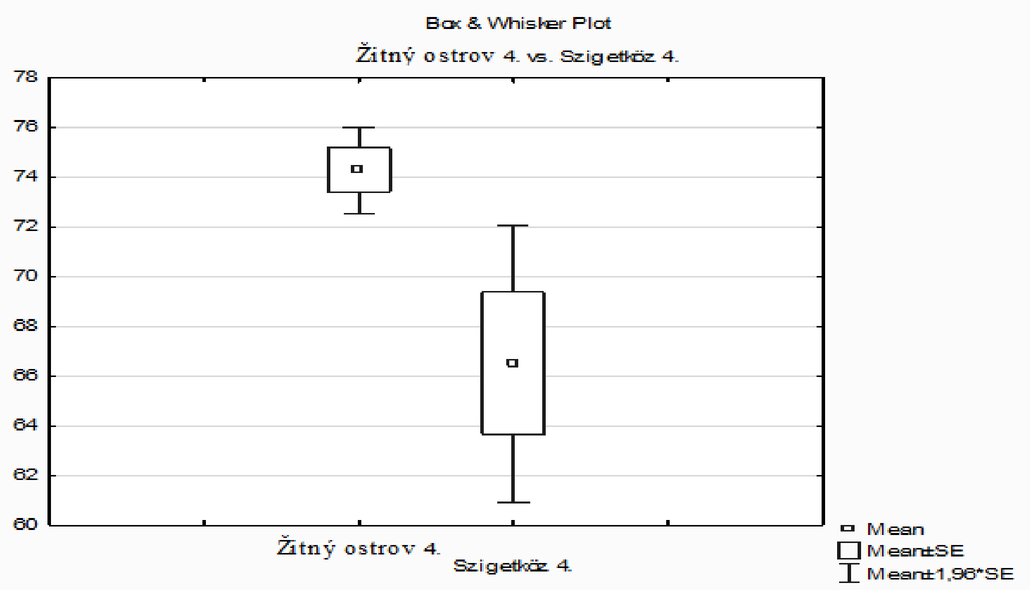


**FIGURE 3 . CHARACTERISTICS OF ŽITNÝ OSTROV 4. CATEGORY AND SZIGETKÖZ 4. CATEGORY**

Based on statistical analyses of accompanying weed species in Žitný Ostrov results are H=2.55, Hmax=3.18, Evenness ($E_H$) =0.80 and in Szigetköz H=2.52, Hmax=6.16, Evenness ($E_H$) =0.41.

## IV. CONCLUSION

The common ragweed can cause problems in all the crops. The regulation management is a complex task. The first step should be the proper detection of ragweed infested sites. The registration and regulation supposed to be a cross-border issue. The large parts of Žitný ostrov and Szigetköz are seriously infested. On the other side the detailed survey showed that there were sites where the stubble was not infested by common ragweed at all. 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 artemisiifolia* spreading. Statisticaly we verified, that only strong infected ragweed sites showed significant different. The evenness of accompanying weed species is higher in Žitný ostrov, twice the area of Szigetköz, so here are more similar individual numbers.

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