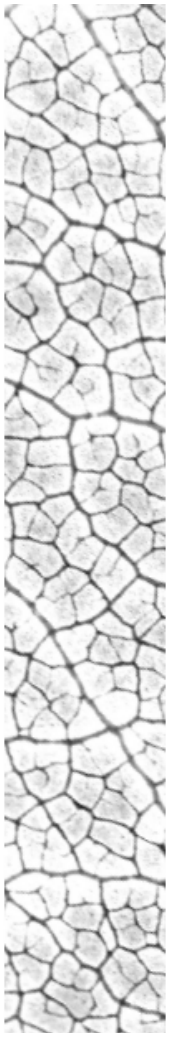

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Comparative analysis of types of plants-transformers in various regions of Central Russia

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Abstract
In this study the results of a comparative analysis of transformer species in nine different regions of Central Russia by life forms of I.G. Serebryakov (1962) and geographical origin of species are presented. Among the invasive and potentially invasive species of the compared regions, there are no common species that are transformers in all 9 regions simultaneously. However, there is a group of plants-transformers, which are represented in 8 of 9 areas.
Analyzing the ratio of life forms of transformer species in 9 regions of Central Russia, it is noted that herbaceous polycarpous plants predominate in 6 of 9 regions (except Lipetsk Oblast, Voronezh Oblast and Belgorod Oblast). Their number gradually decreases in various regions of Central Russia in the direction from the North to the South. Annual species, classified as the transformers, are consistently represented in a significant number of plants in all studied regions, while a group of herbaceous monocarpous plants is often missing among the plants-transformers in different regions. By geographical origin, the North American species predominate among the transformer species in all areas.

Keywords: alien component of the flora, transformer species

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INTRODUCTION

One of the priorities of modern botany is the cataloguing of the species composition of regional flora, including its most dynamic adventive elements (Sharma et al. 2017, Tokhtar et al. 2017, 2018). Currently, the work on the cataloguing of invasive species, the compilation of “black-sheets” and Black books (Vinogradova et al. 2010) is in progress in Russia. Plants-transformers, capable of complete change and transformation of local ecosystems, are of significant interest in the study of biological invasions. Since these plants represent a significant threat to biodiversity, and also it is necessary to identify patterns of formation of these groups of plants in different habitats, we have conducted a study on them (Fitriatin and Simarmata 2016).

OBJECTS AND METHODS

The objects of the research were transformer species of 9 regions of Central Russia: Belgorod Oblast (according to the research of the authors), Bryansk Oblast, Voronezh Oblast, Ivanovo Oblast, Kaluga Oblast, Lipetsk Oblast, Tver Oblast, Tula Oblast, and Yaroslavl Oblast (Horun 2013, Krylov and Reshetnikov 2009, Notov et al. 2010, Panasenko 2014, Rzhevuskaya 2012, Starodubtseva et al. 2014, Tremasova et al. 2013, Vinogradova et al. 2010). The analysis of plants-transformers by life forms of Serebryakov (1962) and by geographical origin of species is carried out.

RESULTS AND DISCUSSION

During the study of the flora invasive component of the South-West of the Central Russian upland for the period of 2011-2018, the annotated abstract of the flora invasive component was created for the first time in Belgorod Oblast and it included 75 species of higher plants, 8 of which are transformer species. To clarify the specific features of transformer species, a comparative analysis of transformer species in 9 regions of Central Russia was carried out. 38 transformer species are indicated in different administrative regions of this district. The volume of the group is quite diverse and includes from 7 species in Tver Oblast to 20 in Lipetsk Oblast (Gebremeskel et al. 2016).

Among the invasive and potentially invasive species of the compared regions, there are no species that are transformers in all 9 regions at the same time. However, there is a common group of plants-transformers that is

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Table 1. The ratio of life forms according to I. G. Serebryakov (1962) among the transformer species of the regions of Central Russia

Life forms, %	Tver Oblast	Yaroslavl Oblast	Ivanovo Oblast	Kaluga Oblast	Tula Oblast	Bryansk Oblast	Lipetsk Oblast	Voronezh Oblast	Belgorod Oblast
Annual plants	0	20.0	25.1	25.0	40.0	10.0	35.0	33.35	25.0
Herbaceous polycarpous plants	85.7	50.0	50.0	50.0	50.0	70.0	35.0	11.1	12.5
Herbaceous monocarpous plants	0	0	8.3	6.25	0	0	15.0	11.1	0
Shrubs	14.3	10.0	8.3	6.25	0	10.0	10.0	33.35	12.5
Trees	0	20.0	8.3	12.5	10.0	10.0	5.0	11.1	50.0

represented in 8 of 9 regions (3): *Acer negundo*, *Echinocystis lobata* (except Tver Oblast, 2nd status of invasiveness), *Elodea canadensis* (except Belgorod Oblast, 2nd status of invasiveness). *Heracleum sosnowskyi* is represented in 7 of 9 regions (except Belgorod Oblast). In 6 of 9 regions *Lupinus polyphyllus* is indicated (absent in Lipetsk Oblast and Belgorod Oblast).

