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Distribution of four alien plants in Tyumen Region (Western Siberia): contribution of citizen science and expert data

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Summary: Biological invasions represent a highly important research field in modern plant biology. They could serve as dangerous processes that threaten natural ecosystems. The distribution patterns of alien plants serve as a basis for the development of biological invasion management plans and counteraction to them. Tyumen Region is situated in the south of West Siberia. This area is one of the least studied in Russia in terms of alien plant composition and distribution. This study aimed to demonstrate the current distribution of some alien plants in the Tyumen Region, namely *Echinocystis lobata*, *Impatiens glandulifera*, *Heracleum sosnowskyi* and *Calystegia sepium* subsp. *americana* (*C. inflata*). We compared their distribution within the entire Tyumen Region and the Tyumen Urban Area. The study was based on two data types, including expert (observations of professional, graduated, botanists, herbarium specimens, publications) and citizen science (observations made by amateur naturalists presented in the platform iNaturalist) data. To visualise the alien plant distribution, we used two grid mapping schemes, including 10×10 km cells for Tyumen Region and 1×1 km cells for Tyumen Urban Area. We found that in the Tyumen Region, *Heracleum sosnowskyi* occurs in nine grid cells (37 expert data records and 12 citizen science data), *Echinocystis lobata* in 17 grid cells (70 expert data records and five citizen science data records), *Impatiens glandulifera* in 15 grid cells (123 expert data records and nine citizen science data records) and *Calystegia sepium* subsp. *americana* in 20 grid cells (43 expert data records and five citizen science data records). We demonstrate the significant differences (p<0.05) in number of alien plant records between the territories of inside and outside of the Tyumen Urban Area. We suppose a further increase in the number of records of these alien plant species in the Tyumen Region provided by intense botanical investigations. We propose the need of similar studies in relation to other alien plants in the Tyumen Region.

Keywords: biodiversity, *Echinocystis lobata*, *Impatiens glandulifera*, *Heracleum sosnowskyi*, *Calystegia sepium* subsp. *americana*, Russia, biological invasion, grid mapping

Among traditionally recognised challenges, biological invasions are one of the most important and growing issues in many regions all over the world. It is well known that alien organisms (including invasive ones) cause both direct and indirect impacts on natural ecosystems, population status, morphological traits and physiology of native species as well as human health (Dumalisile & Somers 2017; Betekhtina et al. 2019; Dubovik et al. 2019; Schaffner et al. 2020). This makes it necessary to develop various management measures aimed to slow or eradicate both introduction and spread of alien species. Despite numerous publications devoted to progress in counteracting to alien organisms, problems related to biological invasions still occur in many regions worldwide (Zernov & Mirzayeva 2016; Liebhold et al. 2017; Pyšek et al. 2010; Blossey et al. 2021). By having lists of invasive or potentially invasive species, it is possible to combat further alien organism introductions as well as to monitor them (Sintayehu et al. 2020; Vacek et al. 2020). Such lists of all historical records of alien species play an important role in their managing as well as in helping to implement management plans. Currently, producing lists of alien and, particularly, invasive organisms is a common tool to manage biological invasions at various scale levels (Lakoba et al. 2020; Meddour et al. 2020; Tuniyev & Timukhin 2017;

Starodubtseva et al. 2017). Therefore, creating a list of alien organisms serves as important mandatory stage in developing a system of combating biological invasions.

Although on global scale, biological invasions are treated as one of the strongest drivers of plant extinction (Le Roux et al. 2019), their influence in biodiversity coldspots is less pronounced (Le Roux et al. 2019). Concerning Russia, biological invasions play an exceptionally little role in threatened plant extinction (Khapugin et al. 2020a). Besides plant extinction, the Russian territory is characterised by a relative lack of published data on plant invasions. This is well shown by van Kleunen et al. (2015), where most parts of Russia represent a 'white gap' concerning data availability on invasive plants. In addition, Khapugin (2019) demonstrated that data on invasive trees most common in Eurasia are less presented in Russia than in Western Europe and North America. Now, the most comprehensive study on invasive plants of Russia has been conducted by Vinogradova et al. (2018) who encountered data from 45 regions. However, the mentioned study did not include data from regions of Western Siberia, namely Tyumen Region, Khanty-Mansi Autonomous Okrug and Yamalo-Nenetsky Autonomous Okrug. Thus, these regions are characterised by an exclusively little amount of published data on alien plants.

