BELARUSIAN STATE UNIVERSITY

State Research and Production Association
SCIENTIFIC AND PRACTICAL CENTER OF THE NATIONAL ACADEMY OF SCIENCES OF BELARUS FOR BIORESOURCES

A. N. SEVERTSOV INSTITUTE OF ECOLOGY AND EVOLUTION OF THE RUSSIAN ACADEMY OF SCIENCES

ALIEN SPECIES OF ANIMALS, FUNGI AND PLANTS IN BELARUS AND NEIGHBORING COUNTRIES

Book of Abstracts
of the 1st International Scientific Conference

Minsk
Belarus
March 23, 2021

MINSK
BSU
2021

UDC 574.1(082)

With the support of GCRF COMPASS
(GCRF UKRI ES / P010849/1)

Alien species of animals, fungi and plants in Belarus and neighboring countries : Book of Abstracts of the 1st International Scientific Conference, Minsk, Belarus, March 23, 2021 / Belarusian State University ; D. G. Zhorov [et al.] (eds.). – Minsk : BSU, 2021. – 119 p.
ISBN 978-985-881-255-3.

The scientists' materials presented are devoted to modern aspects of faunal, florial and fungal research, and monitoring and ecology of alien and invasive species in Belarus and neighboring countries.

The materials are intended for researchers, university lecturers, graduate students, and students of specialized educational fields. The authors of each paper are solely responsible for the accuracy of the information presented, correctness of the citation sources, statistical, personal and other data given in the articles.

UDC 574.1(082)

ISBN 978-985-881-255-3

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CONFERENCE PROGRAMME

Link to join the conference: https://peregovorka.by/ias-conference.2021

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Section 1. Invasive And Alien Animal Species

THE PRESENCE OF *OTIORHYNCHUS ARMADILLO* (ROSSI, 1792) (COLEOPTERA: CURCULIONIDAE: ENTIMINAE) IN NORTH POLAND

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Introduction. In the recent years a strong expansion of *Otiorhynchus armadillo* in the northerly direction has been observed in Europe. It is a species, which until recently was encountered only in North-West Balkans and mountainous regions of several countries located in Central Europe (Frieser 1981). In 1995 it reached Sweden, and in 2010 – Norway (Staverløkk, 2010). In Poland *Otiorhynchus armadillo* had been first recorded in the city of Warsaw (Mazur & Mokrzyck, 2011).

Materials and methods. In 2018–2020 a lot of specimens were collected in small household plot bordering with municipal South Park in Słupsk. In mid-September 2020, up to 5–7 males and females/day were observed simultaneously on the shaded wall of the house.

Results. The origin of this flightless species in Słupsk is unknown; it is possible it had been transferred with soil or with plants, as had frequently taken place in other countries (Staverløkk, 2010). The biology of *O. armadillo* has been studied quite extensively because locally it has the status of a pest. The species is polyphagous. In Italy Bene and Parrini (1986) observed over 100 plant species and cultivars in 50 genera (mostly of woody plants) susceptible to attack by *O. armadillo*. They note economic damage was caused on *Camellia japonica, Prunus laurocerasus* and *Azalea*, *Rhododendron* and *Taxus* spp. Imagines have been observed to feed on leaves of various species of trees and shrubs; larval feeding on the roots was studied in Norway (Staverløkk, 2010). In some countries the impact of its presence on economy is significant enough to attempt eradication of the species both chemically and biologically (Grassi et al., 2003).

In Słupsk beetles gnawed at night on the leaves of rhododendrons and yellow azalea *Rhododendron luteum* Sweet, 1830. According to preliminary observations some females probably hibernate, although this needs to be confirmed by special studies.

Conclusion. The weevil can create stable populations in northern Poland. Its dispersal is limited by the transfer of infected soil with larvae. Further resettlement can lead to a massive appearance of a dangerous pest of garden and ornamental plants.

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INFLUENCE OF ALIEN SPECIES ON THE AVIFAUNA OF THE REPUBLIC OF BELARUS

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Introduction. The world around us is rapidly changing not only under the influence of climate change, but also as a result of human activities. The problem of alien species has become due to human activity that has displace local species and change biological diversity. Against the background of such changes, it is interesting to know whether the avifauna of Belarus is displaced by alien species.

Materials and methods. To study this issue, we conducted an analytical review of the literature data.

Results. In order to enter another territory, a species must overcome a number of different barriers. For example, the geographical barrier for birds is easy to overcome. Abiotic barrier is more difficult to overcome, for this the species must be highly adaptable to various factors. The biotic barrier is the main filter that determines the survival of the species in the new territory. Often, in order to survive, new species occupy specific habitats, which allow them to increase quickly in numbers. Predatory species have the best way to overcome this barrier (Alekhnovich et al., 2016).

Belarus has a transit, which makes it vulnerable to the introduction of alien species. So, due to the change in climatic conditions, a number of steppe species living in Ukraine began their advance on Belarus as, an example – Steppe Eagle (*Aquila nipalensis*). From the territory of southern Europe, we got the Black-Headed Gull (*Ichthyaetus melanocephalus*), Syrian Woodpecker (*Dendrocopos syriacus*), Ringed Turtledove (*Streptopelia decaocto*), Great Cormorant (*Phalacrocorax carbo*) and other species. However, their number is small, and they do not pose a threat to native species. Also, some species, such as White Cormorant (*Phalacrocorax carbo*), which have already populated our territories, climate change has made it possible for them to return. The settlement of territories with these bird species did not lead to the displacement of local species (Nikiforov & Samusenko, 2015).

Some species of birds only occasionally fly into the territory of Belarus, but do not stay to nest. As an example – Pine Crossbill (*Loxia pytyopsittacus*) and White-Winged Crossbill (*Loxia leucoptera*). Crossbills remain on our territory only during periods of rich fruiting of spruce, and the next year they leave. Such species do not pose a threat to native species, since they do not occupy the habitat of the Common Crossbill (*Loxia curvirostra*), which does not leave Belarus (Nikiforov & Samusenko, 2015).

Despite the fact that it is easy for birds fly over long distances, they prefer to return to their previous nesting sites, therefore, the development of new territories is often a forced process. Human is often involved in the appearance of birds in new territories. It can be like deliberate settlement of a certain species or an indirect effect of human activity. An example of an indirect effect is land reclamation, ornithologists have found that this has reduced the population of Waders (Charadrii), Great Bodew (Charadriim), Meadow Pipit (*Anthus pratensis*), Lapwing (*Vanellus vanellus*). A decrease in the number of one species will lead to the settlement of these territories by other species, which will reduce the biological diversity of the avifauna (Nikiforov & Samusenko, 2015).

It should be noted that after conducting research on alien species of animals in Belarus, the “Black Book of Invasive Animal Species of Belarus” was created, but birds were not included in it. This may mean that the situation with invasive bird species is not critical (Alekhnovich et al., 2016).

Conclusion. The territory of Belarus is a place for the settlement of various alien species. The avifauna of Belarus is changing due to natural movements of birds and human activities.

However, alien species of birds rarely replace native species, what leads to an increase in the biological diversity of avifauna.

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ON THE NORTH-EASTERN INVASIVE RANGE LIMIT OF *AGRILUS PLANIPENNIS* (COLEOPTERA: BUPRESTIDAE) IN THE EUROPEAN RUSSIA

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Introduction. The invasion of the East Asian emerald ash borer (*Agrilus planipennis* Fairmaire) (Coleoptera: Buprestidae) into Europe started with an unintended introduction and the first outbreak of the species in Moscow (Russia), presumably in the late 1990s, although the first record in Moscow refers to 2003. Since than the buprestid has covered a distance of about 600 km southward from Moscow and has reached Ukraine (Orlova-Bienkowskaja et al., 2020). North of the Moscow Province, it reached only Yaroslavl located 240 km north-east of the suburbs of Moscow and still in habits there (Vlasov, 2020). The Yaroslavl "enclave" of the emerald ash borer is separated from its main invasive range by approximately 180 km to the north-eastern direction, and no records of *A. planipennis*are known so far in the cities of Rostov and Pereslavl-Zalessky situated between Moscow and Yaroslavl and planted with ash trees (*Fraxinus*) (Vlasov, 2020). Earlier, we suggested that northward spreading of the emerald ash borer can be limited by such factors as insufficient heat accumulation and absence of necessary food supply (European and North American ash species) on the way of the emerald ash borer from Moscow to St. Petersburg (Afonin et al., 2016). Therefore, in this work, we aimed to identify the factors determining the disruption's limits of the emerald ash borer's invasive range between Moscow and Yaroslavl.

Materials and methods. To identify the ecological limits of the distribution of the species in the north, we carried out an ecological niche analysis of the well mapped invasive range of *A. planipennis* in North America. The developed ecological niche model was used to determine the boundaries of the potential range of the emerald ash borer in northern Europe. The method of ecological niche modeling was described earlier (Afonin & Sokolova, 2018). Data on the distribution of *A. planipennis* were taken from various published sources (including (Orlova-Bienkowskaja et al., 2020)). The global maps of the accumulated degree days used in the analysis and modeling were recalculated from the monthly mean temperature layers taken from the spectroradiometer of the Terra spacecraft – the product MOD11C3 (Afonin, Milyutina & Fedorova, 2019).

Results. The ecological niche modeling demonstrated that the northern limit of distribution of *A. planipennis* in North America is well described by the isoline of 700 accumulated degree-days (ADD) above the lower temperature threshold of development of 10 °C. Application of this model to the territory of Europe demonstrated that the continuous isoline of 700 ADD runs somewhat north of Moscow near Sergeev Posad, and further to north-east towards Yaroslavl (but only as isolated heat islands with ADD > 700). In Sergeev Posad and Yaroslavl, the ADD value is more than 700, and *A. planipennis* has been found in these cities (Vlasov, 2020), whereas in Pereslavl-Zalessky and Rostov the ADD is less than 700, and the emerald ash borerhas not been found there (Vlasov, 2020).

Conclusion. Thus, we conclude that the occurrence of *A. planipennis* in cities along the line Sergeev Posad – Pereslavl-Zalessky – Rostov – Yaroslavl is determined by the ADD at each particular settlement: the emerald ash borer is distributed only in areas where the ADD exceeds 700.

Funding. The study was funded by the Russian Foundation for Basic Research (grant 19-05-00610).

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ALIEN SPECIES OF EARTHWORMS IN THE ECOSYSTEMS OF THE URALS

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The introduction of alien species is part of global natural changes and often results in significant losses of biological diversity and the importance of ecosystems prone to biological invasions. Of the approximately 3700 species of earthworms described, about 3 % are invaders in certain regions. The share of lumbricides (family Lumbricidae) accounts for about 30 species. Alien species of earthworms have appeared in the Urals recently. According to our data obtained as a result of genetic analysis of DNA using a "molecular clock", the age of introduction of *Aporrectodea caliginosa* is about 200 years (Shekhovtsov et al., 2016). According to T.S.Vsevolodova-Perel, in natural habitats of the Urals (until 1985), *Lumbricus rubellus* was absent, the distribution of *A. caliginosa* and *A. rosea* was limited, with rare exceptions, to synanthropic habitats and arable lands.

The aim of the research was to study the distribution of alien and native species of earthworms in the Urals.

The inventory counting of earthworm species from our own collections (from 2006 to 2020) was carried out using the Vsevolodova-Perels'key (1997) with the updating of the names in the international database. The data of the Identification guide "Earthworms of the Fauna of Russia: Cadaster and Key" by T.S Vsevolodova-Perel (1997) were taken as the initial species composition. To analyze the ratio of native and alien species of earthworms in natural habitats, in 2015 and 2020 various counts were carried out in the main types of natural habitats, in the Southern, Middle and Northern Urals, where the maximum diversity of endemic species of earthworms in the Urals had been previously noted. In the process of calculating the proportion of invasive species, the cosmopolitan species *D. octaedra* and *O. tyrtaeum* were not taken into account.

On the territory of the Urals, 18 species and three subspecies of earthworms were noted. Additionally, *Dd. rubidus subrubicundus*, *A. caliginosa trapezoides*, *A. longa*, *E. balatonica*, *E. sibirica*, *El. tetraedra hercynia*, *L. rubellus* were reported.

For the Southern Urals, 16 species and 1 subspecies have been identified. *A. trapezoides, L. rubellus* (ubiquitous)**,** *E. balatonica* were appeared. *A. caliginosa* was widespread. According to 2020 data, the habitats located in the subalpine belt and higher, as well as nemoral forests, had been least affected by invasions. No invasive species have been noted there. The endemic species of the Urals were dominant: *P. tuberosa*, *P. diplotetratheca*, *E. intermedia*, or *E. n. nordenskioldi* – above the subalpine belt.

In the aspen forests, even on the territory of the Zyuratkul National Park, the share of endemic species was 33 %, the share of invaders was 17 %. *L. rubellus*, *P. tuberosa*, and *E. intermedia* were dominate. 2 endemic and 1 invasive species have been reported.

All types of meadows are significantly captured by invasions. The share of endemic species was 25 % – *E. intermedia*, alien species – *L. rubellus* – 25 %. *L. rubellus* dominates.

The maximum proportion of invasive species was 75 % – has been noted in floodplain areas, both in forests and meadows. The share of endemic species iwas 25 %. Dominated by *A. c. caliginos*a and *L. rubellus*. *P. tuberosa* was noted among the endemic species.

Quantitative and qualitative surveys in 2020 did not show the *E uralensis* species, which are characteristic of the floodplains and meadows of the Southern Urals.

A. longa appears in the Urals (in synanthropic habitats); *P. tuberosa*, *O. tyrtaeum*, *A. rosea* (locally as a dominant), *E. fetida*, *E. balatonica*, *E. uralensis*, *El. t. tetratheca*, *L. rubellus* were found in the Middle Urals in mountain ecosystems in comparison with the data of the cadastre-guide of earthworms of Russia (1997). *L. terrestris*, *Dd. rubidus subrubicundus* were found in cities. *A. c. caliginosa* was reached wide distribution, including in natural habitats. Boggy sedge meadows lack alien and endemic species.

The share of invading earthworm species in forb- gramineous meadows was 17 %, endemic – 33 %. *L. rubellus* and *P. diplotetratheca* were dominant. The endemic ones were characterized by *P. diplotetratheca* and *P. tuberosa*.

Fir-spruce forests of different types were distinguished by a wide variety of lumbricid fauna (up to 8 species on one site). The share of endemics was 25 %, alien species – 37 %. *P. diplotetratheca* was dominant. The following species acted as subdominants: *A. c. caliginosa*, *L. rubellus*, *A. rosea*.

The floodplain habitats were characterized by the absence of endemic species and the dominance of *L. rubellus*. The share of alien species was 60 % (*A. c. caliginosa*, *L. rubellus*, *A. rosea*). 7 species of earthworms were found in the Northern Urals.

The following species have been reported for the first time: *E. atlavinyteae*, *L. rubellus*, *O. tyrtaeum*, *A. c. caliginosa*.

The Northern Urals were characterized by the absence of alien species of earthworms in most habitats. The percentage of endemic species is up to 0–50 %. *E. atlavinyteae, E. nordenskioldi*, and *P. diplothetrateca* were dominant.

Invasive species have been noted on the banks of water reservoirs. 100 % alien species were found in sedge meadows. *A. c. caliginosa* and *L. rubellus* were dominant. In forb and green moss pine forests, the percentage of alien species was 37 %, endemic – 17 %. *A. c. caliginosa* was dominant. *P. diplothetrateca* is common among endemic species.

For the Subpolar and Polar Urals in mountain habitats, 3 species of lumbricids have also been noted. In the floodplain of the Ob Bay, the habitat of *E. sibirica*, *E. balatonica*, *Dd. rubidus subrubicundus*, *O. tyrtaeum*, *El. t. hercynia* (dominant in coastal emissions).

As a result of the research, there has been noted a shift towards the north of the area of endemics of the Southern Urals: *P. tuberosa*, *E. uralensis*; endemic of the Southern and Middle Urals – *P. diplotetratheca* (distribution in mountain ecosystems further to mountain tundras). There has also been noted a spread of invasive species of European origin in natural biotopes, which has been increasing over time: *A. c. caliginosa*, *A. rosea*, *L. rubellus*.

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DYNAMICS OF ABUDANCE AND BIOMASS OF *OITHONA DAVISAE* (FERRARI F.D. & ORSI, 1984) IN THE DANUBE REGION OF THE BLACK SEA IN 2016–2019

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Introduction. Introduction of new species into a water is one of the most pressing environmental problems of marine biology. Accidental introduction of alien species is recognized as the most powerful form of anthropogenic impact on the Black Sea ecosystem. From time to time, Mediterranean species of copepods have been recorded in the Black Sea plankton near the Bosporus area.

Some specimens of a cyclopoid copepod new to the Black Sea were found in Sevastopol Bay in December 2001. The zooplankton species *Oithona davisae* (Ferrari F.D. & Orsi, 1984) is indigenous to coastal areas of Japan and the China Seas. However it has successfully invaded in many other coastal marine regions such as San Francisco Bay, the Mediterranean Sea, the North Sea and the Black Sea. It had transported in ballast water tanks. The species was identified as *Oithona brevicornis*. Recently, the species was reidentified as *O. davisae* (Altukhov, Gubanova & Mukhanov, 2014).

O. davisae is a pelagic cyclopoid copepod. The naupliar and copepodite phases are separated into six stages each. *O. davisae* has a wider potential salinity tolerance due to the estuarine lifestyle, due to which it has a higher body density, exhibits greater motor activity and the rate of oxygen consumption, the value of which is comparable to the theoretically expected respiration rate of calanoid copepods (Gubanova et al., 2019; Polischuk & Nastenko, 2006).

For the period 2005–2013 in the Odessa sea region and in the Danube region, the zooplankton structure was replenished with new Black Sea alien species – *O. davisae*. An outbreak of development of *O. davisae* was noted in September 2012, when it completely replaced the native form of *Oithona minuta* (T. Scott, 1894). Its number was 35459 ind/m^3 and biomass was 85.53 mg/m^3 (Aleksandrov et al., 2017).

