УДК 573

Distribution features and species composition of invasive plant species of Russia and China

Тохтарь Валерий Константинович

доктор биологических наук, старший научный сотрудник, директор Научно-образовательного центра «Ботанический сад» Белгородского государственного национального исследовательского университета

Фангхао Ван

доктор философии, научный сотрудник Государственной ключевой лаборатории биологии болезней растений и насекомых-вредителей Института защиты растений Китайской академии сельскохозяйственных наук (Китай, Пекин)

Руй Ван

научный сотрудник Государственная главная лаборатория биологии болезней растений и насекомых-вредителей Института защиты растений Китайской академии сельскохозяйственных наук (Китай, Пекин)

Курской Андрей Юрьевич

заведующий сектором Природной флоры Научно-образовательного центра «Ботанический сад» Белгородского государственного национального исследовательского университета

Третьяков Михаил Юрьевич

кандидат биологических наук, заведующий лабораторией Генетики и селекции растений Научно-образовательного центра «Ботанический сад» Белгородского государственного национального исследовательского университета

Зеленкова Виктория Николаевна

заведующий лабораторией Экспериментальной ботаники Белгородского государственного национального исследовательского университета

Abstract: *The article provides data on dangerous invasive species of Russia and China. The general list includes 38 species of vascular plants, of which only five species are common: Amaranthus retroflexus, Ambrosia artemisiifolia, Erigeron annuus, E. canadensis, Galinsoga*

parviflora. "Unique" invasive plant species for China are 12 species: Ageratina adenophora, Ageratum conyzoides, Alternathera philoxeroides, Amaranthus spinosus, A. viridis, Aster subulatus, Chenopodium ambrosoides, Eupatorium odoratum, Flaveria bidentis, Lepidium virginicum, Phytolacca americana, Solanum rostratum. Invasive plant species that are noted only in the Russian Federation are 21 species. 10 species may be potentially dangerous as a result of migration along the Trans-Siberian Railway to China: Acer negundo, Amelanchier spicata, Ambrosia psilostachya, A. trifida, Cyclachaena xanthiifolia, Fraxinus pennsylvanica, Heraculum sosnowsky, Reynoutria × bohemica, Rosa rugosa, Oenothera biennis, Solidago canadensis, S. gigantea.

***Аннотация**: В статье приводятся данные по опасным инвазионным видам России и Китая. Общий список включает 38 видов сосудистых растений, общими из которых являются только пять видов: Amaranthus retroflexus, Ambrosia artemisiifolia, Erigeron annuus, E. canadensis, Galinsoga parviflora. «Уникальными» инвазионными видами растений для КНР являются 12 видов: Ageratina adenophora, Ageratum conyzoides, Alternathera philoxeroides, Amaranthus spinosus, A. viridis, Aster subulatus, Chenopodium ambrosoides, Eupatorium odoratum, Flaveria bidentis, Lepidium virginicum, Phytolacca americana, Solanum rostratum. Инвазионными видами растений, которые отмечены только в РФ является 21 вид. Потенциально опасными в результате миграции по Трансибирской магистрали в Китай могут быть 10 видов: Acer negundo, Amelanchier spicata, Ambrosia psilostachya, A. trifida, Cyclachaena xanthiifolia, Fraxinus pennsylvanica, Heracleum sosnowskyi, Reynoutria × bohemica, Rosa rugosa, Oenothera biennis, Solidago canadensis, S. gigantea.*

***Keywords**: invasive plant species, Trans-Siberian Railway, Russia, China.*

***Ключевые слова**: инвазионные виды растений, Транссибирская Магистраль, Россия, Китай.*

Currently, biological invasions of alien organisms are among the main threats to biodiversity and natural and agricultural ecosystems. Experts estimate the damage caused by these alien invasions to be worth billions of dollars annually. The introduction and spread of non-native species pose a direct threat to native species and crop losses from weeds, many of which are invasive, range from 9 to 20 percent. The impact of non-native organisms on flora, fauna and society as a whole is of global importance as, for the time being, their worldwide distribution can be dealt with only at the international level. Local measures cannot give positive results and require the efforts of different countries, as expansion of non-na-

tive organisms occurs beyond all borders. The need to study non-native species is determined by the fact that they are either economically valuable or harmful invasive species that displace local native species.

The considerable length of the borders between Russia and China and the similarity of climatic conditions in the transboundary areas of the countries facilitate the migration of plant complexes and associated phytophages to new habitats (Tokhtar et al., 2021; Vinogradova et al., 2021). This exchange takes place in two main forms: in the form of unintentional introductions of organisms with consignments and through the deliberate introduction of predominantly woody species for greening. There is also an active invasion of non-native organisms in each region, particularly, North American species that pose a significant threat to native species in Russia and China.