Tyumen region is located at the border of Europe and Asia. Consequently, its flora contains traits of European and Siberian (Northwest Asia) vegetation. Nevertheless, Tyumen flora is still poorly studied (Kuzmin 2016). Concerning non-native components of the flora, only the preliminary list of potentially invasive alien plants is currently known (Kuzmin 2012). Previously, no comprehensive studies of alien plants of this region have been conducted. However, new records of alien plants for the Tyumen Region have been published to date (e.g. Nobis et al. 2020; Verkhozina et al. 2020). Previously, it was demonstrated that the joint use of both citizen science (i.e. obtained by amateur, non-professional naturalists) and expert (observations of graduated botanists, herbariums, publications) data could provide most complete data on plant distribution (Kuzmin & Khapugin 2020) as well as supplement national and regional lists of the flora (e.g. Khapugin et al. 2020b; Schuette et al. 2018).

This study is aimed to generalise the current data on actual distribution of four highly recognisable alien plant species in Tyumen region, namely *Echinocystis lobata* (Michx.) Torr. & A. Gray, *Impatiens glandulifera* Royle, *Heracleum sosnowskyi* Manden., *Calystegia sepium* subsp. *americana* (Sims) Brummitt (in Russia, it is commonly named as *Calystegia inflata* G. Don). We studied these data for both Tyumen Region and Tyumen Urban Area. The last was chosen, because we hypothesised that this is the most alien species-rich area in the Tyumen Region.

Materials and methods

Study area. The study area represents the Tyumen Region located in the West Siberian Plain (Russia) (between 55.146607° E and 59.989174° E and between 64.828526° N and 75.200345° N). The region covers about 160,122 km^2. In the Tyumen Region, climate is temperate continental (Degefie et al. 2014). About two-third of the precipitation amount occurs from May to September (Gvozdetskiy 1973). According to the classification of Dinerstein et al. (2017, 2019), the northern part lies within the ecoregion of West Siberian taiga in the biome of boreal forests (taiga) (Fig. 1). A middle part refers to the ecoregion of Western Siberian hemiboreal forests of the biome of temperate broadleaf and mixed forests with typical small-leaved trees (*Betula pendula* Roth, *Populus tremula* L.) and conifers (predominantly *Pinus sylvestris* L.).

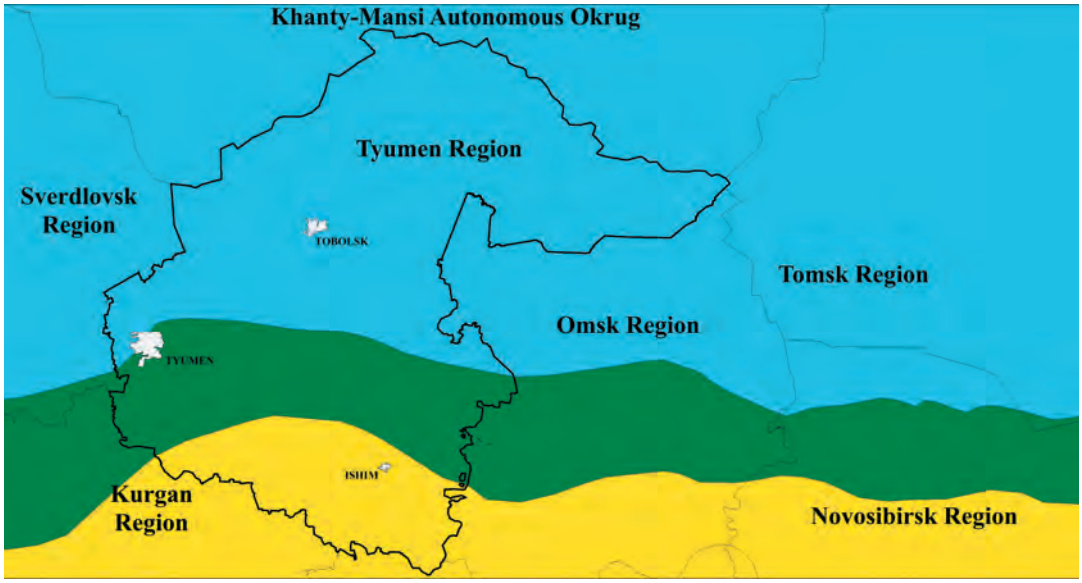

Figure 1. Tyumen Region in the south of West Siberia (Russia). Designation of biomes according to Dinerstein et al. (2017, 2019): blue colour – boreal forests (taiga); green – temperate broadleaf and mixed forests; yellow – temperate grasslands, savannas and shrublands.