In the Odessa Sea Region in 2013 and 2014 were also identified 159 specimens of *O. davisae* (biomass – 4 mg/m^3). With increasing of the abundance of the *O. davisae* a further decrease in the abundance of *Oithona similis* (Claus C., 1866), that was not recorded in samples from 2013, was observed (Aleksandrov et al., 2017).

The aim of the work was to reveal the change in the abundance and biomass of *O. davisae* in the Danube region in 2016–2019.

Materials and methods. In Danube region 23 samples of zooplancton were taken in 2016, 22 samples in 2017, 12 samples in 2018 and 17 in 2019.

Zooplankton samples were taken using a standard Juday plankton net with the mouth area 0.1 m^2 and mesh size 150 µ. Samples were fixed with buffered formaldehyde solution (4 % final concentration). The samples were processed under binocular microscope. Abundance and biomass of *O. davisae* were determined according the standard method (Alexandrov & Kharytonova, 2019).

Results. In the Danube region of the North-Western part of the Black Sea, *O. davisae* had been observed since 2011. Its was completely naturalized in North-Western part of the Black Sea and belongs to the dominant taxa not only among Copepoda, but also of all zooplankton. For example, in 2016, its biomass reached 328 mg/m^3 (35 % of the biomass of all zooplankton in this period). It should be noted that this omnivore species belongs to the forage zooplankton for fish, therefore, its mass development may have a positive effect on planktophagous fishes (Polischuk & Nastenko, 2006).

The highest abundance and biomass of *O. davisae* in the Danube region were observed in 2016: 4479.9 ind/m^3, and 26.879 mg/m^3 respectively. In 2017 and 2018 these indicators practically did not differ. In 2019 we observed a significant decrease in the abundance (607.4 ind/m^3) and biomass (3.645 mg/m^3) of *O. davisae.*

In 2016–2019 *O. davisae* was one of the main components of forage zooplankton. Its biomass formed a significant proportion of the total biomass of Copepoda. In 2016, the % *O. davisae* of all Copepoda biomass was 29.21 %. During subsequent years, we observed a slight decreasing of % of *O. davisae* from the biomass of Copepoda. This metric was reached 20.5 % in 2017, but increased to 21.4 % in 2018, and up to 23.46 % in 2019.

Conclusion. *O. davisae* completely naturalized in the North-Western part of the Black Sea and is one of the main components of forage zooplankton. The abundance and biomass of *O. davisae* decreased from 2016 to 2019 in the Danube region together with decreasing of all Copepoda number and biomass.

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USING DIFFERENT METHODS FOR THE CONTROL OF INVASIVE PHYTOPHAGES IN THE BREST REGION

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Introduction. Biological invasion is a very important component of global environmental change and imposes significant economic and ecological damages (Lars & Santanu, 2008). The Brest region, located in the south-west of Belarus, is characterized by mild climatic conditions favorable for the growth of thermophilic introduced plants. However, in the last decades their vitality, and, consequently, decorativeness, has significantly decreased in green grands caused by invasive leaf phytophagous species. This article presents the result of our study (2016–2020) on invasive pests: *Parectopa robiniella* Clemens (*Robinia pseudoacacia* L.), *Cameraria ohridella* Deschka, Dimič (*Aesculus hippocastanum* L.), *Phyllonorycter issikii* Kumata (*Tilia cordata* Mill and *Tilia platyphyllos* Scop.) and the first registration *Cydalima perspectalis* Walker (*Buxus sempervirens* L.) in Brest (Sinchuk et al., 2020).

Material and methods. The material was collected in Brest recreation park and in the botanical garden of Ecology Center (Brest State A.S. Pushkin University). The species were identified by imago. The specimen were deposited in private collection of A. Sinchuk. The degree of damage to plant leaves was determined and methods for pest control (chemical and mechanical) were tested.

Results. The analysis of damage to the studied plants showed its high variability (20–50 %) and territorial spread, which is primarily due to the large number of pest generations in favorable conditions. At the same time, the species-specificity of plants in the degree of damage was noted, so the population of large-leaved linden was 40 % lower than that of small-leaved linden, *Robinia ispida* and *Aesculus octandra* and *Aesculus pavia* are practically not affected in comparison with the studied species of horse chestnut and robinia.

Evaluation of the effectiveness of agrotechnical control measures showed that autumn harvesting of foliage in *A. hippocastanum* plantations can reduce the degree of damage to leaf blades by 2.5 times, while in *Robinia* plantations it can reduce the population of *P. robiniella* by 1.8 times.

Of particular concern is the active invasion of *C. perspectalis* in the green stands of Brest can lead to serious consequences for *B. sempervirens*. In the central part of Brest, we caught an imago, collected larvae and pupae and revealed significant damage on plants 20–30 years old. It is noted that the use of the tank mixture of system ("Aktara") and contact ("Karate") insecticides has shown high efficiency in pest control in the garden of Ecology Center.

At present, isolated infected plants have been detected. However, unless it is done in sanitary measures to protect the boxwood plantations, Brest may become the primary hotspot of the settlement of the box tree moth throughout the territory of Belarus.

Conclusion. Thus, in this article, we report the consequences of the activity of four invasive phytophages on ornamental plants and methods of their control in the Brest region, which is very important for the further expansion of their range.

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ALIEN SPECIES OF SUCKING INSECTS DAMAGING LARCH (*LARIX* MILL.) IN BELARUS

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Introduction. A number of larch (*Larix* Mill., 1754) species has been introduced in Belarus during the previous century and earlier. At present, European (*Larix decidua* Mill., 1768), Polish (*Larix* x *polonica* Racib., 1912) and Siberian (*Larix sibirica* Ledeb., 1833) larches and some other species of *Larix* are growing in green areas and forest plantations. In aboriginal areas larches are damaged by wide range of phytophagous insects (Pleshanov, 1982). Some of them have changed the geographical distribution as the growing area of the host plants had expanded. At present, a single alien species of sucking insects, damaging larches, *Cholodkovskya viridana* (Cholodkovsky, 1896), is included in "Black book of invasive animal species of Belarus" (Alekhnovich et al., 2016). However, the species richness of alien species of sucking insects damaging larch in the country is higher.

Materials and methods. The list of alien species of sucking insects damaging larches in Belarus were based on own research results; the data available from open online sources have also been used.

Results. At present, at least 5 alien species of sucking insects damage larches in green areas and forest plantations in Belarus were noted. All of them were specialized in *Larix* feeding. All these larch species have been introduced in Belarus (Yurkevich, 1980), thereby, their specialized phytophagous insect species cannot be aboriginal.

Adelges laricis Vallot, 1836 is host-alternating between spruces (*Picea* A. Dietr., 1824) and larches. On spruce shoot aphids form terminal globular or ovate galls, which open in June or July when alatae migrate to larches; they are blackish, and secrete little or no wax. On larch needle feeding *A. laricis* larvae cause discoloration and deformation. The species is registered in Belarus everywhere where primary and secondary hosts are growing together.

Cholodkovskya viridana (Cholodkovsky, 1896) is widely spread in Belarus and common or abundant on host plants everywhere where larches are growing. The species was anholocyclic on *Larix* spp. The overwintering first instar larvae are yellowish-green to green, usually hide under bark of the stem. The adult alatae are grey-green, covered in white wax, lay eggs on needles. In green areas white wax easy to notice, damaged needles become yellowed.

Sacchiphantes viridis (Ratzeburg, 1843) is host-alternating between spruce (*Picea* spp.) and larch. Aphids form pineapple galls on spruces, which open in July or August. Immatures within galls and the alatae are powdered with white wax. Sexuparae developing on larch the following spring are pale greenish with sparse wax. The colonized needles are sharply bent, locally thickened and yellowed. The aphids on the needles are pale to dark green, with little wax, and with only a light dusting. The species was registered in Belarus wherever primary and secondary hosts are growing together.

Cinara cuneomaculata (del Guercio, 1909). Aphids are feeding in small colonies on young twigs and shoots of larches, usually but not always ant-attended. In Belarus it is a rare species having local geographical distribution.

Cinara laricis (Hartig, 1839). Aphids form small dense colonies on twigs of lower (3- to 5-year old) branches, or on trunks of young larch trees. Usually but not always ant-attended. In Belarus it is a rare species having local geographical distribution.

Conclusion. At present, there are 5 alien species of sucking insects damaging larches in green areas and forest plantations in Belarus: *Adelges laricis* Vallot, 1836, *Cholodkovskya viridana* (Cholodkovsky, 1896), *Sacchiphantes viridis* (Ratzeburg, 1843) (Phylloxeroidea: Adelgidae); *Cinara cuneomaculata* (del Guercio, 1909), *Cinara laricis* (Hartig, 1839)

(Aphidoidea: Lachnidae). Among them, *Ch. viridana* is a common pest of larches in green areas, *A. laricis* and *S. viridis* damage young spruces in Christmas tree plantations. *C. cuneomaculata* and *C. laricis* are rare species not significant for forestry and horticulture.

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INVASIVE SPECIES OF TERRESTRIAL WOODLICE IN EUROPE. PROSPECTS FOR RESEARCHING WOODLICE IN BELARUS

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Introduction. Terrestrial woodlice perform an important role in the ecosystem, particularly in soil formation. They are common in different variety of habitats, they often live in big groups and are very sensitive to many heavy metals which makes them perspective for analysis of soil pollution.

Due to the global warming and human activity some woodlice species are spreading around the world quite fast and invade habitats they have never been to before. Sometimes it is damaging for the local flora and fauna and causes the decrease of local biodiversity as some species do not have resilience to fight their competitors off. Such invasions may also cause economic and social problems, so the goal is to list invasive species of woodlice in Europe and to predict which of these species may be found in Belarus in the nearest future. Some species have been found recently – *Hyloniscus riparius* (in different regions) (Ostrovsky, 2019) and *Porcellionides pruinosus* (in Gomel region) (Ostrovsky, 2020).

Material and methods. Different databases have been used to analyze the species. The woodlice were taken from the Global register of Introduced and Invasive species from different European countries and then were correlated with DAISIE (2020) – Inventory of alien invasive species in Europe and World catalog of terrestrial isopods (Schmalfuss, 2003), after that the distribution maps of these woodlice were checked on their closeness to Belarus.

Results. The results are represented in a table. All the following species were considered invasive according to DAISIE and other scientific sources.

Table

Potential species of woodlice in Belarus

Species	Origin	Potential to find in Belarus
Agabiformius lentus	Mediterranean coasts	—
Anchiphiloscia balssi	East Tropical Africa	—
Androniscus dentiger	Europe and North Africa	—
Armadillidium assimile	Southern Europe	—
Armadillidium kossuthi	Italy, Sicily	—
Armadillidium nasatum	Europe	+
Benthana olfersii	Southern America	—
Burmoniscus meeusei	Hawaii, Brazil, Taiwan	—
Burmoniscus orientalis	Indonesia	—
Cordioniscus stebbingi	Europe	—
Haplophthalmus danicus	Europe	+
Metatrichoniscoides leydigii	Western Europe	—
Miktoniscus linearis	Northern America	—
Nagurus cristatus	Pantropical	—
Nagurus nanus	Tropics	—
Platyarthrus schoebli (synonym for many species)	Southern Europe, Asia, Africa	—

Species	Origin	Potential to find in Belarus
Porcellio dilatatus	Europe	+
Porcellio laevis	Europe and North Africa	+
Proporcellio vulcanius	Southern Italy, Sicily and Pantelleria island; Greece, Western Asia	—
Protracheoniscus major	Asia-Tropical	—
Reductoniscus costulatus	Seychelles, Mauritius, Malaysia and Hawaiian Islands	—
Styloniscus spinosus	Mauritius, Réunion, Madagascar, Hawaii	—
Synarmadillo pallidus	Africa	—
Trichoniscus provisorius	Southern Europe, Africa and Western Asia	—
Trichoniscus pusillus	Europe	+
Trichorhina tomentosa	Tropical America	—
Venezillo parvus	Tropical and subtropical regions	—

+ – can be found in Belarus;
— – unlikely to be found in Belarus or can be found in greenhouses.

Conclusion. According to the distribution range, the following invasive species can be found in Belarus: *Armadillidium nasatum, Haplophthalmus danicus, Porcellio dilatatus, Porcellio laevis, Trichoniscus pusillus*. Their range comprises different zones and habitats similar to those which we can find in Belarus, that is why there is a chance to encounter them in the country. As it was mentioned above, some of them have already been found – *Hyloniscus riparius* and *Porcellionides pruinosus*.

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INVASIVE SPECIES OF TRUE BUGS (HEMIPTERA: HETEROPTERA) ON THE TERRITORY OF BELARUS

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Introduction. The whole fauna of Belarus, probably except some its representative species that inhabit springs, is allochthonic and adventive. It appeared and formed in the post-glacial periods. The appearance of adventive species in regional faunas is a natural factor of fauna genesis, caused by global zoogeographic and evolutionary processes (migrations, pulsations of habitats, population waves, etc.).

However, not all the species new to the fauna are adventive in the modern sense, i.e., discovered in historical times and originating from exotic habitats not related to a specific territory. Perhaps they are simply rare, or there was no specialist in a particular taxonomic group in the region. Or new techniques have emerged that allow to discover covertly living species. Development of systematics and taxonomy also leads to distinction of new taxons. At the same time not all allochthonic species are invasive (spread rapidly, transform existing natural systems and complexes, negatively affect humans and their activities).

But a number of processes and phenomena of the recent decades (weather anomalies, the rapid development of transport networks, globalization) have put issues related to allochthonic and especially invasive species among the main and global problems of our time (not only ecological, but also medical, economical, etc.). All of the above is relevant for Belarus, which lies at the peculiar biotic and economic crossroads between the north and the south part of Europe.

Materials and methods. The material for this article was done from own collections of true semiparasitic insects (Hemiptera: Heteroptera) carried out from 1982 to 2020 in all the administrative areas of Belarus. Also the author extremely grateful to his colleagues for their collections that were included in the research.

The material was collected by standard methods widely used in entomological studies like this – mowing with an entomological net, hand-picking, shaking off branches, sifting various substrates through soil sieves, trapping, interrupting flight traps, trapping by a light source, etc.

Results. As a result of our studies, taking into account published data of colleagues, 561 species of bugs were registered in Belarus. Among them 45 species have been reported in the last 20 years, and only about half of them can be considered allochthonic.

From the number of allochthonic species recorded in Belarus only 3 species are considered invasive: *Cimex hemipterus* (Fabricius, 1803), *Leptoglossus occidentalis* Heidemann, 1910, and *Halyomorpha halys* (Stål, 1855) (Rabitsch, 2010).

In Belarus, only *Cimex hemipterus* (Khryapin, Pugayev & Matveyev, 2017) really demonstrates the properties of invasive species, rapidly expanding its area, displacing the bed bug *Cimex lectularius*, that appeared earlier from the established parasitocenosis, and has a social and economic significance as a human haematophage.

Leptoglossus occidentalis, that was discovered in Brest region in 2020, has a high invasive potential, but there are still no data on its territorial expansion within the country and on the damage done to coniferous plantations; it is necessary to have the monitoring of this species (Bubenko, Lukashuk & Naiman, 2020).

Invasive *Halyomorpha halys* (Stål, 1855) was found in the country sporadically and rather curiously (Lukashuk & Bogovet, 2019), and there are no data on its naturalization in our conditions. But still we should expect its appearance in the future. It might be imported by transport and plant introduction or natural expansion from the regions of the Caucasus, southern Russia, Ukraine and countries of southern Europe.

The other species have not naturalized in Belarus yet, or just have been discovered and data on the dynamics of their dispersal and their impact on ecosystems are not available, they are potential invaders and require additional monitoring.

Conclusion. The appearance of allochthonic and especially invasive species emphasizes the necessity to preserve and develop classical branches of zoology, such as faunistics, zoosystematics, chorology, zoogeography.

Moreaver, it is necessary to develop a national system of faunistic monitoring, that provides timely discovering and monitoring of the dynamics of allochthonic species dispersal, and the ability to study international experience in regulating the number of invasive species and preventing their occurrence in the country.

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INVASIVE SPECIES OF PHYTOPHAGES IN GRODNO (BELARUS)

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Introduction. Detection and identification of invasive species are extremely important for Belarus due to its geographical location, that has the physical and geographical borders of subzones borders, so the process of invasions in Belarus is increasing. Invasive species are able to increase their numbers rapidly and occupy new territories, that leads to the displacement of native species (Semenchenko & Pugachevsky, 2006).

Materials and methods. The collection of materials was carried out during the 2020 field season (May–September). Trees and shrub plants of green stands were inspected in Grodno. 5 biotopes were shosen for the research: B1 – Zhiliber Park; B2 – Kalozha Park; B3 – Rumlevo Forest Park; B4 – Pyshki Forest Park; B5 – landscape of Dovator Street. The collection of material for the presence of phytophages or damage caused by them on woody and shrubby plants was carried out during a visual inspection of leaf blades (Gusev, 1990). Fragments of damaged plant parts by phytophages were collected for analysis and herbarization.

Results. During the field season 2020, 58 species of phytophages were identified in Grodno. 10 species out of 58 were invasive, such as: *Aceria cephalonea* (Nalepa, 1922), *Aculus hippocastani* (Fockeu, 1890), *Vasates quadripedes* (Shimer, 1869), *Obolodiplosis robiniae* (Haldeman, 1847), *Cryptomyzus ribis* (Linnaeus, 1758), *Pemphigus spyrothecae* (Passerini, 1856), *Cameraria ohridella* (Deschka & Dimič, 1986), *Phyllonorycter issikii* (Kumata, 1963), *Macrosaccus robiniella* (Clemens, 1859), *Aphis craccivora* (Koch, 1854).

The identified invasive species of phytophages damaged 6 species of woody and shrub plants, 5 species of them are introduced. Only *Phyllonorycter issikii* damaged the native species *Tilia cordata* Mill.

Assessment of the level of population and caused damage to woody and shrub plants was carried out by using the scales proposed by Dmitriev (Dmitriev, 1975). *Cameraria ohridella*, *Phyllonorycter issikii*, *Macrosaccus robiniella*, *Obolodiplosis robiniae*, *Vasates quadripedes* had the high est level of population and caused strong damage to trees and shrubs.