For the more northern regions (Tver Oblast, Yaroslavl Oblast, Ivanovo Oblast) the common species of the same status are 9 species. 8 of them possess a high invasive status in the region. They include 3 transformer species: *Amelanchier spicata*, *Elodea canadensis*, *Lupinus polyphyllus*, and 5 species of potential transformers, which have the 2nd status of invasiveness: *Aronia mitschurinii*, *Epilobium adenocaulon*, *Juncus tenuis*, *Sambucus racemosa*, *Saponaria officinalis*.

In Tula Oblast and Kaluga Oblast, there are more plants-transformers: 10 and 16 respectively. 7 species are common for them: *Acer negundo*, *Echinocystis lobata*, *Elodea canadensis*, *Heracleum sosnowskyi*, *Impatiens glandulifera*, *Lupinus polyphyllus*, *Solidago gigantea*.

A number of transformer species are only registered in Tula Oblast: *Bidens*, *frondosa*, *Cyclachaena xanthiifolia*, *Reynoutria japonica*. In Kaluga Oblast there are 9 species found only in this region classified as transformers: *Aster salignus*, *Erigeron canadensis*, *Festuca arundinacea*, *Hyppophae rhamnoides*, *Oenothera biennis*, *Phalacroloma strigosum*, *Solidago canadensis*, *Sorbaria sorbifolia*, *Trisetum flavescens*.

Three transformer species: *Elodea canadensis*, *Heracleum sosnowskyi*, *Lupinus polyphyllus* are common for the northern and southern regions. Only in Kaluga Oblast or Tula Oblast the following species are marked as transformers: *Aster salignus*, *Erigeron canadensis*, *Oenothera biennis*, *Phalacroloma strigosum*, *Sorbaria sorbifolia*, *Trisetum flavescens* (in Kaluga Oblast), *Cyclachaena xanthiifolia*, *Reynoutria japonica* (in Tula Oblast).

For Bryansk Oblast, the most western of the studied regions, 95 invasive and potentially invasive species are presented, 10 of which are transformers: *Acer negundo, Acorus calamus, Amelanchier spicata, Aster salignus, Echinocystis lobata, Elodea canadensis, Heracleum sosnowskyi, Lupinus polyphyllus, Solidago canadensis, Zizania latifolia.*

In Lipetsk, Voronezh and Belgorod Oblasts, which are located to the south, in the forest-steppe and steppe zones, there are also a different number of transformer species: 8 species in Belgorod Oblast, 9 species in Voronezh Oblast, 20 species in Lipetsk Oblast. Common species for them are: *Acer negundo*, *Bidens*, *frondosa*, *Echinocystis lobata*. Transformer species found in 2 of 3 regions are: *Amelanchier spicata* (not in Belgorod Oblast), *Arrhenatherum elatius* (potential for Voronezh Oblast), *Elodea canadensis* (2nd status of invasiveness in Belgorod Oblast), *Phalacroloma annuum* (3rd status of invasiveness in Belgorod Oblast), *Xanthium albinum* (2nd status of invasiveness in Belgorod Oblast).

The species classified as transformers in Lipetsk Oblast only include: *Bunias orientalis*, *Epilobium adenocaulon*, *Epilobium pseudorubescens*, *Lepidium densiflorum*, *Oenothera rubricaulis*, *Parthenocissus quinquefolia*. *Parthenocissus inserta* and *Sambucus racemosa* are presented as transformers only in Voronezh Oblast. In Belgorod Oblast *Amorpha fruticosa*, *Fraxinus pennsylvanica*, *Robinia pseudoacacia* are classified as transformers, and their status is different in other areas.

Analyzing the ratio of life forms of transformer species in 9 regions of Central Russia, it is noted that in 6 of 9 regions (except Lipetsk, Voronezh and Belgorod Oblasts) herbaceous polycarpous plants predominate: from 50.0% (in Yaroslavl, Ivanovo, Kaluga and Tula Oblasts) to 85.7% (Tver Oblast). In Lipetsk Oblast the groups of herbaceous annuals and polycarpous plants take the first and the second places (35.0% both). In Voronezh Oblast, annuals and shrubs are at the first and the second places (33.35% both), and in Belgorod Oblast trees predominate (50.0% of the total number of all transformer species) (**Table 1**). The second place in 4 of 9 regions (Ivanovo, Kaluga, Tula and Belgorod Oblasts), is occupied by annuals (from 25.0% in the Kaluga Oblast and Belgorod Oblast to 40.0% in Tula Oblast).

Herbaceous monocarpous plants are not among transformer species in 5 regions (Tver Oblast, Yaroslavl Oblast, Tula Oblast, Bryansk Oblast, Belgorod Oblast) (**Table 1**).