The central and southern areas of the Tyumen Region lie in the ecoregion of Kazakh forest steppe in the biome of temperate grasslands, savannas and shrublands, according to Dinerstein et al. (2017, 2019), where macro-mosaic of light birch (*Betula pendula*) forests and grasslands occur (Gvozdetskiy 1973).

Data sampling and processing. We studied data on the distribution of four alien plant species (*Echinocystis lobata*, *Impatiens glandulifera*, *Heracleum sosnowskyi*, *Calystegia sepium* subsp. *americana*). The scientific names are used according to the database POWO (http://www.plantsoftheworldonline.org/). The records were collected from two sources. First of them were expert data, i.e. herbarium specimens and photograph-based observations of professional botanists (in our study: the second author of the paper) during special investigation of plant distribution in the study area. The second source was represented by citizen science data extracted from Research Grade-level observations made by amateur naturalists on the platform iNaturalist (Ueda 2021). If an author of a Research Grade-level observation was a professional expert-botanist, it was considered as a part of expert data, being excluded from citizen science data set.

For each alien plant, the distribution was demonstrated using grid mapping schemes. Analysis was performed at two scale levels, including the whole Tyumen Region and the Tyumen Urban Area. For visualisation, the 10×10 km cell scheme was used for distribution in the Tyumen Region (Khapugin & Kuzmin 2020), while 1×1 km cell scheme for Tyumen Urban Area (Kuzmin & Khapugin 2020). Since the southernmost and northernmost parts of the Tyumen regions were free of records of alien plants, we reduced the map for better presenting the symbols indicating the records of species.

We tested, whether the number of alien plant records is different within and outside Tyumen Urban Area. For this purpose, we used the two-sampled paired test using PAST 3.14 software (Hammer et al. 2001).

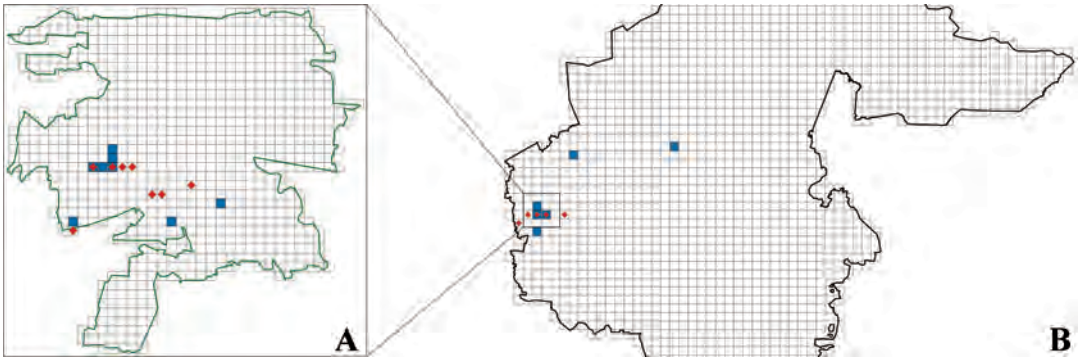

Figure 2. The distribution of *Heracleum sosnowskyi* in the Tyumen Urban Area (A) and Tyumen Region (B) based on the grid mapping scheme. Designations: blue squares refer to expert data; red diamonds indicate citizen science data.

Results and discussion

All of the studied alien plant species are relatively well identifiable. These species are widely cultivated by citizens except for *Heracleum sosnowskyi*. Therefore, we expected the higher number of records within urbanised landscapes. Indeed, we found a higher number of records within boundaries of the Tyumen Urban Area (see Figs 2; 3; 4; 5).

For *Heracleum sosnowskyi*, we analysed expert data on 37 records in the Tyumen Region, including 31 ones from the Tyumen Urban Area (Fig. 2). They were arranged into nine 10×10 km grid cells in the Tyumen Region. By 06 March 2021, iNaturalist contained data on 12 Research Grade observations made in the Tyumen Region, including eight from the Tyumen Urban Area. In three of nine 10×10 km grid cells situated in the map of the Tyumen Region, only citizen science data support the knowledge on *H. sosnowskyi* distribution. Fig. 2 shows 2-cell overlapping at macro-scale (in the area of the entire Tyumen Region using 10×10 km grid cell scheme) and 2-cell overlapping at micro-scale (in the Tyumen Urban Area using 1×1 km grid cell scheme).