Conclusion. Thus, it was identified 10 invasive species of phytophages, pests of trees and shrub plants in Grodno. 5 of them hade the highest level of population and caused damage to trees and shrubs.

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GIS MODELING AND STUDY OF THE INFLUENCE OF INVASIVE MAMMALIAN SPECIES' DISTRIBUTION ON EUROPEAN POND TURTLE

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Introduction. European pond turtle *Emys orbicularis* (Linnaeus, 1758) is a reptile species that requires special protection under a number of international agreements. This species is listed in Resolution 6 and Appendix II of the Bern Convention (1979) and has "Near Threatened" (NT) status in IUCN. Recently, pond turtle have faced many enemies in its natural habitat. For example, in addition to the aboriginal predators such as the grey wolf *Canis lupus* (Linnaeus, 1758) and the red fox *Vulpes vulpes* (Linnaeus, 1758), the turtles also suffer from the presence of invasive raccoon dog *Nyctereutes procyonoides* (Gray, 1834), golden jackal *Canis aureus* (Linnaeus 1758), raccoon *Procyon lotor* (Linnaeus, 1758), and stray dogs. The influence of invasive predators can be especially dangerous for pond turtles' small populations of on the border of the *E. orbicularis* range: *N. procyonoides* is widely distributed in Latvia, while *C. aureus* was registered here only in several recent years. Such invasive species as raccoon dog and golden jackal often live in the neighborhood with turtles occupying territories with light soils, sometimes near arid areas along small waterbodies, where turtles breed. Golden jackal has been actively migrating north for at least the last 20 years and is now known in most of Eastern Europe, including Estonia. This social predator is omnivorous, consuming wide range of food items from fruits and insects to small vertebrates (including pond turtles). Being widely introduced in the former Soviet Union as a fur animal in 1950s *N. procyonoides* has become now widely distributed invasive species in European Union as well. It is known that raccoon dog is a more environmentally flexible species than jackal. Its number in Ukraine has increased significantly in the past decades; in Latvia it is known since 1943 and ~15 000 individuals were registered in 2006. For example, in Belarus (Polissia), about 40 % of all turtles' clutches are excavated and eaten by foxes, raccoon dogs, wolves, stray dogs, and other predators in the very first days of incubation (Drobenkov, 2012). Therefore, the purpose of our study was to identify what factors influence the dispersal of the invasive predator *N. procyonoides* and its potential feeding object – *E. orbicularis* with the help of GIS modeling.

Materials and methods. With a ecological niche modeling technique and Species distribution modelling (SDM) has been used to determine potential range distribution of invasive species in new environments (MaxEnt with 25 replicates, DivaGis (Bioclim)). Bioclimatic variables from the CliMond dataset (35 variables, Kriticos et al., 2014; https://www.climond.org/) were used. Our occurrence data consisted of 1525 and 3560 georeferenced points for *N. procyonoides* and *E. orbicularis*, respectively. For analysis, GBIF data (http://www.gbif.org), literature (Kauhala & Kowalczyk, 2011 etc.) and modern original record points from Ukraine (Nekrasova O.), Latvia (Pupins M.) were used.

Results. As a result of our investigations in southern Ukraine, it was found out that about a half of all turtles' clutches suffered from predators – 25 excavated nests (eaten) and 5 turtles' remnants (some identified as females) were found in the Volyzhin Les arid areas (Black Sea region, Kinburn Spit, 2019) and 1 excavated nest with eaten 8 eggs was found for the first time in Southeastern Latvia (2019, unpublished observation, Silene Nature park, Natura 2000). In addition 2 excavated nests (a total amount of approximately 32 eggs' remnants) of *E. orbicularis* were registered on the river edge on the Sobachyj island in Kaniv Nature Reserve (Cherkas'ka oblast', Ukraine, 2012). And such finds were not rare, as the habitats of invasive predators and native species, go their food resources were changed with climate change. Using DivaGis we found that the bioclimatic factors of the sites of *N. procyonoides* (70 %) have a wider range: Annual Mean Temperature (b1) from +1 to +14 °C (limit -3.1 – +18 °C), Annual Precipitation (b12) – 400–1600 mm (limit 173–2783 mm). Important factors that affect its distribution are – b14 (Precipitation of Driest Month), to a small extent – b4 (Temperature Seasonality (standard deviation * 100) and b6 (Minimal Temperature of Coldest Month) (Maxent). The turtle were more vulnerable, especially in the north of the range and were limited by temperature factors (70 %): b1 – 6–17 °C (limit +2 - +19.6 °C), b12 – 300–1200 mm (limit 153–2231 mm). Its distribution is also affected by the factors: b19 Precipitation of Coldest Quarter, b23 Radiation seasonality (C of V), b6 Minimal Temperature of the Coldest Week (°C), respectively. These two species have very similar living conditions in the north of their natural range. So, when comparing SDM models (Maxent) and when constructing a regression, the correlation coefficient was 0.5 in Latvia reliably.

Conclusion. The active advance to the north of new invasive mammalian predator species that are resistant to cold climates may affect the number of turtles in small northern populations. In the Baltic countries, where recent discoveries of turtles have been noted, it is important to minimize the impact of invasive predator species to ensure the protection of aboriginal biota.

Acknowledgements. The research was partly supported by the project "Pond aquaculture production and ecosystem service innovative research with modelling of the climate impact to tackle horizontal challenges and improve aquaculture sustainability governance in Latvia" (lzp-2020/2-0070) financed by Fundamental and Applied Research Projects (FLPP).

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FIRST RECORD OF ALIEN SPECIES *CHYMOMYZA AMOENA* (LOEW 1862) (DIPTERA: DROSOPHILIDAE) IN BELARUS

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Introduction. The arrival of alien species of Diptera to Europe has exponentially increased since the second half of the 20th century. Ninety-eight species of Diptera have already been established in Europe, 18 of which belonging to the family of Drosophilidae. The majority of alien Diptera were introduced into or within Europe unintentionally. Almost one third of them originate from North America (Skuhravá et al., 2010).

The genus *Chymomyza* is represented by four Neotropical species in Europe and *Chymomyza amoena* (Loew, 1862) (Diptera: Drosphilidae) is the only species considered to be fully established in Europe (Bächli et al., 2002, 2004; Skuhravá et al., 2010). This phytophagous drosophilid native to North America (Skuhravá et al., 2010) was first discovered in Europe in 1975 in the Czechoslovakia and was probably introduced into Europe on apples (Clemons, 2009). It was distributed throughout Switzerland, Germany, Spain, France, Great Britain, Hungary, Lithuania, Poland, Romania, Serbia, Slovakia, Slovenia, Croatia, and Russia (Máca, 2009). The presence of *C. amoena* was identified during the monitoring of invertebrate biodiversity in the south-east part of Belarus in the autumn 2020.

Material examined. The examined specimen was found in spontaneous landfill of household waste between the village of Uza and the village of Rudenets, Buda-Koshelevo district, Gomelskaya oblast, Belarus, among the garbage, 52°35'30"N, 30°49'01"E, 138 a.s.l., 01.11.2020, 1♀ (Figure), leg. et det. A.M. Ostrovsky. The examined specimen was put in the author's collection.

Fig. *Chymomyza amoena* (Loew, 1862)

Diagnostic signs. The body length of species ranges between 2 and 4 mm. *C. amoena* has strikingly bright red eyes, yellowish to brownish matt colored thorax and black brownish colored abdomen. Morphological characteristics unique to this species are yellowish legs and wings with two distinct brown transverse bands and a dark spot along R1 (Bächli et al., 2004).

Remarks. The biology of *C. amoena* was studied in detail in North America. It is a multivoltine species which can produce a new generation within a month during the breeding season (Band, 1988). The most *Chymomyza* species breed under the bark of various trees and the adults are usually attracted to the peeled areas of trees and to cut logs. *C. amoena* is the exception – it breeds in parasitized fruits and nuts damaged from primary pest attack (Bächli et al., 2004, Band et. al., 2005). In eastern United States, the species overwinters as the third instar larva in a variety of substrates such as black walnut husk, native crabapples and domestic (imported) apples and breeds from spring through autumn. In spring, females prefer to oviposit in soften overwintered native crabapples and later in fallen parasitized plums. In summer oviposition continues in early fallen parasitized unripe apples as well as in ripening parasitized fallen and unfallen apples. Parasitized apples and pears may continue to be used for oviposition in autumn but females also switch to nuts, especially parasitized black walnut husk and other suitable substrates which will serve as overwintering sites for the developing larvae. In early fallen and ripening apples, females oviposit in scars, codling moth tunnels or frass which also serves as food for females. In nuts, it prefers parasitized rather than just damaged acorns and use native crabapples as the breeding substrate (Band, 1988; Band et al., 2005). Experimental studies in Europe have revealed that breeding in parasitized fruits and nuts had been maintained in European specimens of *C. amoena*. Further research established its presence in European apple orchards and chestnut forests and is considered to be the principal drosophilid breeding in parasitized fruits and nuts in both North America and Europe (Pajač Živković et al., 2017).

Conclusion. The genus and species of the fruit fly are formally new to Belarusian invasive species list: *Chymomyza* Czerny, 1903, and *Chymomyza amoena* (Loew, 1862) (Diptera: Drosphilidae). This phytophagous drosophilid was probably introduced into Belarus on apple fruits or nuts.

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RISK ASSESSMENT AFTER THE HARMONIA+ PROTOCOL OF INVASIVE ALIEN GALL-FORMING ARTHROPOD SPECIES IN BELARUS

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Introduction. Risk assessment of invasive alien species is effective instrument enabling decision makers to develop risk management strategies resulting in control and eradication measures. Detailed risk assessment methods are quite labour-intensive and there is a wide range of scientific approaches. Using the same protocol makes it possible for territories sharing similar invasive species and eco-climatic conditions to exchange information on a comparable basis.

Materials and methods. Risk assessment of invasive alien gall-forming arthropod species has been made using the internet-based Harmonia+ protocol (BFIS, 2019) developed by the Belgian Biodiversity Platform and widely used in the Benelux countries and beyond (Vanderhoeven et al., 2015; Ries, Krippel & Pfeiffenschneider, 2020). Harmonia+ belongs to the risk-screening procedures which inherently deal with negative impacts only, and leave eventual positive impacts outside of scope. The protocol can be used for prioritisation schemes of already present alien species (D'Hondt et al., 2015). This protocol refers to multiple kinds of impacts. It consists of 41 questions grouped in 6 categories, which concern environment, cultivated plants, domesticated animals, public health, human infrastructure, and ecosystem services. A risk score and level of confidence are assigned to each issue. As results are numerical scores between 0 and 1, they allow for a clear ranking of species' overall risks.

The list of invasive alien gall-forming arthropod species carried out invasions into Belarus during the current century and information on their geographical distribution, biology, ecology, and pestfulness for decorative trees and shrubs in green areas are based on own studies; data available from published sources and open internet-databases on gall-forming arthropods has also been used.

Results. A risk assessment of 6 invasive alien gall-forming arthropod species has been carried out for Belarus, using the internet-based Harmonia+ protocol that assesses the invasion process and the impacts on the environment, cultivated plants, domesticated animals, public health and on human infrastructure. Among them walnut leaf gall mite (*Aceria erinea* (Nalepa, 1891)) (Acari: Acariformes: Eriophyidae), walnut blister mite (*Aceria tristriata* (Nalepa, 1890)) (Acari: Acariformes: Eriophyidae), boxwood psyllid (*Psylla buxi* (Linnaeus, 1758)) (Insecta: Sternorhyncha: Psyllidae), cherry plum aphid (*Brachycaudus divaricatae* Shaposhnikov, 1956) (Insecta: Sternorhyncha: Aphididae)), black locust gall midge (*Obolodiplosis robiniae* (Haldeman, 1847)) (Insecta: Diptera: Cecidomyiidae) and honey locust pod gall midge (*Dasineura gleditchiae* (Osten Sacken, 1866)) (Insecta: Diptera: Cecidomyiidae) which carried out invasions in Belarus during the current century (Petrov, 2019). A species with the highest overall risk score is *Brachycaudus divaricatae* (0.48) which has wide geographical distribution in Belarus and damages Myrobalan plum (*Prunus cerasifera* Ehrh.) in orchards and green areas. A species with the lowest overall risk score is *Aceria tristriata* (0.07) which has local geographical distribution in Belarus and damages the common walnut (*Juglans regia* L.) only sporadically. The values of invasion risk were the next: 0.59 for *Aceria erinea*, 0.22 for *Aceria tristriata*, 0.79 for *Brachycaudus divaricatae*, 0.40 for *Psylla buxi*, 0.50 for *Obolodiplosis robiniae*, and only 0.01 for *Dasineura gleditchiae.* The values of impact were the next: 0.33 for *Aceria erinea* and *Aceria tristriata*, 0.60 for *Brachycaudus divaricatae*, 0.50 for *Psylla buxi*, *Obolodiplosis robiniae*, and *Dasineura gleditchiae.*

Conclusion. A risk assessment of 6 invasive alien gall-forming arthropod species were carried out by using the internet-based Harmonia+ protocol that assessed the invasion process and the impacts on the environment, cultivated plants, domesticated animals, public health and on human infrastructure. A risk assessment protocol resulting in numerical scores that were suitable for ranking a list of invasive alien species with the purpose of identifying those which caused the strongest impact and/or the highest risks, and thus, should be included in the invasive alien species list of national concern.

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ZEBRA MUSSEL IN NATURAL ECOSYSTEMS OF BELARUS

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Introduction. A problem of invasion of alien animal species on the territory of many countries is indicated. The introduction of alien species is directly related to the environmental and economic safety of the country. The list of problems and patterns of the invasive process caused by the introduction of river dreissen was considered.

Materials and methods. Analytical review of literature data.

Results. In recent decades, invasive species of animals that are harmful elements of the fauna and flora, have been observed in Belarus. The activation of the invasive process is associated with global warming, which is explained by the penetration of alien species from more southern latitudes and the increase in commodity relations between countries. Therefore, there is a global environmental problem recognized all over the world (Hulme, 2017).

With a small population, an alien species does not have a visible impact on the environment, but when they reach a high level, the impact can have a global scale up to the extinction of native species and loss of biodiversity. Then the species exclude from the category of and belong "alien" to the category of the "invasive".

The importance of the studying and predicting invasive processes in the fact that Belarus has an invasive corridor through which Ponto-Caspian species enter Belarus and further into the Baltic Sea basin (Galil, Nehring & Panov, 2007).

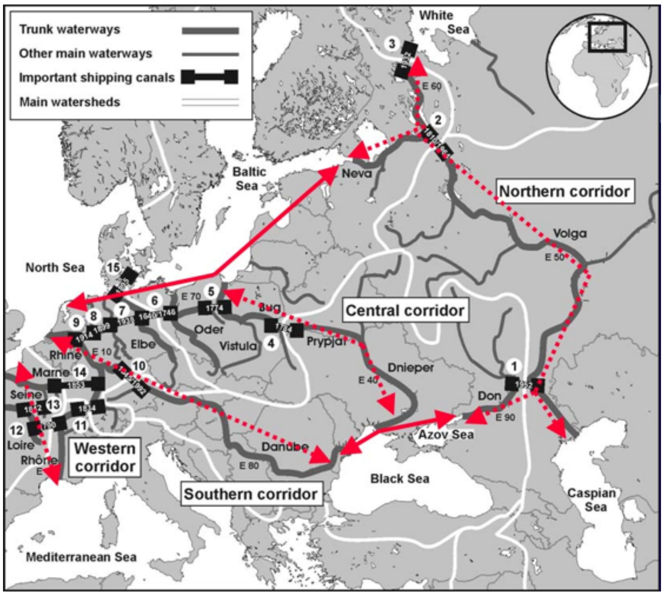

Fig. European invasive corridors (https://vunivere.ru/work96941)

Many alien species have high plasticity, which gives them the opportunity for introduction to a new ecosystem, a high reproduction rate, which allows them to increase the number of individuals, quickly and a high competitive ability, which leads to the displacement of native species. One such species is zebra mussel (*Dreissena polymorpha*), that is included in the hundred most harmful invasive species of the planet. This mussel lives at depths of up to 10 m, and has the ability to create serious disturbances in the using of pipelines and water vessels. Individuals overgrow structures, forming druses. This phenomenon significantly worsens the quality of work and equipment operation (Burlakova, 1998).

A zebra mussel occurs in most reservoirs and watercourses of Belarus so it causes the need for periodic cleaning of drains and pipes. Also, the massive development of alien species can lead to the restructuring of ecosystems. For example, due to the invasion of the river *Dreissena* in lake Naroch, the development of phyto– and zooplankton has decreased.

Conclusion. Reproduction of an invasive species can be limited in the initial stages, when the number is small. Monitoring, hot spot detection, and early warning systems are the most effective ways to control alien species. Invasion of alien species is an irreversible process that has the ability to increase as a result of human activity. Many invasive processes have unpredictable consequences. However, if we know the patterns of the invasive process, we can estimate expected effects of invasions (Semenchenko, 2016).

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ALIEN INSECT SPECIES ESTABLISHED IN LITHUANIA IN THE LAST TWO DECADES

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Introduction. The spreading of alien species can significantly alter the balance of natural habitats and ecosystems. The spread of some alien invertebrates species in Lithuania is directly related to the introduction and transit of ornamental plants and transit transport. Observed climate change helps settle southern species.

Materials and methods. The material was collected in the whole territory of Lithuania at 2007–2020 years. Insects were collected using an entomological net, light and pheromone trapping, plant mine collecting was used.

