

RESEARCH ARTICLE

Alien plant species pathways on the territory of Altai Krai and their role in the formation of phytocenoses

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The article characterizes the family spectrum of all the alien plant species represented in the territory of Altai krai. It considers the pathways of adventitious species of the flora (escapees from cultivation, seed weeds, or other pathways, such as migration along the motile substrates of the primary and secondary origin). The analysis of the most active adventitious plants list is carried out.

Keywords: adventitious species; flora; vegetation; synanthropization of vegetation cover

Introduction

Since the beginning of the 20th century, active introduction of adventitious species into ecosystems has been observed worldwide. Most often, the penetration occurs via anthropogenically disturbed communities. Due to the increase in the intensity of the flow of goods, this process accelerated significantly. This phenomenon is called biological invasions in domestic and foreign literature. Migration of species most often occurs due to the following reasons: natural migration associated with population fluctuations and climatic changes; intentional introduction and reintroduction of economically and aesthetically important organisms; accidental introduction with imported agricultural products, luggage, seeds, etc. Alien species often hybridize with the populations of closely related aboriginal species, considerably alter the structure of ecosystems, and their appearance has substantial economic and social consequences.

Invasive alien species are rightfully considered to be the second most significant (after habitat destruction) threat to biodiversity (Olmstead, 2006).

Materials and methods

In order to identify alien plants in natural and anthropogenic ecosystems, field studies were conducted by means of the traditional route method. The completed geobotanical descriptions were processed with the help of the Turboveg software.

Results

Taking into account the peculiarities of Altai krai, where, in the first place, the agrarian and tourism sectors are well developed, we should note that the adventitious species settle in anthropogenically disturbed habitats. The adventitious species present in the flora of the krai already cause significant problems transiting to the invasive group. They are *Cyclachaena xanthifolia* (Nutt.) Fresen, actively spreading in the Altai foothills; *Ambrosia artemisiifolia* L., inhabiting the outskirts of the Biysk city; *Acer negundo* L., invading the roadsides, forest clearances, floodplains; *Solidago canadensis* L that appeared in pastures and along the roadsides.

A total of 341 adventitious plant species grow on the territory of Altai krai, which accounts for 15.06% of the entire flora (Silantsev, 2013). These species were introduced at different times, but their flow has especially increased in recent decades. The fact that the plains of Altai krai are to a large extent characterized by the disturbed vegetation cover mostly due to plowing plays a pivotal role in this process. The degree of vegetation disturbance approaches 75-80%. Adventitious plant species belong to 56 families. Some families contain 1-3 species of plants. They include *Resedaceae* S.F. Gray, *Vitaceae* Juss, *Tiliaceae* Juss, *Ulmaceae* Mirb., *Urticaceae* Juss., *Euphorbiaceae* Juss *Grossulariaceae* DC, *Aceraceae* Juss., *Rutaceae* Juss, *Linaceae* S.F. Gray, *Oxalidaceae* R. Br, *Geraniaceae* Juss, *Balsaminaceae* A. Rich, *Elaeagnaceae* Juss., *Hydrangeaceae* Dumort, *Dipsacaceae* Juss. *Gentianaceae* Juss, *Asclepiadaceae* R. Br., *Convolvulaceae* Juss, *Polemoniaceae* Juss., *Hydrophyllaceae* R. Brown, *Convallariaceae* Horaninow, *Commelinaceae* R. Br.

On the other hand, some families contain from 44 to 10 species. They are the families shown in Table 1. In addition, another 10 families contain from 7 to 4 species.

Table 1. Pathways of the adventitious species in Altai krai

Family	Number of species	Escapees from cultivation	With contaminated seeds	Other pathways
<i>Asteraceae</i> Dumort	44	9	7	25
<i>Fabaceae</i> Lindl	33	25	2	6
<i>Poaceae</i> Barnhart	31	12	11	6
<i>Cruciferae</i> Juss.	27	12	13	8
<i>Rosaceae</i> Juss	22	20	2	-
Other families	176	85	59	62
Total	341	162 (47.51%)	101 (29.62%)	98 (28.74%)

Discussion

A significant part of the adventitious plants is referred to escapees from cultivation (47.51%). Among them, there are species that are not actively expanding, reproducing mostly in the places of cultivation. They include *Juglans mandshurica* Maxim., *Glaucium corniculatum* (L.) Rudolph, *Aquilegia vulgaris* L., *Aquilegia × hybrida* Hort. In Altai krai, one can find different varieties of columbines originated from American species: *A. chrysantha* A. Gray, *A. coerulea* E. James, *A. canadensis* L. They are the species of the colonophyte category. Other species are spreading quickly due to active actions of animals and first and foremost birds. They are *Quercus robur* L., *Corylus avellana* L., *Grossularia reclinata* (L.) Mill., *Ribes aureum* Pursch, *Ribes rubrum* L., *Elaeagnus angustifolia* L., *Elaeagnus argentea* Pursch, *Tilia cordata* Mill. These actions are so active that they cause changes in the landscape. The emergence of the oleaster in the steppe led to the formation of so-called "lokhovniki" (oleaster groves). The occurrence of *Elaeagnus angustifolia* increases from east to west in the steppe area of the region. Being a drought-resistant glycolhalophyte (Shibanova, Grebennikova, Kirina, 2013), this species is actively settling in saline habitats.