For *Echinocystis lobata*, we obtained expert data on 70 records in the Tyumen Region, including 50 from the Tyumen Urban Area (Fig. 3). They were arranged into 17 10×10 km grid cells in the Tyumen Region. By 06 March 2021, iNaturalist contained data on five Research Grade observations made in the Tyumen Region. All of them are situated within the Tyumen Urban

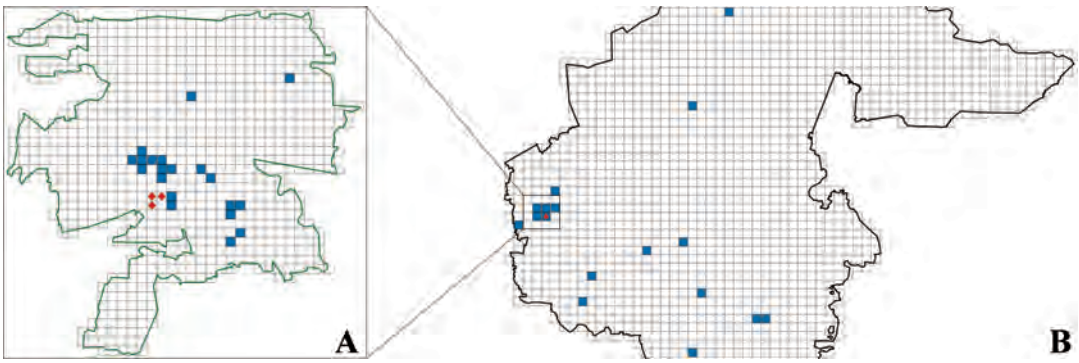

Figure 3. The distribution of *Echinocystis lobata* in the Tyumen Urban Area (A) and Tyumen Region (B) based on the grid mapping scheme. Designations: blue squares refer to expert data; red diamonds indicate citizen science data.

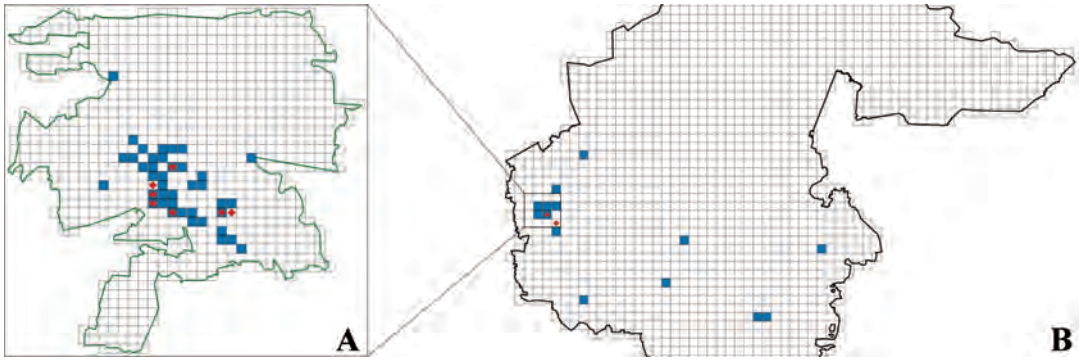

Figure 4. The distribution of *Impatiens glandulifera* in the Tyumen Urban Area (A) and Tyumen Region (B) based on the grid mapping scheme. Designations: blue squares refer to expert data; red diamonds indicate citizen science data.

Area. For this species, citizen science data do not supplement the knowledge on *E. lobata* distribution supported by expert data at macro-scale, while at micro-scale, iNaturalist data ensure three of 23 1×1 km grid cells. Fig. 3 shows 1-cell overlapping at macro-scale and no overlapping at micro-scale in the Tyumen Urban Area.

For *Impatiens glandulifera*, we had expert data on 123 records in the Tyumen Region, including 99 ones from the Tyumen Urban Area (Fig. 4). They were arranged into 15 10×10 km grid cells in the Tyumen Region. By 06 March 2021, iNaturalist contained data on nine Research Grade observations made in the Tyumen Region, including eight from the Tyumen Urban Area. In one of fifteen 10×10 km grid cells in the Tyumen Region, only citizen science data support the knowledge on *I. glandulifera*. At the same time, at micro-scale, two of 42 1×1 km grid cells are supported by citizen science data only. Fig. 4 shows 1-cell overlapping at macro-scale and 5-cell overlapping at micro-scale in the Tyumen Urban Area.