Results. Black locust *Robinia pseudoacacia* L. trees were introduced to Lithuania many years ago as an ornamental plants. It is endemic to a few small areas of the United States, but it has been widely planted in temperate zone and is considered an invasive species in Lithuania and other European countries. The species associated with black locust, as *Macrosaccus robiniella* (Clemens, 1859), *Parectopa robiniella* (Lepidoptera, Gracillariidae), *Obolodiplosis robiniae* (Haldeman, 1847) (Diptera, Cecidomyiidae) were discovered since 2007 (Ivinskis, Rimšaitė, 2008). *M. robiniella* is currently widespread and abundant in Kaunas, Vilnius. On the Curonian spit, where species was discovered in 2007, it is currently not found. Only few leaves with mines of *P. robiniella* were found in Curonian spit in 2007. Further investigation of these mines on *R. pseudoacacia* in Lithuania did not yield any results, until in 2019 – we found many mines in Vilnius, Kaunas, Curonian Spit and Šalčininkai region. Meanwhile*, O. robinia,* found stably and widespread in Lithuania. This year, *Caloptilia fidella* (Lepidoptera, Gracillariidae) mines were common on hops (*Humulus lupulus* L.), butterflies were also caught. Until this year, the species was unknown in Lithuania, now found in 10 regions of Lithuania. Another species, *Cydalima perspectalis* (Walker, 1859) (Lepidoptera, Crambidae), associated with common box (*Buxus sempervirens* L.), is spreading in Lithuania. It was first detected in Lithuania in 2018 (Paulavičiūtė, Mikalauskas, 2018), and in 2020 it was found on the Curonian Spit, Palanga, Vilnius, Kaunas. *Helicoverpa armigera* (Hübner, [1808]) (Lepidoptera, Noctuidae) every year immigrate in Lithuania.

In 2010, there was a massive appearance of *Otiorhynchus armadillo* (Rossi, 1792) (Coleoptera Curculionidae) in Vilnius, beetles damage ornamental plants in the flower garden (Ivinskis et al., 2013). The beetles were observed in 2020 again. This species spread due to trade of plants. Import of horticultural plants seems to be the most effective way for the weevils to reach new areas as many of them lack the ability to fly. The horticultural plants are often imported with soil that gives all life stages of the weevils the ability to come as stowaway. Adults often feed on the foliage of different host plants making round cuts along the leaf edge, while the larvae feed on the roots (Staverløkk, 2010).

Lignyodes bischoffi (Blatchley, 1916) (Coleoptera, Curculionidae) at first found in Kaunas Botanical garden in 2015. The species are origin from South America, but now known from Central Europe, Poland. The species is trophic associated with *Fraxinus* spp., larvae develop in seeds. Ladybird species *Harmonia axyridis* (Pallas, 1773) (Coleoptera, Coccinellidae) first found in Curonian spit in 2011 (Nagrockaitė et al., 2011). Now the species are found over all Lithuania, in Vilnius city are abundant.

Some alien species establish in new territories and form massive foci such as the horse-chestnut leaf miner *Cameraria ohridella* Deschka & Dimić, 1986 (Lepidoptera, Gracillariidae). Found in 2005 after a few years it became a massive species, damaged greenery of settlements.

In the last decade, the spread of *Mantis religiosa* (Linnaeus, 1758) (Mantodea, Mantidae) was observed throughout Lithuania. The species, first discovered in 2008, has now spread throughout Lithuania and successfully reproduce. This species is not alien, but its natural range has always been much south of Lithuania.

Conclusion. The immigration and establishing of species in Lithuania are observed during the two last decades. The observation of immigration of alien species helps to understand the immigration paths, the scale of settlement and find methods of control.

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ALIEN SPECIES OF HYDROPHILIDAE (INSECTA: COLEOPTERA) IN THE BELARUSSIAN FAUNA

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Introduction. Natural successional processes in the biosphere and individual ecosystems are associated primarily with changes in climatic conditions. A number of insect species are expanding their ranges, both northward and southward. In some cases, the expansion of the boundaries of the species range is natural, in others, the dispersal of the species is facilitated by humans. Some species, being included in the regional fauna, can be considered not only alien, but also invasive species. Among Hydrophilidae both terrestrial and water species, there are some species that expand their range.

Materials and methods. Species composition studies of hydrophilids have been carried out since 1987 and are ongoing. Standard methods of entomology and zoogeography have been used for this study.

Results. The fauna of Belarus includes 57 species of Hydrophilidae (Ryndevich et al., 2014). Among the representatives of the family there are both water and terrestrial species of beetles. Seven of them can have the status of alien species for the Belarusian fauna.

Two other species of hydrobiont hydrophilids were recorded only once in Belarus. Beetles were collected at light.

Berosus (Enoplurus) bispina Reiche & Saulcy, 1856 (Minsk reg., Nesvizh distr., Gorodeya, at Uf-light, 16.VII.1998, leg. Ryndevich S.K., 2 specimens). This species has a West Palaearctic-Central Asian subboreal-subtropical range, located in the temperate (south of the taiga zone) and subtropical zones of Europe, North Africa, Southwest and Central Asia.

Berosus (Enoplurus) spinosus (Steven, 1808) (Minsk reg., Pukhovichi distr., Kopeynoe, Uf-trap, 26.VII.1997, leg. Prishchepchik O.V., 2 specimens). The species has a Trans-Eurasian subboreal range, covering Eurasia south of the taiga zone, and can penetrate the mountains into the subtropical belt.

Enochrus (Lumetus) bicolor (Fabricius, 1792). At the moment, the range of this species is greatly expanding both to the north and to the south. It includes Europe, southern Siberia, Central and Eastern Asia south of the taiga, as well as the subtropical belt of the Palaearctic (North Africa, etc.), extending through the mountains of Central Asia into the subequatorial belt to the north of Hindustan. The coenorange (part of the range where the species is most abundant) of *Enochrus bicolor* is located in the subboreal (steppes and deserts) and subtropical regions of Eurasia and North Africa. On the territory of Belarus, it was recorded in 1988 (Vileika district), then for a long time it was not recorded, despite constant studies of the fauna of water beetles in Belarus. Only in 2012 and 2014, single finds were made already in the south of Vitebsk region (Ushachi and Lepel districts). The finding of *Enochrus bicolor* in Pripyat (Zhitkovichi district) in 2017 indicates a stable population in Belarus. The spread of this species in Belarus is probably associated with climate warming and is the result of self-dispersal.

Laccobius (*Microlaccobius*) *gracilis gracilis* Motschulsky, 1855. This species has a West Palaearctic subboreal-subtropical range located in North Africa, Southwest Asia and in the south of the taiga zone in Europe. The only specimen was collected in the Pripyat River near Pinsk in 2013.

Perhaps it was a single settling of heat-loving species (*Berosus bispina*, *B. spinosus* and *Laccobius gracilis gracilis*) into the territory of Belarus. Permanent populations have not formed here, or they are quite local and have not been found yet as in the case of *Enochrus bicolor*, beetles have not been discovered for over 20 years. Probably, the penetration of alien species into the territory of Belarus occurred from the western and southwestern directions, in particular along the Pripyat river basin.

Among alien species, three species are polysaprobiont hydrophilids, being mainly inhabitants of bird and mammalian excrement. Two species of *Cercyon* have cosmopolitan polyzonal ranges.

Cercyon (Cercyon) nigriceps (Marsham, 1802). In Eastern Europe, this species is rare and local. This species is common and most abundant in tropical regions (Oriental and Afrotropical), which indicates its probable origin from one of these zoogeographic regions. This is also indicated by the finding of the ranges of a larger number of *Cercyon nigriceps* species group from the Oriental Region. In Belarus, it was first recorded in Baranovichi district in 1999. In neighboring countries, it was registered much earlier (Yaroslavl region in 1894, Estonia – 1903, the Crimea in 1920). Recorded in Brest and Gomel regions.

Cercyon (Paracycreon) laminatus Sharp, 1873. The primary range is in East Asia. In Belarus it was first collected in Verkhnedvinsk district in 1995. Recorded in Brest, Minsk, Vitebsk and Gomel regions. This species is not rare in Belarus and has a stable population.

Cryptopleurum subtile Sharp, 1844. Currently, the species has Circum-Holarctic-Southeast Asian polyzonal range (it covers the entire Holarctic from the subarctic to the subtropical belt, as well as the north of the Oriental region (in the subequatorial belt of Southeast Asia). The species, probably, originally inhabited Southeast Asia, but later spread through wide areas of the Holarctic and Oriental regions. In Belarus, it was first recorded in Zhitkovichi district in 1987, the species was collected in Brest, Minsk, Vitebsk and Gomel regions. *Cryptopleurum subtile* is not rare in Belarus. The reasons for the expansion of the range of this, like the two previous species, are anthropogenic in nature.

In the European part of Russia, *Cercyon (Cercyon) castaneipennis* Vorst, 2009 is listed as an alien species (Orlova-Bienkowskaja, 2019). The range includes Western and Eastern Europe, the southwest of Northern Europe and the Canary Islands. The species has been known from the territory of Belarus (Nesvizh district) since 1988. *Cercyon castaneipennis* was collected in Brest, Grodno, Vitebsk and Minsk regions. A stable population of this species has fixed in Berezinskiy Biosphere Reserve since 1994. It is impossible to reliably classify it as an alien species for Belarus because its initial range is not known yet. The fact is that it has not been previously recorded in certain territories, so it does not mean its absence there. Indeed, even in well-studied territories, new species of insects for the fauna and for science are found, which were not previously known due to their rarity or lack of knowledge of the biology of these species.

Conclusion. The expansion of the ranges of Hydrophilidae can be both natural and anthropogenic. The Belarusian fauna includes seven alien species of hydrophilids.

Acknowledgement. The study was performed with the support of the Belarusian Republican Foundation for Fundamental Research (project B20MS-018).

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BLACK LOCUST APHID, *APPENDISETA ROBINIAE*: FURTHER EXPANSION IN CENTRAL AND EASTERN EUROPE

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Introduction. *Appendiseta robiniae* (Insecta: Rhynchota: Aphidoidea: Drepanosiphidae) has been described by C.P. Gillette in 1907 as *Callipterus robinae* from Denver (Colorado, USA) (Gillette, 1908). At present, *A. robiniae* is widespread in North America and introduced into South America, Europe, the Middle (http://www.aphidsonworldsplants.info/) and Far East. The species is known in the south of Europe from Iberian, Apennine, and Balkan peninsulas, Northern Black Sea Coast regions (Martynov & Nikulina, 2019) and up to Iran in the East (Entezari, Namaghi & Moravvej, 2016). The species was registered in Belarus in the forest zone of Eastern Europe (Zhorov, Sautkin & Buga, 2016). Black locust (*Robinia pseudoacacia* L., 1753), the main host plant of *A. robiniae*, is a common tree in numerous regions of Eastern Europe that provides opportunities for further expansion of *A. robiniae.*

Materials and methods. The article is based on materials collected in Kaliningrad province of Russia by S. Buga (2016) and all administrative regions of Belarus by F. Sautkin, S. Buga, A. Sinchuk, and A. Roginsky (2012–2017). Microscope slides were prepared by using Faure-Berlese mounting fluid and were stored in the collection of Zoological Department at Belarusian State University.

Results. In Belarus *A. robiniae* was collected for the first time in 2012 in Petrikov (Polessie, Gomel region) only, while in green areas in neighboring districts, the species was not recorded. Up to 2017, the species was registered in all areas of the country where black locust grew. Among them were districts of Vitebsk, Mogilev and Gomel regions along the border with Russian Federation. However, a targeted inspection of black locust specimens in green areas of Moscow and the Moscow province (Klin district) in 2019 did not reveal that alien species.

In Kaliningrad province of Russia *A. robiniae* was abundant in 2016 on *R. pseudoacacia* in green areas of Kaliningrad, Guryevsk, and Zelenogradsk. The high level of population density indicates that the invasion of this alien species occurred earlier in previous years.

Conclusion. *Appendiseta robiniae* (Gillette, 1907) is an alien aphid species of Nearctic origin that have invaded Central and Eastern Europe. The species was registered for the first time in Kaliningrad province (Russia) in 2016 as abundant on black locust (*Robinia pseudoacacia* L., 1753) in green areas of Kaliningrad, Guryevsk, and Zelenogradsk. In Belarus *A. robiniae* was registered in districts of Vitebsk, Mogilev and Gomel regions along the border with Russian Federation. Inspection of specimens of *R. pseudoacacia* in green areas of Moscow and the Moscow province in 2019 did not reveal this alien species.

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NEW DATA ON THE DISTRIBUTION OF *CALOPTILIA ROSCIPENNELLA* IN BELARUS

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Introduction. The penetration of alien species has become a global problem with serious economic, environmental and social consequences (Semenchenko & Pugachevsky, 2006). Due to the intensification of transport flows and changes in the regional climate, extensive penetration of insects beyond their natural range is noted.

For the first time in Belarus, *Caloptilia roscipennella* was noted in 2015 (Sinchuk, Buga & Baryshnikova, 2020). The species is included in the "Black Book of Invasive Animal Species of Belarus" with category A2 due to the decreases in the photosynthetic surface area and productivity of walnut (Sinchuk, Baryshnikova & Sinchuk, 2020).

Materials and methods. Damaged walnut leaf blades were collected during 2020 in Belarus. The pest was identified by the nature of the damage (Ellis, 2007).

Results. During the collection season 2020, *Caloptilia roscipennella* was identified in the following locations:

Grodno region, Grodno (Kolozhsky Park), 53°40'52.9"N 23°49'13.3"E on *Juglans* sp., 15.07.2020, col./det. A.V. Sinchuk, N.V. Sinchuk; Grodno (Kolozhsky Park), 53°40'51.5"N 23°48'55.5"E on *Juglans regia,* 15.10.2020, col./det. A.V. Sinchuk;

Brest region, Pruzhany (Lazo Str., 7), 52°33'07.9"N 24°28'37.9"E, on *Juglans regia*, 15.07.2020, col./det. A.V. Sinchuk, N.V. Sinchuk;

Gomel region, Dobrush (Gagarin Str.), 52°25'07.3"N 31°18'34.4"E photo by D.Yu. Kondratenko, on *Juglans regia* (https://www.inaturalist.org/observations/58500496), 15.08.2020, det. A.V. Sinchuk.

Conclusion. The larvae of *Caloptilia roscipennella* damage leaves of the common walnut (*Juglans regia* L.). There are 3 new points of registration of the invasive phytophage that have been established in Belarus. The northernmost registration of the species of the country in Grodno.

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NEW DATA ON HARLEQUIN LADYBIRD HARMONIA AXYRIDIS (PALLAS, 1773) (COLEOPTERA, COCCINELLIDAE) DISTRIBUTION IN BELARUS

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Introduction. Multicolored asian ladybird, or harlequin ladybird (*Harmonia axyridis* (Pallas, 1773)) is entomophagous, bug, but feeding on ripe fruits is also marked. According to a number of authors, in case of mass reproduction, this ladybird can damage winemaking, viticulture and fruit growing because the beetles can feed on fruits. In addition, it causes disturbance to people, accumulating in homes in autumn, and leads to a decrease in the number of native Coccinellidae species in various regions. However, recently the harmfulness of this species has been questioned. The possible way of invasion of *Harmonia axyridis* in Belarus from adjacent territories of the Ukraine, Baltic countries and Poland are individual migration, unintentional introduction of imago with fruits and transportation with cars and other vehicles especially during the search of overwintering places. The species spreads quickly and adapts well to local conditions. Depending on the weather characteristics of the growing seasons in the region, it can give several generations per year, which overlap in terms of development. Adults overwinter in various shelters. (Alekhnovich et al., 2016; Solodovnikov, Kotsur & Derzhinsky, 2020) in Belarus.

Until 2018, *Harmonia axyridis* was marked only in southern and central parts of Belarus (Kruglova, 2015; Ostrovsky, 2017). In Vitebsk region the species was first found in 2018 in Dokshitsy district (Alekhnovich et al., 2016). Next, it was caught near Vitebsk in 2019 (Solodovnikov, Kotsur & Derzhinsky, 2020).

Materials and methods. Ladybird were collected with standard entomological techniques by net sweeping and manual collection in 2019–2020.

Results. In 2020, many new locations of *Harmonia axyridis* were found throughout the Belarus. The exact information about these finds are given below. **Vitebsk region,** Senno distr., Novoselki vill. env., south bank of Soro lake, on the leaves of *Alnus incana*, h = 133 м, 54.993845° N, 29.820624° E, 11.06.2020 (I.A. Solodovnikov), 1 female; Vitebsk distr., 1,5 km south from Vitebsk, slope of railway hill between Lutchesa and Sosnovka stations, near the bridge, on the flowers of *Verbascum nigrum*, h = 149 m, 55.138632° N, 30.207342° E, 29.06.2019 (I.A. Solodovnikov), 1 ex. ('fresh' imago, exiting the pupa in nature); Vitebsk distr., Bolshuhi vill., 28 km east from Vitebsk, on the fence, h = 242 m, 55.20376° N, 30.64032° E, 11.06.2020 (V.M. Kotsur), 1 ex.; Vitebsk, Pravda str., 63-6, on the southern wall of building, h = 187 m, 55.179239° N, 30.244589° E, 29.10.2020 (I.A. Solodovnikov), 6 ex.; Vitebsk, Moskovskiy Ave., 33, VSU main campus, on the window of fourth floor, 29.10.2020 (V.M. Kotsur), 1 ex.; Vitebsk, Moskovskiy Ave., 13-4, on the flowers of *Solidago canadensis*, h = 165 m, 55.180100° N, 30.209935° E, 20.09.2020 (V.M. Kotsur), 1 m; Vitebsk, Pobedy Ave., 10, on the window, h = 173 m, 55.172679° N, 30.227449° E, 03.10.2020 (V.M. Kotsur), 1 ex. **Grodno region**, Grodno, crossing of Slavinsky and Pobedy str., on the wall of building, h = 166 m, 53°38'53.5" N, 23°49'58.9" E, 20.09.2019 (A. Shapovalov), 20 ex. **Mogilev region,** Krichev distr., Krichev town, near the bridge across Sozh river, by net sweeping on *Prunus padus*, 17.05.2020 (I.A. Solodovnikov), 1 ex. **Brest region,** Brest distr., Orhovo vill., (south of Tomashevka vill.), net sweeping in grasses on the bank of Orhovo lake, 51.539116° N, 23.607084° E, h = 162 m, 04–05.07.2020 (Kuznetsov V.A.), 1 ex.; Drogichin distr., Yamnik vill., «Zvanets» natural reservation, on the window, 04.05.2019 (V.M. Kotsur), 25 ex. **Gomel region,** Lel`chitsy distr., 2 km southwest from Markovskoe vill., 51°42'43.74"N, 28°11'8.02"E, pine-oak forest, day flight on sandy bank of Ubort` river, 22.10.2020 (Ye.A. Derzhinsky), more than 100 ex.; Mozyr` distr., 1,5 km west from Strelsk vill., ravine with hornbeam, oak and maple, on the leaves of *Salix* sp., h = 139 m, N 51.947952°, E 29.447035°, 13.05.2020

(I.A. Solodovnikov, V.M. Kotsur), 14 ex.; Kalinkovichi distr., 2 km southwest from Kozlovichi vill., clearing in a pine forest, on the grass, h = 155 м, 52.360537° N, 29.376625° E, 28.07.2020 (I.A. Solodovnikov), 1 ex.