During our surveys of the flora of the Trans-Siberian Railway (TSR), we have fully identified the plant species composition of this transport network. It has been found to be the main supplier of alien organisms migrating from Asia to Europe and back (Vinogradova et al., 2020; Tokhtar et al., 2020; Kotenko et al., 2022). It is therefore an important task to further identify the nature of alien migrations from the Trans-Siberian Railway infestation sites to major cities, nearby agricultural fields and local natural ecosystems in Russia and China.

To preliminarily identify the distribution patterns of invasive plant species in Russia and China, we compared the lists of the most dangerous invasive species of Russia (Dgebuadze et al., 2018) and China (Horvitz et al., 2017). The study revealed differences in the species composition of invasive species in Russia and China, which seems to be primarily explained by differences in natural and climatic conditions in different biomes.

The overall list of the most endangered invasive species in Russia (29) and China (17) includes 5 species of higher plants. They occur in both countries: *Amaranthus retroflexus, Ambrosia artemisiifolia, Erigeron annuus, E. canadensis, Galinsoga parviflora*. The "unique" invasive plant species of China that have not been recorded to date in Russia or are noted as ephemerophytes (*) include 12 species: *Ageratina adenophora, Ageratum conyzoides, Alternathera philoxeroides, Amaranthus spinosus* (*), *A. viridis* (*), *Aster subulatus, Chenopodium ambrosiodes* (*), *Eupatorium odoratum, Flaveria bidentis, Lepidium virginicum* (*), *Phytolacca americana* (*), *Solanum rostratum* (*). Currently, several species appear to have

the potential for wider spread from China to Russia: *Amaranthus spinosus, A. viridis, Lepidium virginicum* (Horwitz et al., 2017). Annual species of North American origin occupy similar native habitats and climatic conditions in Russia. In addition, they are capable of migrating along roads and railways (including the FSR) well to the north of their natural range boundaries. The remaining species currently show little potential to overcome local natural geographical, ecological and biotic barriers. However, given the gradual warming of the climate, these species may be able to successfully acclimatise and establish themselves in local natural communities in the future.

Invasive plant species recorded in the Russian Federation alone are 21 species. Ten of them seem capable of spreading widely in China and some already have a limited distribution there. These include not only European and Asian species but also North American plants which are actively migrating along the routes. These are woody species of North American origin: *Acer negundo, Amelanchier spicata, Fraxinus pennsylvanica*). Among the herbaceous monocarpics they include: *Ambrosia trifida, Cyclachaena xanthiifolia, Oenothera biennis*. The herbaceous polycarps of North American origin, *Ambrosia psilostachya, Solidago canadensis, S. gigantea*, as well as the herbaceous monocarp of Caucasian origin *Heracleum sosnowskyi* have a high invasive potential. Species such as *Reynoutria × bohemica, Rosa rugosa*, in our opinion, will not tend to spread actively at present.

A study of the main TSR connecting the European part of Russia and China found that the nucleus of species most frequently found at all sites includes the following species: *Taraxacum officinale, Artemisia vulgaris, Acer negundo, Erigeron canadensis, Linaria vulgaris, Geranium sibiricum, Chenopodium album*. Presence of these plants varies from 29,3% of total descriptions, in which this species was noted, in *Chenopodium album*, to 50,7% in *Taraxacum officinale*.

Given the occurrence of the species in the descriptions of the floras of the various railway territories, we have identified the "ideal colonist plants" of TSR. These include: *Acer negundo* (164 descriptions, 44.6% of the total number of descriptions), *Hordeum jubatum* (81, 21.9%), *Erigeron canadensis* (143, 38.7%), *Lepidium densiflorum* (82, 22.2%), *Ulmus pumila* (54, 14.6%), *Geranium sibiricum* (131, 35.5%), *Bromopsis inermis* (69, 18.7%) etc. However, a number of plants have been recorded only within specific geographical areas and ecotopes (Table 1).

Table 1. **Species recorded within different geographical areas and TSR ecotopes.**