Thus, analyzing the ratio of life forms of transformer species in 9 regions of Central Russia, it was found that in 6 of 9 regions (except Lipetsk Oblast, Voronezh Oblast and Belgorod Oblast) herbaceous polycarpous plants predominate. Their number gradually decreases in various regions of Central Russia in the direction from

Table 2. The ratio of transformer species by geographical origin of the regions of Central Russia

Geographical origin of species, %	Tver Oblast	Yaroslavl Oblast	Ivanovo Oblast	Kaluga Oblast	Tula Oblast	Bryansk Oblast	Lipetsk Oblast	Voronezh Oblast	Belgorod Oblast
North American species	71.4	80.0	66.7	62.7	70.0	70.0	75.0	77.8	75.0
Caucasian species	14.3	10.0	8.3	6.2	10.0	10.0	5.0	0	0
European species	14.3	10.0	8.3	18.3	0	0	5.0	22.2	12.5
Asian species	0	0	16.7	6.2	20.0	20.0	10.0	0	12.5
Siberian species	0	0	0	6.2	0	0	0	0	0
Mediterranean species	0	0	0	0	0	0	5.0	0	0

the North to the South (**Table 1**). Annual species, classified as the transformers, are consistently represented in a significant number of plants in all studied regions, while a group of herbaceous monocarpous plants is often missing among the plants-transformers in different regions (**Table 1**).

By geographical origin North American species predominate among the transformer species in all studied areas (from 62.7% in Kaluga Oblast to 80.0% in Yaroslavl Oblast) (**Table 2**). Asian species (from 10.0% in Lipetsk Oblast to 20.0% in Tula Oblast and Bryansk Oblast) are on the second place in 4 of 9 regions (Ivanovo Oblast, Tula Oblast, Bryansk Oblast, Lipetsk Oblast). European species takes the second place in Kaluga Oblast and Voronezh Oblast (from 18.3% in Kaluga Oblast to 22.2% in Voronezh Oblast) (**Table 2**).

Caucasian species are not represented among transformer species in Voronezh Oblast and Belgorod Oblast. European species are absent in the number of transformer species in Tula Oblast and Bryansk Oblast, and Asian species are absent in the number of transformer species in Tver Oblast, Yaroslavl Oblast and Voronezh Oblast (**Table 2**).

A specific feature of the transformer species of Belgorod Oblast in comparison with other areas is a significant number of transformer species that belong to the group of trees and shrubs. This is due to the implementation in the region of large-scale works on planting of greenery in urban and rural settlements within the regional programs of the local government.

CONCLUSION

Among the invasive and potentially invasive species of the compared regions, there are no common species that are transformers in all 9 regions simultaneously. However, there is a group of plants-transformers, which are presented in 8 of 9 areas (3): *Acer negundo*, *Echinocystis lobata* (except Tver Oblast, 2nd status of invasiveness), *Elodea canadensis* (except Belgorod Oblast, 2nd status of invasiveness). *Heracleum sosnowskyi* is represented in 7 of 9 regions (absent in Belgorod Oblast). In 6 of 9 regions *Lupinus polyphyllus* is indicated (absent in Lipetsk Oblast and Belgorod Oblast).

In Lipetsk, Voronezh and Belgorod Oblasts, which are located to the south, in the forest-steppe and steppe zones, there are also a different number of transformer species: 8 species in Belgorod Oblast, 9 species in Voronezh Oblast, 20 species in Lipetsk Oblast. Common species for them are: *Acer negundo*, *Bidens*, *frondosa*, *Echinocystis lobata*. Transformer species found in 2 of 3 regions are: *Amelanchier spicata* (not in Belgorod Oblast), *Arrhenatherum elatius* (potential for Voronezh Oblast), *Elodea canadensis* (2nd status of invasiveness in Belgorod Oblast), *Phalacroloma annuum* (3rd status of invasiveness in Belgorod Oblast), *Xanthium albinum* (2nd status of invasiveness in Belgorod Oblast).

Analyzing the ratio of life forms of transformer species in 9 regions of Central Russia, it is noted that in 6 of 9 regions (except Lipetsk, Voronezh and Belgorod Oblasts) herbaceous polycarpous plants predominate. Their number gradually decreases in various regions of Central Russia in the direction from the North to the South (**Table 1**). Annual species, classified as the transformers, are consistently represented in a significant number of plants in all studied regions, while a group of herbaceous monocarpous plants is often missing among the plants-transformers in different regions (**Table 1**).

By geographical origin North American species predominate among the transformer species in all studied areas ranging from 62.7% (in Kaluga Oblast) to 80.0% (in Yaroslavl Oblast) (**Table 2**). From the North to the South the number of plants-transformers among the Caucasian species reduces.

A specific feature of the transformer species of Belgorod Oblast in comparison with other areas is a significant number of transformer species that belong to the group of trees and shrubs. This is due to the implementation in the region of large-scale works on planting of greenery in urban and rural settlements within the regional programs of the local government. Therefore, the role of tree and shrub species, introduced into the local plant communities in Belgorod Oblast increases significantly. It is a common modern trend for many European territories, where the number of plants accidentally introduced with the imported goods gradually reduces, though the number of wild ergasiophyte plants that have been successfully penetrating in the local community increases.

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