Conclusion. During 2020, it was dramatic increasing the number of *Harmonia axyridis* locations. Distribution range expansion in the northern part of Belarus was indicated. Some locations were in anthropogenic ecosystems and some in natural habitats. The possible reason of this increasing might be abnormal warm winter 2019–2020.

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MOLECULAR KEYS FOR THE IDENTIFICATION OF APHIS SPECIES ASSOCIATED WITH APPLE TREES IN BELARUS

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In Belarus *Aphis pomi* de Geer, *Aphis spiraecola* Patch (Foottit et al., 2009; Razmjou et al., 2014), *Dysaphis anthrisci* Börner, *Dysaphi splantaginea* Pass., *Dysaphis radicola* Mordvilko (Rakauskas, Bašilova & Bernotienė, 2015), *Eriosoma lanigerum* (Hausmann) (Holman, 2009) and *Rhopalosiphum insertum* (Walker) (Holman, 2009) are the major pests in appleorchards. These aphids often cause irreversible damage to leaves, branches, and bourgeons and are responsible for severe losses of yield. Despite the biological distinction and potential harmfulness, these species are difficult to separate using their morphological characters, which lead to the difficulties with correct diagnosis of the species. Using of molecular-genetic methods of the species identification allows to solve such problems (Valenzuela et al., 2007). PCR-RFLP identification is a precise and cheap method of the identification of morphologically similar species of aphids. In this regard, we have developed the PCR-RELP keys based on the COI gene sequence to identify 6 aphid species included in the list of apple pests of the fauna of Belarus.

Available sequences of the mitochondrial COI gene (137 of *A. pomi*, 212 of *A. spiraecola*, 1 of *D. anthrisci*, 22 of *D. plantaginea*, 9 of *D. radicola*, 26 of *E. lanigerum*, and 8 of *R. insertum*) were obtained from GenBank NCBI. To avoid any discrepancies when analyzing data, sequences were aligned by reference. The length of the fragment was 708 bp. The restriction maps that allowed distinguishing between all 6 species of aphids were constructed. The COI sequences of analyzed species of aphids possess sufficient conservatism at the intraspecific level that allows developing PCR-RFLP keys for their identification.

The maps included 11 unique restriction sites for *A. pomi*, for *A. spiraecola* it is 8, for *R. insertum* it is 8, for *E. lanigerum* it is 5, for *D. radicola* it is 10, for *D. plantaginea* it is 8, and for *D. anthrisci* it is 6. These endonucleases can be used for precise identification of aphid species by alternative feature. Developed PCR-RFLP keys can also be used to evaluate the frequency of occurrence of the specific species of aphids on apple trees.

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INVASIVE DENDROPHILOUS AGROMYZIDAE SPECIES IN THE FAUNA OF BELARUS

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Introduction. Biological invasions have become a global problem that poses a major threat to biodiversity. The number of non-native species is increasing mainly due to climate change, intensification of trade and expansion of transportation networks.

Agromyzidae (Insecta: Diptera) – abundant and diverse family of mining flies, that contains species, causing significant economic harm by damaging cultivated plants. Larvae of the majority of agromyzids are leaf-miners (Spencer, 1973), feeding within leaf tissues.

Materials and methods. The list of alien dendrophilous Agromyzidae species and phenological information on them are based on own studies; data available from published sources and open internet-databases on mining arthropods has also been used.

Results. Four invasive Agromyzidae species, were revealed during 2017–2020 field investigations. These species were developed in the pre-imaginal phase within leaf tissues of shrubs and trees, including valuable ornamental plant species.

Aulagromyza caraganae (Rohdendorf-Holmanová, 1959) – monophagous on *Caragana arborescens* Lam. (Ellis, 2021). Whitish were mines found on lower or upper (less frequently) leaf surface. If the mine is lower-surface, the upper surface of the leaf blade turns yellow; pupation takes place inside the mine. In Belarus, larvae were found from June to the end of August. The life cycle includes at least two overlapping generations per year.

The species is widespread in Europe, including the countries bordering to Belarus – Poland and Lithuania (Pape & Beuk, 2014). According to our data in Belarus, the species is abundant and presents in all regions of the country.

Amauromyza obscura (Rohdendorf-Holmanová, 1959) – monophagous on *Caragana* Fabr. (*C. arborescens*, *Caragana frutex* (L.) K. Koch) (Ellis, 2021). The species was recorded previously in European countries bordering to Belarus: Lithuania, Poland, Ukraine (Pape & Beuk, 2014). The first record of the species in Belarus was made in 2020 (Volosach, 2020): *A. obscura* was found on *C. frutex* in Vitebsk, Minsk, Bobruisk, and on *C. arborescens* – in Bobruisk and Brest (Volosach, 2020). Mines are upper-surface, starting with a short narrow corridor and turning into a wide blotch. Frass in dark granules. According to our observations, typically several mines were located on a single leaf blade. Pupation occurs within the mine. According to our data, the life cycle of *A. obscura* includes several overlapping generations during the season.

According to the results of the study, it can be stated that *A. obscura* is locally common and abundant in some regions of the country.

Liriomyza amoena (Meigen, 1830) – monophagous on elders (*Sambucus* spp.) (Ellis, 2021). The species is widely spread in Europe (Ellis, 2021). Mines are located on upper leaf surface, at first they narrow, then they widen into irregular blotch with conspicuous secondary feeding lines and dark frass. Pupation takes place outside the mine. According to W.N. Ellis (Ellis, 2021), larvae can be found from June to September (data for Europe).

L. amoena, presumably, can be found throughout the country in low abundance. Phenology of the species in Belarus is unknown.

Agromyza spiraeoidearum Hering, 1954 – narrowly oligophagous species, mining meadowsweets (*Spiraea* L.) and buck's-beard (*Aruncus dioicus* (Walter) Fernald). *A. dioicus* is a Central European species with several growing sites in Belarus: within Kopyl and Novogrudok Uplands. Therefore, the status of *A. spiraeoidearum* (native/invasive) is uncertain and requires further study.

Mines of *A. spiraeoidearum* are upper-sided, often quite large: a single mine can contain multiple larvae. The mine starts as a relatively narrow corridor and gradually widens into a big spot; mine is light-colored, frass in scattered irregular granules, larvae pupate outside the mine.

The species is widespread in the country, common and usually numerous (Volosach & Buga, 2019).

Conclusion. According to our investigation, there are four alien dendrophilous Agromyzidae species were found in the fauna of Belarus: *Aulagromyza caraganae* Rohdendorf-Holmanová (1959), *Amauromyza obscura* (Rohdendorf-Holmanová, 1959), *Liriomyza amoena* (Meigen, 1830), *Agromyza spiraeoidearum* Hering, 1954 (the status of the last species requires further study). *A. caraganae*, *A. obscura* (Rohdendorf-Holmanová, 1959), and *A. spiraeoidearum* cause damage to ornamental plants in green areas.

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Section 2. Invasive And Alien Plant Species

TODAY AND TOMORROW OF *IMPATIENS* INVASIONS IN RUSSIA

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Introduction. Genus *Impatiens* includes about 1000 species, growing mainly in mountains of tropical Africa and Asia, with only dozen or so native species in northern temperate zone. Many of these plants have beautiful flowers and are cultivated as ornamental plants. Some of them escaped from culture and several became important invaders in different parts of the world (Adamowski, 2008). Russia is not exception, but even newest publications (Vinogradova et al., 2018) don't include complete information on the state and possible future of *Impatiens* invasions in the country. There were many erroneous records of *Impatiens* species from different regions of Russia.

Materials and methods. Authors critically reviewed available literature and other sources (iNaturalist and Plantarium portals, Moscow Digital Herbarium, other GBIF-mediated electronic resources, correspondence with colleagues-botanists working in particular territories) to produce maps of invasion status of *Impatiens* species present on the territory of Russia on the level of federal subjects (oblasts, krais, republics, etc.). Authors used terms: „casual" for geographically non-native plants observed as transitory elements of flora, „naturalized" for geographically non-native plants thriving in disturbed habitats and „invasive" for geographically non-native plants encroaching into natural vegetation. In some cases status of plant in particular territory was impossible to ascertain – „undefined".

Results. Five *Impatiens* species are present in different stages of naturalization in Russia. Himalayan *I. glandulifera* is Most widespread (found in 71 out of 81 territories) and clearly invasive spreading in majority of European Russia (Vinogradova et al., 2018), Caucasus (Zernov, 2013), southern Siberia and parts of Russian Far East (Vinogradova et al., 2018). Second Central Asiatic *I. parviflora was* found in 51 territories, also invasive and distributed mainly in European Russia (Vinogradova et al., 2018), with more recent observations in Caucasus (Zernov, Filin & Adzhiyev, 2019), Russian Far East and southern Siberia (Vinogradova et al., 2018). *Impatiens balsamina* (was found in nine territories) from southern and southeastern Asia should be treated as casual both in Caucasus (Zernov, 2013) and Middle Russia (Seregin, 2012). East African *I. walleriana* was reported from Caucasus as casual (two territories) (Zernov, 2013). Another Himalayan species, *I. balfourii* was found in Moscow oblast, also as a casual.

North American *I. capensis* is present in neighboring countries: Finland, Poland and Japan (Adamowski, 2008). Three more Himalayan balsams were recently observed as at least naturalized plants in northern temperate zone: *I. edgeworthii* in Germany, *I. tricornis* in Italy, Austria and Netherlands, as well as *I. bicolor* in Oregon, USA. Spontaneous hybrid *I. balfourii* × *I. parviflora* was recently found in Switzerland.

Conclusion. Non-native balsams do not occur in Russia only in regions with very harsh climate (with short and cold summers – Nenets AO, Yamalo-Nenets AO, majority of Krasnoyarsk Krai and Yakutia, whole Chukotka and Magadan oblast or northern part of Khabarovsk Krai, as well as in dry part of Caucasus and adjoining steppes and semi-deserts – Dagestan, Chechenia, Ingushetia, Kalmykia, or Astrakhan and Volgograd oblast). Tropical *I. balsamina* and *I. walleriana* occur only as casuals, whereas *I. glandulifera* is coming from high altitudes in Himalaya and invades also high latitudes. Four out of five non-native balsams are occuring in Russia annually, only *I. walleriana* is perennial in native distribution. New records of particular species for particular territories were collected over time. Introduction of new taxa into culture, global trade and ongoing climate change lead to appearance of further species out of cultivation that seems to be inevitable.

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THE SPREAD OF INVASIVE PLANT SPECIES IN MINSK

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Introduction. The problem of invasive plant species is especially acute in urbanocenoses. On the one hand, there is a weakening of the natural flora under anthropogenic pressure, on the other hand, the concentration and variety of introduced species are capable of exhibiting invasive properties. As a result, settlements and the immediate vicinity act as a springboard for the introduction and subsequent dispersal of invasive plant species.

Materials and methods. The studies were carried out in 2016–2020 in Minsk. There are 419 objects of landscape (parks, forest parks, cemeteries, public gardens, street plantings, etc.) were examined by using the standard route method.

Results. Total number of places of growth of 46 invasive and potentially invasive species in Minsk during field research 2016–2020 were marked (the occurrence is indicated in brackets): *Acer negundo* L. (44,8 %), *Aesculus hippocastanum* L. (1,9 %), *Amelanchier spicata* (Lam.) K. Koch (3,1%), *Asclepias syriaca* L. (0,7 %), *Conyza canadensis* (L.) Cronquist (23,7 %), *Crataegus sanguinea* Pall. (4,4 %), *Echinocystis lobata* (Michx.) Torr. & A. Gray (5,1 %), *Erigeron annuus* (L.) Pers. (20,6 %), *Geum macrophyllum* Willd. (3,6 %), *Helianthus tuberosus* L. (13,3 %), *Heracleum asperum* (Hoffm.) M. Bieb. (3,9 %), *Heracleum sosnowskyi* Manden. (6,3 %), *Hippophae rhamnoides* L. (2,4 %), *Impatiens glandulifera* Royle (2,2 %), *Impatiens parviflora* DC. (1,9 %), *Juglans mandshurica* Maxim. (2,2 %), *Ligustrum vulgare* L. (1,5 %), *Lupinus polyphyllus* Lindl. (10,4 %), *Mahonia aquifolium* (Pursh) Nutt. (0,5 %), *Medicago sativa* L. (2,9 %), *Oxalis stricta* L. (2,2 %), *Padus serotina* (Ehrh.) Borkh. (1,0 %), *Parthenocissus quinquefolia* (L.) Planch. (23,2 %), *Physocarpus opulifolius* (L.) Maxim. (9,7 %), *Populus alba* L. (1,2 %), *Prunus cerasifera* Ehrh. (5,3 %), *Quercus rubra* L. (2,2 %), *Reynoutria japonica* Houtt. (17,9 %), *Reynoutria sachalinensis* (F. Schmidt) Nakai (0,5 %), *Rhus typhina* L. (7,0 %), *Robinia pseudoacacia* L. (15,3 %), *Rudbeckia hirta* L. (1,0 %), *Rudbeckia laciniata* L. (3,4 %), *Rumex confertus* Willd. (1,0 %), *Sambucus nigra* L. (1,2 %), *Sambucus racemosa* L. (3,1 %), *Saponaria officinalis* L. (4,1 %), *Solidago canadensis* L. (47,0 %), *Solidago gigantea* Aiton (36,6 %), *Sorbaria sorbifolia* (L.) A. Braun (1,2 %), *Swida alba* (L.) Opiz (2,2 %), *Symphoricarpos albus* var. *laevigatus* (Fernald) S.F. Blake (4,8 %), *Symphyotrichum × salignum* (Willd.) G.L. Nesom (4,4 %), *Symphytum caucasicum* M. Bieb. (3,6 %), *Thladiantha dubia* Bunge (0,7 %), *Vinca minor* L. (1,9%).

The most common introduced species in the green stands of Minsk were *Acer negundo* L., *Solidago canadensis* L., *Solidago gigantea* Aiton, *Conyza canadensis* (L.) Cronquist, *Erigeron annuus* (L.) Pers., *Parthenocissus quinquefolia* (L.) Planch. A particularly alarming situation was observed with regard to *Solidago canadensis* L. and *Acer negundo* L., since they are common in more than 45 % of all parks and street plantings. The fact of the invasion of *Acer negundo* L., by analogy with *Heracleum*, requires immediate resolution and widespread control.

Generic complex *Heracleum* within *Heracleum asperum* (Hoffm.) M. Bieb. and *Heracleum sosnowskyi* Manden. in urban plantings was distributed on 25–35 % of plantations until 2017, however, the depletion of the soil and seed stock undoubtedly influenced on the nature of their invasion. The expansion of such species as *Solidago gigantea* Aiton, *Conyza canadensis* (L.) Cronquist, *Parthenocissus quinquefolia* (L.) Planch., *Erigeron annuus* (L.) Pers., *Reynoutria japonica* Houtt., *Robinia pseudoacacia* L., *Helianthus tuberosus* L., *Lupinus polyphyllus* Lindl., *Physocarpus opulifolius* (L.) Maxim. requires additional attention, because they were noted in 10–40 % of all plantings.

Separately, a number of species should be noted for which isolated cases of feralization have been noted: *Heliopsis helianthoides* (L.) Sweet, *Coreopsis lanceolata* L., *Cosmos* *bipinnatus* Cav., *Rubus odoratus* L., *Mahonia aquifolium* (Pursh) Nutt., *Echinops sphaerocephalus* L., *Bryonia alba* L., *Alkekengi officinarum* Moench, *Padus avium* ssp. *pubescens* (Regel & Tiling) Browicz, *Alcea rosea* L., *Hordeum jubatum* L.

Conclusion. It was possible to distribute invasive plant species in Minsk according to the gradation of the risk of invasions:

- aggressive invasion was typical of *Acer negundo* L., *Solidago canadensis* L.;
- active invasion was typical of *Reynoutria japonica* Houtt., *Robinia pseudoacacia* L., *Parthenocissus quinquefolia* (L.) Planch., *Helianthus tuberosus* L., *Solidago gigantea* Aiton;
- local invasion was indicative of *Quercus rubra* L., *Physocarpus opulifolius* (L.) Maxim., *Sorbaria sorbifolia* (L.) A. Braun, *Symphytum caucasicum* M. Bieb., *Symphoricarpos albus* var. *laevigatus* (Fernald) S.F. Blake, *Rhus typhina* L., *Lupinus polyphyllus* Lindl., *Rumex confertus* Willd.

It would be advisable to assess in more details the local risk of biological invasions in order to motivate the decision of including species that have the risk of active and aggressive invasion into groups.