Geographical area*	Rails	Embankment slopes	The exclusion zone	Ditches
E	Atriplex patula, Eragrostis minor, Fraxinus pennsylvanica, Oenothera rubricaulis, Panicum miliaceum, Sedum spectabile, Sinapis arvensis	Agrostis stolonifera, Anisantha sterilis, Avena sativa, Bromus commutatus, Cerasus besseyi, Lonicera tatarica, Padus virginiana, Salix myrsinifolia	Angelica sylvestris, Anthoxanthum odoratum, Brassica campestris, Bromus squarrosus, Elytrigia intermedia, Leymus racemosus, Lycium barbarum, Solidago virgaurea	Alnus glutinosa, Caragana frutex, Helianthus tuberosus, Onopordum acanthium, Rudbeckia laciniata, Salix fragilis
S	Arenaria serpyllifolia, Avena fatua, Hordeum vulgare, Serratula coronata	Artemisia dolosa, A. gmelinii, Barbarea vulgaris, Carthamus tinctorius, Microcerasus tomentosa, Mycelis muralis, Spiraea aquilegifolia, S. flexuosa, Youngia tenuifolia	Achnatherum splendens, Amelanchier spicata, Arctopoa subfastigiata, Duschekia fruticosa, Phleum phleoides, Salix brachypoda, S. jenisseensis, S. rosmarinifolia, S. triandra, Sium suave	Alopecurus aequalis, Bidens tripartita, Lycopus europaeus, Scirpus sylvaticus
FE	Brassica juncea, Lactuca sativa, Lepidium virginicum, Lespedeza bicolor, L. davurica, L. juncea, Saussurea amara	Crataegus dahurica, Diplazium sibiricum, Ixeridium chinense, I. gramineum, Kalimeris integrifolia, Larix dahurica, Maackia amurensis, Senecio vernalis, Viburnum opulus	Angelica dahurica, Eragrostis pilosa, Hemerocallis middendorffii, Iris ensata, Lilium pensylvanicum, Lonicera maackii, Spiraea salicifolia, Trommsdorffia ciliata	Artemisia integrifolia, A. rubripes, Carex appendiculata, C. capricornis, C. cespitosa, Iris sanguinea, Maianthemum bifolium, Phragmites australis subsp. altissimus

* Symbols: **E — European part, S — Siberia, FE — Far East**

Analysing the results (Table 1), it can be noted that each geographical area has a "peculiar" set of species that occurs only in that region. For example, in the European part these are: *Fraxinus pennsylvanica, Oenothera rubricaulis*, in Siberia: *Carthamus tinctorius, Microcerasus tomentosa* and in the Far East: *Hemerocallis middendorffii, Iris ensata, Lilium pensylvanicum.*

European species such as: *Achillea millefolium* penetrates from the European part of Russia to the Far East along all sections of the railway, except the areas of drainage ditches, and *Senecio vulgaris* — only along the railway track and slopes. In the European part of Russia they belong to the indigenous flora, while in the Far East they are part of the invasive component of the flora.

Asiatic species such as *Echinochloa crusgalli* penetrates into the European part mainly along the railroad tracks and nowadays is a common, widespread species within agricultural fields of the European part of Russia. *Artemisia sieversiana* actively spreads along the TSM, forming thickets on slopes and railway embankments. However, in the European part of Russia it is still restricted to other habitats, mainly along transportation routes and occasionally in ruderal habitats. *Impatiens parviflora* is found on the slopes of the TSM, often forming thickets. In the European part of Russia, this species is found outside the railway, in ruderal habitats, and also as part of natural communities, where it is found within broad-leaved woodlands.

Currently, to identify the main trends of phytoinvasions of alien species, it is necessary to develop and implement completely new innovative methods and approaches that allow visualizing the patterns of their distribution in different natural and anthropogenic conditions (Dmitriev et al., 2022a; 2022b; Tokhtar et al., 2011; Tokhtar, Groshenko, 2014; Tokhtar et al., 2020; 2021). At present, preliminary studies of spectral characteristics of the most common weed species occurring in agrocenoses of cereal crops using hyperspectral complex have been conducted on the basis of the Botanical Garden of NRU "BelSU" (https://ckp-rf.ru/usu/200997/). The results of the study showed high efficiency of using vegetation indices in hyperspectral data processing for the purposes of species identification of *Ambrosia artemisiifolia* L., *Euphorbia seguieriana* Neck., *Atriplex tatarica* L., *Glycyrrhiza glabra* L. and *Setaria pumila* (Poir.) Roem. & Schult. when taken from a short distance.

Thus, the spread of alien plant species from Europe to Asia and back represents a global phenomenon that can seriously affect the state of Eurasian natural ecosystems. A preliminary analysis of the species composition of dangerous

invasive plants distributed in Russia and in China shows that a number of species are widely distributed in the biomes of both countries, other plants occur locally but show tendencies to spread to new habitats, and some species grow only in the places of introduction. Increasing trade and economic ties between the countries and climate change will undoubtedly lead to changes in biome boundaries and species composition, which is of special interest for predicting invasions and developing ways to control and limit them.

The research was supported by grant № FZWG-2021–0018 of the Ministry of Science and Higher Education of Russian Federation "Development and practical introduction of complex physico-chemical methods of plants state estimation for solution of tasks of directional formation of stable crop-phytocenoses of different functional purpose in conditions of industrial and agrarian enterprises".

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