For *Calystegia sepium* subsp. *americana*, we obtained expert data on 43 records in the Tyumen Region, including 37 from the Tyumen Urban Area (Fig. 5). They were arranged into 12 10×10 km grid cells in the Tyumen Region. By 06 March 2021, iNaturalist contained data on five Research Grade observations made in the Tyumen Region, including four within the Tyumen Urban Area. In two of eighteen 10×10 km grid cells in the Tyumen Region, only citizen science data support the knowledge on *C. sepium* subsp. *americana*. At the same time, at micro-

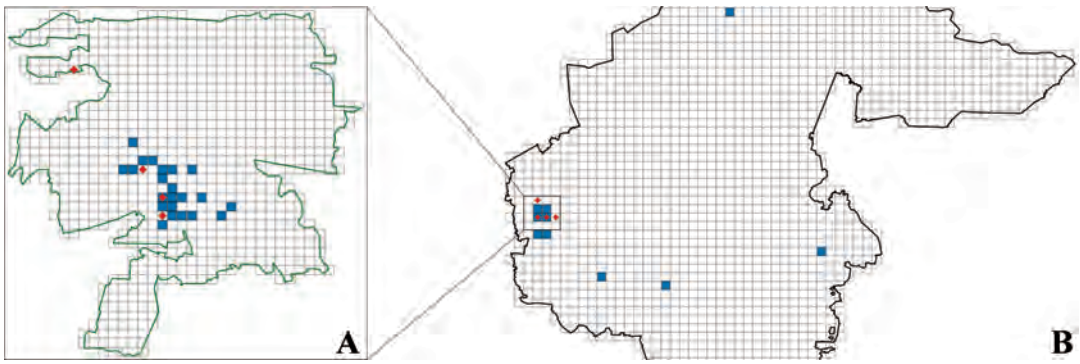

Figure 5. The distribution of *Calystegia sepium* subsp. *americana* in the Tyumen Urban Area (A) and Tyumen Region (B) based on the grid mapping scheme. Designations: blue squares refer to expert data; red diamonds indicate citizen science data.

scale, three of 25 1×1 km grid cells are supported by citizen science data only. Fig. 5 shows 2-cell overlapping at macro-scale and 1-cell overlapping at micro-scale in the Tyumen Urban Area.

The general overview of data demonstrates that the highest number of alien plant records is concentrated within the Tyumen Urban Area. Although the entire Tyumen Region is 119.44 times bigger than the Tyumen Urban Area, the differences in number of alien plant records is significant for expert data (t=2.6661, df=6, p=0.037222). These differences are much more pronounced for citizen science data (t=3.5282, df=6, p=0.012395).

The patterns of spatial arrangement of records in both Tyumen Region and Tyumen Urban Area are quite similar. The highest number of records in the Tyumen Region is limited within the Tyumen Urban Area, while within the Tyumen Urban Area records are predominantly concentrated in its central part. On the one hand, it can be explained by the origin of the alien species, which are widely used by humans as ornamental plants except for *H. sosnowskyi*. In addition, these species are common in Russian regions (Vinogradova et al. 2018). Therefore, we may assume the increase in number of new records of these alien plants in the Tyumen Region. On the other hand, such significant differences in the number of records within and outside of the Tyumen Urban Area make evident the underestimation of the alien plant distribution in the Tyumen Region. Recently, Seregin et al. (2020) demonstrated the high rates in accumulation of data on plant distribution in Russia through data obtained by amateur citizens. Therefore, a participation of citizen science in the biodiversity monitoring could lead to an accumulation of a higher amount of data on plant distribution, including alien plants in the Tyumen Region. We believe that the use of such citizen science data along with expert data obtained by professional botanists can lead to obtain the complete map of species distribution, including invasive and potentially hazardous alien plants (see also Kuzmin & Khapugin 2020). Additionally, the use of grid mapping for visualisation of plant distribution allows us to analyse statistically the results. Such approach provides interesting and valuable results (e.g. Seregin 2014; Uotila 2017; Khapugin & Silaeva 2020).

Conclusions

The distribution of *Echinocystis lobata*, *Impatiens glandulifera*, *Heracleum sosnowskyi*, *Calystegia sepium* subsp. *americana* in the Tyumen Region depends on human activity. So, the number of records was significantly higher within highly populated Tyumen Urban Area. The low amount of data on alien plant distribution outside this area could be improved by a further increase in the number of new records. In addition, the concentration of the highest number of alien plant records within the Tyumen Urban Area allows us to conduct comprehensive population studies of invasive plants on a limited territory. We propose the need to conduct the same studies for other alien species in the Tyumen Region by involving both expert and citizen science data. The application of the developed grid mapping schemes looks to be mandatory for further analysis of distribution data using methods of biological statistics.

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