GROWING THREAD OF INVASIVE MACROPHYTES IN POLAND: THE CASE OF *ELODEA NUTTALLII*

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Introduction. Invasive species are serious threat to biodiversity of ecosystems around the world. Freshwater habitats, such as: lakes, ponds and rivers seem to be especially at risk from alien plant species (Moorhouse & Macdonald, 2015). One of such potentially threatening species is *Elodea nuttallii*. Native to North America, it first appeared in Western Europe at the beginning of 20th century and since then it begun to spread around the continent. *E. nuttallii* often form mass developments (Zehnsdorf et al., 2015) which can present serious problem for both local biodiversity and human use of water bodies. Due their similarities, *E. nuttallii* is often confused with another invasive macrophyte: *E. canadensis*, thus is rarely recorded. It is important to distinguish between those two, because *E. nuttallii* seems to grow more rapidly and be more vigorus than *E. canadensis* (Simpson, 1990), which in most of cases leads to distribution of the latter. In Poland *E. nuttallii* was first spotted in the early 90's in the Biebrza's oxbow lake and in 2007 in Vistula river (Kamiński, 2010), and since then was reported from many other locations. The main objectives of this study were to (1) present current knowledge on recent localities of *Elodea nuttallii* in Poland as well as (2) habitat requirements of this species.

Material and methods. Data concerning of *E. nuttallii* was collected from sites across the entire territory of Poland in 2015–2020. Data relating to water quality in 9 lakes and 2 rivers were collected as part of individual research projects of the contributors.

Results. We collected over 40 records of *E. nuttallii* occurring in rivers, streams and lakes and dam reservoir across the country, spanning historical and own data. Most of the sites were found in the valleys of the large rivers of the Vistula and Odra. This species inhabits both mesotrophic lakes Chara-dominated lakes as well eutrophic dam reservoirs and estuaries.

Conclusion. Our observations show that *E. nuttallii* is continuing its further expansion in Poland, favoring river valleys as well as nearby water bodies. Our findings also prove that this macrophyte can form very dense formations in Poland, which can pose a serious threat to both freshwater biodiversity and human use of water bodies. Further expansion can be only stopped by properly carried out weed control methods.

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NATIVE AND ADVENTIVE STATUS OF SOME ROSES (*ROSA*) AND HAWTHORNS (*CRATAEGUS*) IN THE FLORA OF BELARUS

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Introduction. In the modern flora of Belarus, the status of some species of the genus *Rosa* L. and *Crataegus* L. remains not quite obvious. They can be considered both wild and adventive, but some of them appeared here a long time ago and claim the status of archaeophytes. It is known, that rose and hawthorns are grown for a long period as valuable decorative, medicinal and melliferous plants. Some of them were planted on the site of ancient settlements and settlements in old parks, were used as protective plantings on the ramparts of fortresses and ancient settlements, were bred in monasteries and pharmaceutical gardens, and were used for rootstock of cultivated roses. This also applies to many species of the genera *Rosa* and *Crataegus* in Belarus. Analyzing the locations of these species, it is obvious that they are more often confined to the areas of ancient settlements, in varying degrees of disturbed habitats, in the vicinity of ancient parks, and they are practically absent in wooded and sparsely populated areas.

Materials and methods. The studies were carried out throughout the country using the traditional route-search method. Herbarium collections of the following Herbaria were studied – MSK, KW, LE, WI (their international acronyms are given).

Results. Among the representatives of the genus *Rosa*, the most common species and hybrids in Belarus include *R. canina* L., *R. caesia* Smith (*R. ciesielskii* Blocki), *R. cinnamomea* L., *R. rubiginosa* L., *R. sherardii* Davies, *R.* x *subcanina* (Christ.) Dalla Torre et Sarnth., *R. villosa* L., *R. vosagiaca* (N.H.F. Desp.) Déségl. (*R. dumalis* auct. non Bechst.). Of these, only *R. cinnamomea* is confined to natural or slightly disturbed habitats. The species is more common in river valleys, lake depressions and in adjacent areas, less often at a distance from them. Some forms of this species are cultivated, but rarely. The rest of the listed roses are usually associated with disturbed habitats and are more often recorded along roads, on forest edges, near settlements, old parks, estates, and more often disappear in natural habitats. However, their seeds can be carried long distances by birds and other animals. In this case, they appear along the edges of forests, in meadows, near water bodies, but then you need to look for parent plants in the nearest settlements. According to old herbarium and literary data of the 18th–19th centuries, these species were rare and limited in Belarus, but increased in numbers from the end of the 19th and in the 20th centuries. *R. canina*, *R.* x *subcanina*, *R. vosagiaca*, and *R. corymbifera* Borkh. were often used as a stock for cultivated roses, therefore they are more often registered near old estates and parks, settlements. In places of their joint growth, numerous hybrids with transitional morphological characters are often found. The fact, that *R. canina* is grown in nurseries and is used to inoculate the best varieties of roses is mentioned by K. Cholovsky (Cholovsky, 1882), and the first reliable collections of it are dated 1852 (LE). *R. caesia* has been reliably known from herbarium data since 1869 (SPBU), *R. mollis* since the 1820s. (WI), *R. rubiginosa* from the 1820s. (WI), *R. sherardii* from 1824 (WI), *R.* x *subcanina*, probably known until 1770, *R. villosa* from 1776–1781 (KW), *R. vosagiaca*, probably known before 1770 (for example, the ancient settlement of Drutsk, Tolochin region).

Therefore, all the species listed above in Belarus, except for *R. cinnamomea*, should be classified as an adventive element, but some of them may be archaeophytes, especially *R. vosagiaca*, *R. x subcanina*, *R. sherardii*, and *R. villosa*. The first two species were planted on ancient settlements and ramparts. Their thorny shoots prevented the attack of enemies, and the plants were used for medicinal and food purposes.

R. tomentosa Smith. is found very rarely and locally in Belarus; it was found only in the last decades, confined to disturbed habitats, therefore, it can also be considered an adventive species. Known earlier in the vicinity of the city Turov *R. marginata* Wallr. (*R. jundzillii* Bess.), according to herbarium data (MSK), is a hybrid of *R.* x *subcanina* x *R. sherardii*, therefore this taxon is excluded from the flora of Belarus. In addition, the typical *R.* x *subcanina* is present on the same herbarium leaf as the hybrid. Complex rose hybrids – *R. zalana* Wiesb. (*R. agrestis* Savi x *R. rubiginosa*), *R.* x *lazarenkoi* Chrhan. (*R. caesia* x *R. rubiginosa*), *R.* x *inodora* Fries (*R. agrestis* x *R. elliptica* Tausch), *R.* x *andegavensis* Bast. (*R. canina* x *R.* x *stylosa* Desv.? *R. slobodjanii* (Chrshan.) Dubovik., nom. inval.) are distributed in Belarus to a limited extent and undoubtedly appeared here as adventive plants.

We have almost no doubts about the adventive status of some species of the genus *Crataegus*, which are sometimes considered native in the flora of Belarus – *C. x dunensis* Cinov. (*C. lindmanii* Hrab.-Uhr. x *C. rhipidophylla*), *C.* x *kyrtostyla* Fingerh. (*C. monogyna* x *C. rhipidophylla*), *C. monogyna* Jacg., *C. rhipidophylla* Gand., *C. ucrainica* Pojark. Most of their locations, with the exception of the last species, are confined to old parks and their environs, settlements, roadsides, ancient settlements (for example, islands among lakes, destroyed ramparts around former fortresses). From here, they are carried in the immediate vicinity by animals and humans, but are rare or absent in sparsely populated and wooded areas (for example, in the east of the country, some parts of Polesie). *C.* x *dunensis* is confined in Belarus to the immediate vicinity of the park in the village of Doroshevichi, Petrikov district (near the village of Turok), where a number of exotic plants were previously grown and from where it entered its natural habitats. In the vicinity of the village of Khlupinskaya Buda (Zhitkovichi district), here, in the only locality in the Pripyat reserve, *Rosa rubiginosa* is also known, which confirms the invasive nature of both species. In Ukraine, *C.* x *dunensis* is known from one isolated locality in the Zhytomyr region (Fitzailo & Orlov, 2009), which does not exclude its adventive status in the region. Doubtful status in Belarus has *C. ucrainica*, which occurs mainly in the Belarusian Polesie, more often on the Mozyr ridge and in the vicinity of Turov. It would seem that its location as natural on the northern border of the range, but it is almost always found in disturbed habitats, often in culture and settlements, in places of ancient settlements and foci of ancient agriculture.

These facts confirm that all representatives of the genus *Crataegus* in Belarus are adventive species. That *S. monogyna* s.l. in central Polesie it is very rare, and in the northern outskirts of Polesie, perhaps, only just ran wild from the gardens, mentions I.K. Pachosky (Pachosky, 1897). Judging by the herbarium data of the 18^{th} – early 19th centuries *C. monogyna* s.l. was known near Grodno and Belovezhskaya Pushcha, so some of the species can be archaeophytes, especially *C. monogyna*, *C.* x *kyrtostyla* and *C. rhipidophylla*. The latter species is typical of ancient settlements. However, all of them began to be grown more often from the second half of the 19th century in parks and then successfully ran wild.

Conclusion. Many of the above listed species of the genera *Rosa* and *Crataegus* are currently actively expanding their positions in Belarus, especially *C. monogyma,* and can be considered as invasive or potentially invasive plant species. Only *Rosa cinnamomea* is a native species of roses in Belarus, the rest of the roses are adventive.

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PUTATIVE HYBRID BETWEEN NORTH AMERICAN SPECIES OF *ASCLEPIAS* (APOCYNACEAE, ASCLEPIADOIDEAE) IN BELARUS

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As currently circumscribed *Asclepias* is a genus of Apocynaceae family that include 130–140 species, native to North, Central and South America (Woodson, 1954). Moreover, up to 250 species from Africa sometimes were included in *Asclepias,* but this is not supported by modern phylogenetic studies (Fishbein et al., 2011). Nearly 10 species of *Asclepias* are cultivated as ornamentals and sometimes escape from culture in Europe. The most widespread and invasive species in some South, Central and East European countries is *A. syriaca* L., whereas *A. curassavica* L. and *A. incarnata* L. have been recorded as casual or locally naturalized aliens in various regions of Europe (Gudžinskas & Petrulaitis, 2019). In 2019 Gudžinskas and Petrulaitis are reported from Lithuania new to Europe alien species – *Asclepias speciosa* Torr.*,* that is similar to invasive *A. syriaca* and was misidentified as the latter for the long time (since 1962) (Gudžinskas & Petrulaitis, 2019). In Belarus only one species – *A. syriaca* was mentioned as a cultivated and potentially invasive alien (Dubovik et al., 2020; Kozlovskaja, 1998). *Asclepias incarnata*, *A. tuberosa* L. and probably a few other species began to be cultivated as ornamentals just in recent years.

During field seasons of 2019–2020 putative hybrid between North American species of *Asclepias* was discovered in central part of Belarus. Small colony of plants seemed to be intermediate between *A. syriaca* and *A. speciosa* was found in abandoned ornamental plantings. Hybridization between these two species, as well as in general between representatives of the genus has not been previously reported in Belarus.

Field studies were carried out in summer and autumn of 2019–2020. Herbarium specimens of putative hybrid were collected in south-west part of Minsk city (N53.847227, E27.460848). Those species were photographed and the flowers compared with those of its parent species. Most flower and inflorescence characters were measured in the field, using x10 magnifying lens. Coronal diameter was measured apically and at maximum width. Hood height represented the vertical span from the base of the hood to the top of its uppermost median projection. The distance that the horn extended beyond the interior lateral margin of the hood was measured. The main data (place, date and photos) were added to the citizen science Internet platform iNaturalist (https://www.inaturalist.org/observations/54628837). Herbarium of all *Asclepias* species stored at the Department of Botany at Belarusian State University (MSKU) was examined. Specimens collected during this research were also deposited at the same Herbarium.

During of summer field season in 2019 our attention was attracted by a small population of unknown *Asclepias* species that appeared to be plants of *A. syriaca*. It looked also very similar in description to *A. speciosa* indicated recently from Lithuania as new for Europe alien species, but differ from latter in color and shape of hoods in corolla. In July of 2020 we examined more precisely a dense stand (2 m^2) of this possible hybrid situated near the municipal middle school in abandoned ornamental plantings. After the close examination of collected flowering specimens and their comparison with flowering plants of typical *A. syriaca* and descriptions and photos of *A. speciosa* we assumed of its belonging to the hybrid between these two species.

Asclepias speciosa can be reliably distinguished from the morphologically similar *A. syriaca* only at the flowering stage. The most characteristic features are the size and shape of corolla. Hoods of *A. speciosa* are 10–14 mm long, very narrowly ovate-lanceolate, gradually attenuate, and the horns are much shorter than the hoods. Hoods of *A. syriaca* are 4–5 mm long, ovate, with a gradually rounded to acuminate apex, and the horns somewhat shorter than the hood. Another important diagnostic character is the indumentum of the pedicels, that are densely covered with short white hairs and tomentose in *A. speciosa*, whereas those of *A. syriaca* have sparse pubescence (Woodson, 1954; Fishbein et al., 2011). These two species although often placed in different sections, are extremely difficult to distinguish with no flower. Rest of the traits that are indicated as diagnostic between two species (number of flowers in the inflorescence, form and venation of middle cauline leaf blades and their base, fruit surface etc.) probably have minor importance as they have great variability in different populations of both species.

Hybridization seems to be rare between species of *Asclepias*, judging by the few reports available in the literature and the general failure of attempts to produce hybrids artificially. But *A. syriaca* and *A. speciosa* can form an occasional fairly common spontaneous hybrids when they grow together, and the cross has been performed experimentally. It is likely that interspecific hybridization may account for the variation that is found within these species in the wild (Woodson, 1954).

The putative hybrid was observed during our study maintained the tall habit (nearly 2 m) of *A. syriaca* with its multiple lateral umbels of pink-purple flowers (normally on somewhat nodding pedicels). Pedicels are densely tomentose as in *A. speciosa.* Hoods have intermediate size and form between the two species. They are not so narrow and attenuate as in *A. speciosa*, but clearly longer and not so wide as in *A. syriaca*. The leaves (leaf venation, shape and size) were also intermediate between the two species.

The putative hybrid between *A. syriaca* and *A. speciosa* seems to be rare alien taxon in Belarus and was registered in the country for the first time. It is likely that this (or other) hybrids already occur in other regions of Belarus for the rather long time and overlooked due to morphological resemblance with the very similar *A. syriaca*. Botanists should pay special attention to determination of hybrids and their parent species in nature, and critically review collected specimens of genus *Asclepias* in Herbaria.

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NORTH AMERICAN TREES AND SHRUBS IN THE GREEN SPACES OF SURGUT (NORTH OF WESTERN SIBERIA)

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Introduction. The city of Surgut is located in the middle taiga in the north of Western Siberia. The conditions for the existence of plants are quite inclement here. Surgut is the largest city in the Khanty-Mansi Autonomous Region, and sufficient attention is paid to the creation and maintenance of green spaces in good condition. Information about introduced plants in the settlements located in the Far North is quite poor. However, knowledge of their composition and condition allows us to develop a sustainable and effective assortment for gardening in inclement conditions and to gain new knowledge about alien species. The study of the state of trees and shrubs in green spaces is part of a comprehensive study on the development of a sustainable assortment for landscaping in the north of Western Siberia (Egorov et al., 2019). This report presents an assessment of the diversity and status of North American tree and shrub species in the green stands of Surgut.

Materials and methods. The materials for the analysis were data on the composition of introduced trees and shrubs in the green areas of Surgut (Kukurichkin et al., 2014), as well as data from field surveys since 2015 of the green areas of the city. During evaluation the condition of plants, a winter hardiness scale was used, reflecting the frequency of freezing. We also took into account such indicators as the height of the plant and the form of growth (tree or shrub), the occurrence in the green spaces of Surgut. Special attention was paid to the self-seeding of the introduced species, that shows a certain degree of naturalization.

Results. In the green stands of Surgut, 12 species of trees and shrubs naturally growing in North America were identified, including 4 species of trees (for example, *Acer negundo*, *Populus balsamifera*, etc.) and 8 shrubs (for example, *Amelanchier alnifolia*, *Symphoricarpos rivularis*, etc.). It should be noted that such a species as *Padus virginiana*, that grows in the form of a tree in its natural range, in the conditions of Surgut grows in the form of bushe up to 3 m high. The other species retained their life forms. The tallest North American introduced tree species is *P. balsamifera* (up to 20 m tall), followed by *A. negundo* (up to 8 m), the others are below 2.5 m. The shrubs are up to 3 m tall. *P. balsamifera*, *Amelanchier spicata*, *P. virginiana*, and *Physocarpus opulifolius* are common North American species found in the city's green spaces. Other species are rare. Of the 12 North American introduced plants, 5 species showed resistance to winter conditions: *A. alnifolia*, *Ph. opulifolius*, *P. balsamifera*, etc. Naturalization (ornithochoria) has been observed in one species – *A. alnifolia*.

Conclusion. The survey of green stands in the Far North provideed important information about the composition and condition of plants for the purposes of their introduction, identification of alien flora and the degree of its naturalization.

The work was supported by the Department of Education and Youth Policy of the Khanty-Mansi Autonomous Region – Ugra (Order No. 10-P-1308 of 4.09.20).

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ADVENTIVE PLANTS SPECIES IN THE FLORA OF DROHOBYCH

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Introduction. Cities belong to the most anthropogenically transformed ecosystems, that are characterized by a specific urban environment, in which almost all its components are subject to change, including vegetation, and in it – flora. Due to the concentration of a significant part of the population in cities, the environment is under anthropogenic pressure, as a result, the urban environment is transformed into a zone of ecological disaster, characterized by unfavorable conditions for biodiversity. In Ukraine, special studies of urban flora began with large industrial cities, studies on small towns are not so much, so the study of urban flora and their adventitious fractions does not lose relevance (Derevyanskaya, 2013; Zavyalova, 2008).

Drohobych is located on the border of the Transnistrian plain and the Carpathian foothills, on the river Tysmenytsia, in the southwestern part of Lviv region. The city is located in temperate latitudes and belongs to the humid temperate-warm acroclimatic zone. The city is characterized by high humidity (70–80 % in winter, 85 % in summer) and low atmospheric pressure (725–745 mm Hg) (Agrosoil regions…, 1965). The area of the city is 44.5 km^2.