Rosaceae comprises the most of escaped plants: *Amelanchier spicata* (Lam.) K. Koch (as well as *A. ovalis* Medic., *A. florida* Lindl., *A. canadensis* (L.) Medik.), *Amygdalus nana* L., *Aronia mitschurinii* A. Skvorts. et Maitull., *Cerasus fruticosa* Pall., *Cerasus vulgaris* Mill., *Fragaria moschata* Duch., *Fragaria virginiana* Duch., *Fragaria × ananassa* Duch. ex Rozier, *Malus baccata* (L.) Borkh., *Malus domestica* Borkh., *Malus prunifolia* (Willd.) Borkh., *Padus virginiana* (L.) Mill., *Prunus spinosa* L., *Prunus cerasifera* Ehrh., *Pyrus ussuriensis* Maxim., *Rosa rugosa* Thunb., *Sorbaria sorbifolia* A. Br., *Spiraea salicifolia* L. When comparing the germinative capacity in some of these species, *Physocarpus opulifolius* (L.) Maxim. demonstrated the total germinality at 75.3%, which is slightly less than that of the ash-leaved maple (86.0%). This fact foreshadows its active expansion in the near future (Belanova, 2016). Single populations of *Physocarpus opulifolius* are already noted in the territory of Novosibirskaya oblast and Altai krai.

The greatest number of invasive plant species is characteristic of Asteraceae. However, there are not so many escapees among them. Mostly, they are ornamental plant species *Aster novo-belgii* L., *Callistephus chinensis* (L.) Nees, *Centaurea cyanus* L., *Cosmos bipinnatus* Cav., *Rudbeckia hirta* L., *Rudbeckia laciniata* L., *Solidago canadensis* L. Some of them are weeds in their home place, in North America as well. Over the past 20 years, *Solidago canadensis* has been spreading most actively. It occupied dry meadows, floodplain meadows and abandoned fields in the outskirts of Biysk (Ovcharova, Teryokhina, 2016) reaching the maximum abundance of soc and cop3. The representatives of the genus *Centaurea* probably belong to self-seeding species: *C. diffusa* Lam., *C. jacea* L., *C. majorovii* Dumb., *C. pseudophrygia* C. A. Mey., *C. pseudomaculosa* Dobroc., *C. squarrosa* Willd., *C. psammogena* Gayer. They mostly occupy roadsides and inarable lands. However, over the past 10 years, *Centaurea jacea* L. has been reproducing actively thus forming almost homotypical communities with 100% projective cover. It especially affected the dry meadows, where cattle is no longer grazed and abandoned fields (Teryokhina, Ovcharova, 2016).

Cyclachaena xanthifolia (Nutt.) Fresen is also considered an actively self-settling species. It forms large clusters in human settlements in the steppe area of the krai, preferring roadsides, wastelands and cattle camps. Thus, the sump weed, which number is increasing each year, occupies more than 90% of wastelands, roadsides and spoil heaps in the town of Gornyyak. 20 years after its first introduction to the territory, it reached the city of Barnaul (2018), having covered the distance of more than 500 km.

A relatively recent edition of Black Book of Siberia (2016) describes 58 species of invasive plants. The analysis of the most active invasive plants list reveals the fact that the first category species, which are transformers and are actively introducing into natural and semi-natural communities, change ecosystems, distort serai relations, behave as edificators and dominants forming large homotypical thickets, displace or prevent the regeneration of the species of the natural flora are all escapees from cultivation. Adventitious species that are actively settling and are naturalized in disturbed, semi-natural and natural habitats, referred to the second category contain only 25.0% of escapees. Adventitious species that are currently settling and naturalizing in disturbed habitats, some of which are likely to penetrate into semi-natural and natural communities in the course of further naturalization, belonging to the third category include 32.1% of escapees. Potentially invasive species (category 4), capable of regeneration in the places of accidental introduction that proved to behave as invasive species in adjacent regions contain

45.5% of escapees from cultivation. This indicates the fact that the species of the fourth category can actively spread in the future and can play a significant role in the formation of communities in the disturbed habitats.

A rather large group is represented by the adventitious species referred to the plants introduced to other territories along with seeds. Their considerable part entered the territory of the region long ago and it is impossible to define the specific introduction time for them (*Scleranthus annuus* L., *Spergula arvensis* L., *Spergula sativa* Boenn., *Stellaria media* (L.) Vill., *Amaranthus albus* L., *Amaranthus blitoides* S. Wats., *Amaranthus blitum* L. and others). *Ambrosia artemisiifolia* has recently penetrated into the region from the Far East along with the *Glycine max* L. seeds. *Solanum triflorum* Nutt. was introduced with the *Triticum aestivum* L. seeds from Omskaya oblast. These species established sustainable populations. This group comprises about a third of all the adventitious species. Despite the well-developed technique of seed cleaning, many species still spread this way today.

It is difficult to trace the pathways for 98 plant species, but analyzing their habitats, we can note that all of them prefer the areas with disturbed and motile substrate of the primary or secondary origin, i.e. natural sites (river banks, ravines, rockslides, etc.) and re-disturbed anthropogenic habitats (fields, kitchen gardens, dumps, wastelands, etc.).

Thus, we concluded that 71.26% of adventitious plant species in the territory of Altai krai, are escapees from cultivation or spread as weeds of seeds. About 5% of them use both pathways. The remaining 28.74% use other pathways, migrating along the motile substrates of the primary and secondary origin.

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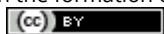
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