Materials and methods. The analysis of the adventitious fraction of flora of Drohobych was prepared on the basis of own field researches. The adventitious fraction of the studied flora of the city of Drohobych was analyzed by the time of deposition, the degree of naturalization, the area according to the statements of V.V. Protopopova (Protopopova, 1991), according to the method of naturalization of the studied group of plants followed Schroeder's system (Schroder, 1969).

Results. According to the results of own field research, the growth of 28 species of adventitious fraction of flora were belonged to 28 genera and 13 families were established. The most common of them were *Cichorium intybus* L., *Medicago lupulina* L., *Vicia villosa* Roth., *Chelidonium majus* L., *Sambucus nigra* L., *Matricaria discoidea* DC. and *Erigeron annuus* (L.) Pers.

Archaeophytes, that include 8 species, predominate among adventitious plants at the time of introduction. Kenophytes include 5 species, eukenophytes – 2 species.

The degree of naturalization is dominated by epecophytes – 8 species. Ergasiophytes (2) and agriophytes (2) are also quite numerous. The smallest number of species are colonophytes (1) and agrioepecophytes (1).

Evapophytes (7), hemiapophytes (8), and eventopophytes (1) are distinguished by the degree of adaptation to the conditions of anthropogenic ecotopes.

Conclusion. It can be concluded that within the city there is a transformation of natural groups with their replacement by adventitious. Therefore, the study of the adventitious species of the city's flora is relevant for further monitoring of its changes and ways of their spread.

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DISTRIBUTION OF ALIEN SPECIES *AILANTHUS ALTISSIMA* (MILL.) SWINGLE AND AMBROSIA ARTEMISIIFOLIA L. IN CRIMEA

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Introduction. The Crimean peninsula is one of the European centers of floristic diversity with a total flora richness of 2536 species (Yena, 2012.). One of the most important threats to biodiversity is the invasion of alien species, which is important for hotspots (Le Roux, 2019), including Crimea. To analyze the spatial features of the invasive species distribution on the Crimean Peninsula, we chose *Ailanthus altissima* (Mill.) Swingle (tree of heaven) and *Ambrosia artemisiifolia* L. (common ragweed).

A. altissima is an Asian plant was brought to Crimea from China about 200 years ago as an attractive ornamental plant. Distributed in many countries around the world. It is used as an ornamental plant for urban greening. The plant is growing rapidly, less demanding on soil, found in transformed habitats.

A. artemisiifolia L. is one of the most threatening alien species from North America and widespread throughout European Russia. It produces an allergenic pollen and poses a threat to public health.

Materials and methods. The data of invasive species locations were obtained from the platform iNaturalist (https://www.inaturalist.org/) and from authors' field observations.

In the Flora of Russia project, 75 observations of *A. artemisiifolia* and 195 of *A. altissima* are located on the Crimean peninsula. The data time range for *A. artemisiifolia* was 2013–2020, for *A. altissima* was 2000–2020. Geographical coverage – the Crimean peninsula, two administrative units – the Republic of Crimea and the Sevastopol city.

Results. *A. altissima* is widespread on the Crimean Peninsula, especially on the southern coast and in southwestern part (Skurlatova & Bagrikova, 2019). It spreads rapidly in flat steppe Crimea, in cities, especially on damaged soils. The main habitats in cities are abandoned construction sites, pits, dug areas, etc. In the Crimean mountains *A. altissima* have been observed near the river Urkusty, at Toropova dacha, etc.

The plant were observed in the protected areas of southern and southwestern Crimea: Baidarsky, Fiolent, Laspi, etc. reserves.

About 20–30 years ago *A. artemisiifolia* was found on the Crimean peninsula very seldom and about 10–15 years ago it could be found in steppe landscapes. At present, it is found everywhere: along highways, along the coast, in cities, on agricultural land and other transformed biotopes and human-dominated landscapes. It prefers relatively moist areas. In the last 3–5 years, an increasing occurrence of *A. artemisiifolia* is associated with construction, including the use of imported soil to create flower beds and urban green areas. For example, the species was recorded in Uchkuevka Park, in Pushkin Square at Cape Fiolent.

In non-urbanized landscapes, the distribution of *A. artemisiifolia* is related with highways, recreational areas and river valleys. Moreover, *A. artemisiifolia* was noted in the "Baydarsky" nature reserve in the Varnutskaya valley, in the Baydarskaya valley, near the village Kolkhoznoye, in the river Uzundzha bed. The species was also recorded in remote forest areas in Crimean mountains: the valley of the Ay-Todorka river, in the Uzundzhi valley. The authors observed "thickets" of *A. artemisiifolia* in the Adym-Chokrak valley. At the same time, there are significant interannual fluctuations in the number of the plant – from 10 to 90 % of the coverage.

According to our observations on the Crimean peninsula, the abundance of *A. artemisiifolia* was decreased when the transformed areas were overgrown with other species.

Conclusion.

1. In Crimea there has been an increasing occurrence of *A. artemisiifolia* over the past 20 years has been detected. The main *A. artemisiifolia* and *A. altissima* habitats were associated with human activities (agricultural land, highways and cities).

2. Both species pose a threat for biodiversity conservation. They are located in protected areas: *A. altissima* in anthropogenically altered habitats, and *A. artemisiifolia* along river, on mountain slopes.

3. At present human activity conditions, a continued occurrence of *A. artemisiifolia* in Crimea is highly possible.

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THE INVASION OF INTERSPECIFIC HYBRIDS OF THE GENUS *HERACLEUM* AT THE SCIENTIFIC-EXPERIMENTAL STATION "OTRADNOYE" BIN RAS AND HIS COMPETITION WITH FEED CEREALS

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Introduction. The scientific-experimental station "Otradnoye" is located in the North-East of the Karelian Isthmus Leningrad Region, on the shore of Lake Otradnoye. The station was found in May 6, 1946 in order to introduce valuable trees and shrubs for agriculture of USSR (Svyazeva, Luks & Latmanizova, 2011). Nowadays the station belongs to the Botanical institute. The current distribution of *Heracleum Sosnowskyi* Manden. and his hybrids in Otradnoye was caused by the introductory experiments during Soviet period. In 1951, the Otradnoye station became one of the centers for the scientific introduction of *Heracleum* species. Breeding trials were perfomed until the end of the 1970s. During this period, a collection of 32 species of the *Heracleum* was collected in Otradnoye, many of which were used for interspecific hybridization. One of the latest selection results was the breeding of a coumarin-free variety "Otradny BIN-1" supervised by of I.F. Satsiperova. The variety was not introduced to agriculture (Latmanizova, 2017). More recent research about the problem of the invasion of *Heracleum* hybrids` at the station does not exist.

Materials and methods. The territory of the station «Otradnoye» is 68.9 ha. It is located on the three low lake terraces. The granulometric composition of the soil is diverse however, clay loams predominate, underlain by ribbon clays at a depth of 30–50 cm. Approximately 40 hectares of the territory are open and semi-open spaces (at the same time, more than 90 % of the area now is without growing crops and without crop rotations). Phototoxic *Heracleum Sosnowskyi* Manden. and his hybrids cover more than 50 % of the area including the borders of the forest. Since 2013, the fight against *Heracleum* has been carried out mainly by chemical methods. Territory treatment is carried out by water dispersion of a mixture of herbicides "Tornado 500" (glyphosate) + "Magnum" (sulfonylureas) + "Adju" (surface-active substance). Chemical treatment is carried out on its own, as well as with the involvement of contractors, without scientific research on the effectiveness of the method and the dynamics of the number of *Heracleum* individuals. In 2019, an experiment was launched, the distribution of *Heracleum* individuals growing in the community of turf grass forage grasses was observed. A field with an area of 2 hectares was selected as an experimental plot. This area is located along the lake and separated from it by a forest 50 m wide. The soils are loamy, the upper horizon is characterized by increased fertility. The relief is represented by a lake terrace, the lower half of which has a slope towards the lake with a height difference of up to 3.0 m by 50 m. There is an annual spring flooding of some areas of the field (with an area of no more than 15 %). In the 1970s and 1980s, this field was occupied by medicinal herbs (mainly the *Compositae*). During recent 25 years the field was not used. In 2016 and 2017, the territory was serviced with a solution of the herbicide "Tornado 500 ". At the time of the survey, in 2018, about 60 % of the field area was again covered with *Heraculum* hybrids, presumably *Heraculum Sosnowsky* x *H. ponticum* (Tkachenko & Zhiglova, 2019), the height of the specimens was 2–3 m. The distribution was represented by extensive arrays with a density of 3–6 specimens on 10 m^2. Hybrids showed high biomass productivity, remontant flowering (up to 3 times) after mowing. In 2019, mechanized processing of this field was carried out (plowing, collecting stones, disking, cultivation), in August 2019, the state farm of JSC PZ "Pervomaysky" sowed fodder grass mixtures.

Results. As of July 2020, the ratio of forage grasses in this field was: 77 % – *Lolium perenne* L., 15 % – *Poa trivialis* L., 3 % – *Phleum pratense* L., 5 % – other types of cereals. The number of *Heracleum* specimens in this area at the end of June 2020 was 305 specimens [A4]. About 30 % of specimens were in a generative state (this is an amazing fact, possibly due to not very careful plowing, specimens of previous years were preserved). The height of plants was from 0.4 m to 1.5 m, the area occupied by one plant was from 0.5 to 1.5 m^2. In order to prevent further spread [A5], all peduncles were destroyed and the stems were cut off at the root collar. According to the results of even a preliminary assessment, it was found that the sown cereals [A6] did not create competition for the *Heracleum* hybrids. But more than 20 % was occupied by perennial lupine (*Lupinus perennis* L.), spreading from the southern periphery of the field. Not a single *Heracleum* specimen has been found in the lupine massifs. Also, a visual reconnaissance of the entire territory of "Otradnoye" showed that *Heracleum* could not occupy the territory of the former experimental field of meadow grasses of A.P. Shennikov, an area of 5 hectares, where experiments were carried out to study meadow plant communities (Shennikov et al., 1963).

Conclusion. An example of resistance to *Heracleum* fields A.P. Shennikova demonstrated that further experiments on the introduction of turf grasses and rhizome perennials are needed to limit the germination of seeds of invasive *Heracleum* species. Also, an annual detailed geobotanical survey of the "Otradnoye" territory is required for the distribution of *Heracleum* representatives with an accurate identification of species and hybrids of this genus. It is necessary to improve the methods of chemical treatment, using mixtures of herbicides of selective soil action (Jodaugiene, Marcinkeviciene & Sinkeviciene, 2018), but the scientific program and resources for these works are not available yet.

A special acknowledgement the staff of the General Geobotany laboratory of the BIN RAS for their help in the qualitative and quantitative identification of species and their percentage: Kabanova Y. (a laboratory assistant), Pukinskaya M. (a scientist).

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INFLUENCE OF ACER NEGUNDO INVASION ON THE SPECIES DIVERSITY OF PLANT COMMUNITIES IN THE FLOODPLAIN OF THE STEPNOI ZAI RIVER (TATARSTAN, RUSSIA)

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Introduction. Over the past decades, the question of the influence of adventive flora on local species and ecosystems has been increasingly raised. The danger from alien species is increasing every year, which is reflected in regulatory documents and laws. The Aichi Biodiversity Target 9 states: "By 2020, invasive alien species and pathways are identified and prioritized, priority species are controlled or eradicated, and measures are in place to manage pathways to prevent their introduction and establishment". The widespread uncontrolled dispersal of ash-leaved maple (*Acer negundo* L.) has become a significant problem. Actively occupying new habitats, it displaces local species from natural communities, prevents the renewal of forest-forming species, and can form continuous dead-cover thickets in humid areas. In this regard, it is extremely important to study the question of how fast is the displacement of natural species by *A. negundo* in natural communities.

Materials and methods. The research area is located in the southeastern part of the Republic of Tatarstan (Russia) and covers the water protection zone of the Stepnoi Zai River within the boundaries of the Karabash to Zainsk reservoirs.

We used 55 relevés made in August 2020 on the plots from 25 to 400 sq. m recording the species name, vegetation layer and cover abundance. The locations of the plots were chosen in such a way as to reveal the species diversity as fully as possible. We studied natural and different degrees of disturbance of plant communities, including pasture areas. Arable lands were not considered. All relevés were entered into the Vegetation Database of Tatarstan (Prokhorov, Rogova & Kozhevnikova, 2017), maintained at the Department of General Ecology of Kazan Federal University. Using the Species Diversity Analysis Module software, the following values were calculated for each plot: the number of species, the number of native species, the proportion of native species, the Whittaker species density coefficient, the Shannon-Weaver index, evenness (as the ratio of the observed diversity to the maximum possible), the Simpson index and the polydominance index (Magurran, 1988). Also, for each plot, the percentage of participation of *A. negundo* was calculated as the sum of the percentage of participation in each of the layers – the first tree layer, the second tree layer, undergrowth and herbaceous cover. The Pearson correlation coefficient was calculated in pairs for all values, the significance of the obtained correlation coefficients was determined, and multivariate analysis of variance was carried out. For the two values that have the highest correlation coefficient and that showed the greatest significance in the analysis of variance, the form of a linear model of biodiversity loss with an increase in the maple cover was determined. All statistical processing was carried out in the R Statistics software (https://www.R-project.org/).

Results. In the studied communities, the number of species ranges from 4 to 35. On average, there are 16.1 species per plot. The distribution of plots by classes of the number of species is close to normal (values for shapiro.test are W = 0.95949, p-value = 0.06127). The calculated species density coefficients for each plot vary from 0.67 to 7.60, with an average of 3.16. The calculated values of the Shannon index vary from 0.23 to 3.21, the average is 1.53. The evenness values vary from 0.14 to 0.96, while the average value is 0.56. Low evenness (less than 0.50) was noted at 24 plots. Average evenness values (from 0.50 to 0.75) are observed at 25 plots. High evenness values (over 0.75) are observed at 6 plots. The Simpson Index ranges from 0.04 to 0.91 (mean 0.42), and the polydominance index ranges from 1.10 to 25.00 (mean 3.97).

The highest correlation for *A. negundo* abundance is observed for the pair total abundance – the proportion of native species (-0.61), it is also more than 0.5 for the evenness (0.56) and rather high for all other dominance indicators. The best results were shown by a linear regression model of the dependence of the proportion of native species on the total maple abundance. The intercept is 95.92161, the coefficient for the "maple abundance" is -0.10140.

Conclusion. The study showed that the invasion of ash-leaved maple significantly reduces the biodiversity of natural communities, which is proved by rather high correlation coefficients between species diversity and total *A. negundo* abundance. These dependencies can be described by a linear function, however, this hypothesis needs to be tested on more extensive material.

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A REVIEW OF RESEARCH ON ALIEN PLANTS IN UZBEKISTAN

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Introduction. At present, the invasion of alien species into ecosystems where they did not occur naturally is a global problem of crucial and increasing importance. The Convention on Biological Diversity (CBD) and International Plant protection Convention (IPPC), as well as IUCN and FAO, have considered invasive alien species (IAS) as one of the main direct drivers of biodiversity loss worldwide (including species extinctions), also causing negative impact on ecosystem functions, human health and economy. Numerous databases with information about the distribution of invasive alien species are available today, as Global Invasive Species Database (GISD) of IUCN ISSG, the International Phytosanitary Portal of FAO, CAB International, Global Invasive Alien Species Information Partnership Gateway and Global Register of Introduced and Invasive Species (GRIIS), etc. These resources were created to be a support to countries in the development of their National Biodiversity Conservation Strategies and Action Plans, National Invasive Alien Species Strategies and Action Plans, targeted control and monitoring.

Flora of vascular plants of Uzbekistan is very rich with a large number of relict, endemic and endangered species. However, approximately 20 % of the area of Uzbekistan (first of all, the valleys of major rivers, oases and foothills) consists of the anthropogenic landscapes with secondary plant communities composed mainly of weeds, including adventive species. A total of 4,148 species is given in the six-volume edition of the "Flora of Uzbekistan" (1941–1962), including 3,663 native and 485 non-native species (alien species together with cultivated crops and ornamentals). Since the publication of this fundamental work, a lot of botanical findings have been made and many new plant species and even genera have been described. Currently, the national checklist counts more than 4,385 species (Li et al., 2020). The intensive extension of new alien species has been noted in different regions of the country as a result of increasing anthropogenic impact (Sennikov et al., 2018). At the same time, some native species of the flora of Uzbekistan (*Euphorbia esula* L., *Impatiens parviflora* DC., etc.) are invasive weeds in other countries (CABI, 2021).

Being a Party to the CBD and IPPC, and recognizing that invasive alien species represent one of the primary threats to biodiversity and food security, the Republic of Uzbekistan has developed national standards, legislative and institutional framework (including a List of Regulated Pests) for the prevention, control and monitoring of biological invasions.

Some studies have been conducted recently to identify taxonomical composition and geographical distribution of alien plant species in Uzbekistan, and the results have been summarized in the national checklist of 228 naturalized and invasive alien species composed within the framework of the Global Register of Introduced and Invasive Species (GRIIS) project (Sennikov et al., 2018). Since the publication of this checklist, a number of new adventive species was recorded as a result of researches devoted to the inventory of the flora of administrative regions of Uzbekistan and publication of a new national edition "Flora".

Materials and methods. Our field studies were carried out in 2018–2020 in different regions of Uzbekistan using traditional methods. Morphological observations of the newly recorded alien species were performed on living plants and dry specimens. The examined material was deposited in the National Herbarium of Uzbekistan (TASH). We also revised and georeferenced more than 1,000 herbarium specimens of invasive plants stored in TASH, and analysed published and online sources (CABI, 2021; Plantarium, 2007–2021, etc.). The coordinates of plant records were imported into ArcGIS 10.0 and transformed into a point map layer. A WGS84 Geographic coordinate system was used as a reference datum. Digitizing of the herbarium specimens was done by scanning with HerbScan TM 224 + Epson Expression 11000 XL. The photographs of adventive plants taken in their habitats, as well as the information on their localities, have been uploaded into Plantarium web-site (Plantarium, 2007–2021).

Results. The following alien species were newly recorded for the flora of Uzbekistan: *Anthriscus caucalis* M. Bieb. (Apiaceae), *Chenopodium ficifolium* Sm. (Amaranthaceae), *Cynosurus echinatus* L. (Poaceae), *Euphorbia prostrata* Aiton (Euphorbiaceae), *Galinsoga quadriradiata* Ruiz & Pav. (Asteraceae), *Pistia stratiotes* L. (Araceae), *Ranunculus sardous* Crantz (Ranunculaceae), *Rorippa palustris* (L.) Besser (Brassicaceae), *Tragopogon marginifolius* Pavlov (Asteraceae), *Xanthium albinum* (Widder) Scholz & Sukopp (Asteraceae). All these species have invaded the flora of Uzbekistan as a result of significant increase of international trade, tourism and transport networks in the last 20–30 years. Most of them were identified during compilation of the State Cadaster of the Flora of Tashkent region.

Our surveys showed that some of the above-mentioned adventive plants occur even in protected areas (*Cynosurus echinatus* and *Ranunculus sardous* – in Ugam-Chatkal National Park, *Euphorbia prostrata* – in Nuratau Nature Reserve). We also observed the expansion of some of these new alien species in anthropogenic habitats. For example, *Xanthium albinum* almost displaced common cocklebur (*Xanthium strumarium* L.), *Galinsoga quadriradiata* displaced *Galinsoga parviflora* Cav., and *Bidens frondosa* displaced *Bidens tripartita* L. in weed communities in Tashkent region. At present, these species grow mostly in disturbed habitats, but the magnitude of their negative impact on natural ecosystems and biodiversity could increase significantly in the future, and these species can become invasive pests.

Conclusion. The review of research on alien plants (including quarantine pests) and the above-mentioned facts of new invasions showed that the national checklist of adventive species in the flora of Uzbekistan is still incomplete and scientific data on their distribution, abundance and impact is insufficient. Thus, a special study focused on this crucial issue is strongly needed.

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ALIEN SPECIES OF PLANTS IN THE FLORA OF THE PRIPYAT POLESYE (BELARUS) AND THEIR INVASIVE POTENTIAL

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Introduction. Currently, one of the most important threats to biodiversity is biological pollution. It means the invasion of alien species of plants and animals into natural communities, which is a consequence of anthropogenic impact. That is why the issues of studying the ways of penetration and the peculiarities of the distribution of alien organisms, as well as their interaction with the representatives of local flora and fauna, are of high urgency (Vinogradova, Mayorov & Khorun, 2009). The problem of the wide distribution of invasive plants is especially relevant for the Belarusian Polesye, the territory of which has a high degree of anthropogenization of landscapes, as well as the transboundary nature of river basins. In this regard, the issues related to the study of the adventive fraction of the flora of the Belarusian Polesye and the assessment of its invasive potential are of high relevance.

Materials and methods. The assessment of the invasive potential of alien plant species of the Belarusian Polesye was carried out using the example of the flora of the Pripyat Polesye. This natural region is located in the central part of the Belarusian Polesye and to the greatest extent reflects the natural features of the entire Polesye region. When compiling a list of alien plant species, we used the results of our own floristic research carried out in the region in 2009–2020, available literary sources on the Polesye flora, as well as materials from herbarium collections (BRTU, GMU, LE, MSK, MSKH, MSKU, MW). The analysis of adventive species was carried out taking into account the introduction time (archaeophytes and neophytes) and method (xenophytes and ergasiophytes), as well as the degree of naturalization (ephemerophytes, colonophytes, epecophytes, agriophytes) (Thellung, 1918–1919) in the natural conditions of southern Belarus.

Results. The modern flora of the vascular plants of the Pripyat Polesye is represented in total by 2.162 species (842 genera, 172 families). These include all wild, and also cultivated in open ground plant species. The indigenous fraction is represented by 881 species from 370 genera and 117 families. 1.281 species (621 genera, 132 families) have alien origin, among them 641 species are noted only in culture. Consequently, 640 alien plant species grow spontaneously in the region and, together with the aborigines, form a spontaneous fraction of the flora.

Taking into account the time of introduction, the group of neophytes, represented by 432 species, prevails among adventive species. These plants (*Lunaria annua* L., *Lepidium densiflorum* Schrad.) have been introduced here since the XIV century (the beginning of the Age of Discovery). The group of archaeophytes (old immigrants) includes 208 species, which are represented mostly by weeds and ruderal plants (*Ballota nigra* L., *Urtica urens* L.).

According to the method of introduction, xenophytes (accidentally introduced plants) predominate among adventive species. The appearance of these 365 species (*Vicia cracca* L., *Viola arvensis* Murray) is not directly related to human activities. Ergaziophytes include 275 species, introduced purposefully for subsequent economic use. These representatives of flora (*Bellis perennis* L., *Nicandra physalodes* (L.) Gaertn.) were able to “escape from culture” and adapt to the natural conditions of the south of Belarus.

The most important characteristic of adventive species, which makes it possible to assess their invasive potential, is the degree of their naturalization. To clarify the extent of penetration of species into flora, it is important to take into account the degree of plant resistance (the ability to reproduce and overwinter), the breadth and frequency of distribution (depends on the regularity of the introduction of seed material and the rate of independent propagation), ecological and phytocenotic features (the ability to penetrate into natural or semi-natural phytocenoses).

The group of ephemerophytes (without signs of naturalization) is represented by 51 species. They include the species of synanthropic communities (*Abutilon theophrasti* Medik., *Fagopyrum tataricum* (L.) Gaertn.) and some cultivated plants (*Cucumis melo* L., *Datura tatula* L.), which grow in places of introduction for a short time. The group of colonophytes is represented by 173 species (*Phlox paniculata* L., *Narcissus poeticus* L.), which can remain in places of introduction for several years, but do not have the ability to spread further). Epecophytes include 316 adventive species (*Alyssum calycinum* L., *Phytolacca acinosa* Roxb.) widespread in various disturbed habitats (roadsides, outskirts of agricultural fields). All of these plants can spread beyond the areas of their primary introduction. Agriophytes, represented by 100 species, are characterized by the highest naturalization. Plants of this group (*Berberis vulgaris* L., *Carex brizoides* L., *Echium vulgare* L.) are able to grow and spread widely in natural phytocenoses.

In accordance with the above, alien plant species that have naturalized well in the conditions of the south of Belarus can be classified as invasive. Among epecophytes and agriophytes, invasive species are those that can spread widely and significantly change the features of the functioning of natural plant communities: *Acer negundo* L., *Acorus calamus* L., *Ambrosia artemisiifolia* L., *Amelanchier spicata* (Lam.) K. Koch, *Angelica archangelica* L., *Asclepias syriaca* L., *Aster* × *salignus* Willd., *Aster novi-belgii* L., *Bidens connata* Muhl. ex Willd., *Bidens frondosa* L., *Conyza canadensis* (L.) Cronquist, *Cyclachaena xanthiifolia* (Nutt.) Fresen., *Echinocystis lobata* (Michx.) Torr et A. Gray, *Elodea canadensis* Michx., *Elodea nuttallii* (Planch.) H. St. John, *Epilobium adenocaulon* Hausskn., *Erechtites hieracifolius* Raf., *Festuca trachyphylla* (Hack.) Krajina, *Galinsoga parviflora* Cav., *Galinsoga quadriradiata* Ruiz et Pav., *Helianthus tuberosus* L., *Heracleum sosnowskyi* Manden., *Hippophae rhamnoides* L., *Impatiens glandulifera* Royle, *Impatiens parviflora* DC., *Lupinus polyphyllus* Lindl., *Oenothera biennis* L., *Oenothera rubricaulis* Kleb., *Padus serotina* (Ehrh.) Borkh., *Parthenocissus quinquefolia* (L.) Planch., *Petasites hybridus* (L.) G. Gaertn., *Phalacroloma annuum* Dumort., *Phalacroloma septentrionale* (Fernald et Wiegand) Tzvelev, *Phragmites altissimus* (Benth.) Mobille, *Populus alba* L., *Quercus rubra* L., *Reynoutria japonica* Houtt., *Reynoutria sachalinensis* (F. Schmidt) Nakai, *Robinia pseudoacacia* L., *Rumex confertus* Willd., *Sambucus nigra* L., *Sambucus racemosa* L., *Sarothamnus scoparius* (L.) W.D.J. Koch, *Schedonorus arundinaceus* (Schreb.) Dumort., *Solidago canadensis* L., *Solidago gigantea* Aiton, *Sorbaria sorbifolia* (L.) A. Braun, × *Sorbaronia mitschurinii* (A.K. Skvortsov et Maitul.) Sennikov, *Xanthium albinum* H. Scholz, *Zizania latifolia* (Griseb.) Turcz. et Stapf. (Mialik, 2016). 50 species listed by origin are predominantly neophytes brought from the temperate latitudes of North America, Asia and adjacent regions of Europe. All these plants are distinguished by high vegetative mobility, as well as the capacity for abundant seed reproduction.

Conclusion. Taking into account the introduction time and method, and the degree of naturalization of the adventive representatives of the flora of the Pripyat Polesie, it can be concluded that out of 1.281 species, only 640 are part of the spontaneous flora. Only 416 species (32.5 %) make up a stable component of the adventive flora, that is, they were able to adapt to the natural conditions of the south of Belarus. Of these, only 50 plants can be classified as invasive in the conditions of the Pripyat Polesye.

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MODERN TRENDS OF INVASION OF INTRODUCED PLANTS IN THE REGIONS OF BELARUS

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In the modern period of climatic changes, naturalization and invasive dispersal of alien plant species is gaining momentum. The places of high concentration of such plants are not only the disturbed areas of urbanized territories, but also a wide range of natural-anthropogenic and natural landscapes. The growth in the number of horticultural farms, density of communications and mobility of the population lead to an increase in the immigration of introduced plants and appearance of plant invasions. Changes in natural and climatic conditions lead to expansion of these processes on a regional scale and contribute to the temporary introduction and consolidation of the first noted and naturalized species for a long time. Therefore, to determine the true invasive state of territories, it is important not only to take into account the status of wild introduced species and their abundance in specific areas, but also to establish conjugate links with environmental factors.

The analysis of the species diversity of wild introduced plants and the targeted cenotic assessment of the invasive pollution created by them, were carried out in 2016–2020 according to the generally accepted route method on the territory of six regions of Belarus. The objects of the study were areas of landscape of natural and anthropogenic origin with real or potential signs of invasive fragmentation of phytobiota. The ojects were considered clean in case of absence of invasion or establishment of an artificial origin of the sites of the alleged infestation. Taxonomic and invasive statuses of the noted species were according to keys and opinions of leading scientists about the signs and criteria of plant invasiveness.

The data on invasive contamination of 1,404 objects in the regions of Belarus were obtained. Sites of invasion were noted at 995 objects. A list of 72 species of potentially invasive (wild and aggressive) plants introduced in Belarus has been compiled. In the Vitebsk region, at 115 out of 234 studied objects 38 species were identified. At 136 of 256 objects of the Mogilev region, 42 species were identified. In the Grodno region, at 145 out of 170 objects, 47 species were identified. At 364 out of 446 objects of the Minsk region, 49 species were identified. 115 species were identified at 143 examined objects of the Gomel region. 27 species were identified at 119 out of 155 studied objects on the territory of the Brest region.

It was noted, that features of invasive pollution of administrative regions are associated not only with their cultural and everyday traditions, landscape features and economic development, but also with conditions of natural and climatic zones. Together, these factors lead to the similarity of regional floras. Therefore, a comparative analysis of the invasive state of the territory of Belarus was carried out for three conditionally identified administrative-climatic zones – Central, North-continental and South. The Central zone included 616 objects of the Grodno and Minsk regions, the North Continental – 490 objects of the Mogilev and Vitebsk regions, the South – 298 objects of the Brest and Gomel regions. Despite the different number of objects in each zone, they cover 35 % of the settlements located there as potential objects of invasion. It was found that the South zone is the least contaminated. On the territory of its two regions, 39 taxons or 54 % of the composition of the invasive flora of Belarus are recorded. Their occurrence at the objects studied reaches 78 %, but is confined mainly to settlements. Mixed-species invasion is typical for only 25 % of the objects. However, aggressive species of *Acer negundo* (30 % of objects) and *Robinia pseudoacacia* (20 %) are widespread here. Territories with *Physocarpus opulifolius* feralization were lobserved quite frequently (15 %), which makes this species inclined to active invasion. The species of *Solidago* and *Heracleum* are noted at 10 % of objects.

The invasive situation in the Central zone is tenser. It numbers 53 species or 75 % of the invasive flora of Belarus. Their occurrence is over 83 %. The share of sites of mixed-species invasion is higher than in the southern part (41 %), since the high level of forest cover of the region leads to compression of spaces for invasion and consolidation of numerous species. *Acer negundo* maple was observed at 30 % of objects, self-seeding of *Robinia pseudoacacia* – 16 %, and the *Physocarpus opulifolius* – 10 %. The species of *Solidago* was observed at 44 % of objects, and *Heracleum* at 10 %.

The occurrence of invasive species at the objects of the Northern Continental zone is lower, than in other regions of Belarus and is equal to 58 %. There are 50 invasive species or 70 % of the invasive flora of Belarus. However, the share of sites of mixed species invasion is the highest and amounts to 43 %. They are concentrated on various elements of relief near construction sites, abandoned estates, and parks more densely than on objects of active urbanization. *Acer negundo* maple was observed at 26 % of the examined objects, *Robinia pseudoacacia* and *Physocarpus opulifolius* only at 10 % and 5 % of the examined objects respectively. The reason of their reduced invasion can be freezing of seedlings in the mainly wet and heavy soils. The species of *Solidago* and *Heracleum* are observed at 37 % of the objects.

Thus, the nature of modern differences in the distribution of potentially invasive species of introduced plants on the territory of Belarus in the context of six administrative regions and three administrative-climatic zones has been established. Their composition was determined in the amount of 72 species. It was found, that 54 species, which were found in more than two regions of the country, are characterized by pronounced invasive trend. The greatest diversity of species of introduced flora was found on the territory of Minsk and Grodno regions. More than 50 % of contaminated objects in Belarus have single-species foci of invasion. Areas of mixed invasion are less common, and their share is reducing from 43 % in the north-east to 41 % in the central-west and 25 % in the south part of Belarus.

SOME IMPORTANT PARAMETERS OF *SOLIDAGO CANADENSIS* L. IN MODEL POPULATIONS IN UKRAINIAN POLESIE

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Introduction. As plant species live in populations, which are characterised by such indices as quantity, population density, individual seed productivity, stock of seeds in soil, study of these important parameters is necessary for prognoses of further distribution of invasive alien plant species. All these parameters are important to control wide spread of *Solidago canadensis* in Ukraine, as it was attributed to invasive transformer-species of plants (Protopopova et al., 2015).

Materials and methods. *S. canadensis* population parameters were studied in 2019 on 3 experimental plots (0.5 ha each), which represented 3 different population models in the Zhytomyr region, Ukrainian Polesie. Experimental plots were situated as follows: S-1 was located in the vicinity of vill. Strizhavka of the Korostyshiv distr., on 15-years fallow on relatively poor soddy-podzolic sandy loam soils, completely overgrown with *S. canadensis*; Z-2 was located in the vicinity of vill. Zarichany of the Zhytomyr distr., on 10-years fallow on relatively rich light-gray forest soils with dense thickets of *S. canadensis*; D-3 was located in the vicinity of vill. Narodichi of the Narodichi distr., in the nature reserve "Drevlyansky", on swampy floodplain on the left bank of the river Uzh, occupied in the past by waterlogged meadows and eutrophic bogs; later a significant part of these biotops were completely overgrown with *S. canadensis*.

Each experimental plot (population model) of *S. canadensis* was devided into 3 registration areas, 25 m^2 each. The values calculated in the areas were total quantity of individuals of this species, quantity of shoots per individual, and separately, quantity of generative shoots. Seed productivity of *S. canadensis* in each population model was defined by the calculation of the following average values: quantity of seeds in 10 anthodiums, collected one by one from 10 plants (1); quantity of anthodiums on 1 generative shoot, collected one by one from 10 plants (2); quantity of generative shoots per 1 individual (calculated for all individuals on each registration area of 25 m^2) (3); population density – quantity of individuals per 1 m^2 (4). Seed productivity of an individual of *S. canadensis* was calculated by multiplication of average values: 1 x 2 x 3; and total stock of seeds on an experimental plot was calculated as 1 x 2 x 3 x 4. The calculation of seeds quantity was conducted with binocular microscope MBS-9. Average values were calculated according to (Lakin, 1973), essentiality of difference of average values of all parameter among populations was determined by ANOVA.

Results. It was found that the highest value of average shoots quantity per individual was observed in the population D-3 (29 ± 0.7). The values of the populations S-1 and Z-2 were significantly less, 19 ± 0.6 and 19 ± 0.7, respectively. The difference in mean values of this index between populations S-1 and Z-2 was inessential on 95 % confidence level, but population D-3 was significantly different from C-1 and Z-2 ($p<0.000$).

The highest value of average generative shoots quantity per individual was also observed in the population D-3 and made up 18±0.3; this index in the populations S-1 and Z-2 were equal to 15 ± 2.0 and 10 ± 0.6, respectively. These average values essentially differ ($p<0.000$).

In population S-1 average quantity of anthodiums per generative shoot was equal to 3,238 ± 185.6 (V = 31.39 %); in Z-2, 2,318 ± 57.5 (V = 13.58 %) and in D-3, 9,824 ± 11.2 (V=11.19 %). All average values mentioned above essentially differ ($p<0.000$).

It was found, that the highest value of average quantity of seeds per one anthodium was maximum in population S-1 and was equal to 22 ± 0.3, while the same minimum value of

20 ± 0.2 was peculiar for populations Z-2 and D-3. It was found, that the studied index in population
S-1 essentially differed from populations Z-2 and D-3 ($p<0.01$).

Field investigations showed that quantity of individuals of *S. canadensis* on 25 m^2 was rather different in studied populations –139 ± 13.0 for Z-2, 120 ± 4.9 for S-1 and 104 ± 5.0 for D-3. Thus, population density of *S. canadensis* calculated for the population Z-2 was 6 ± 0.4 $plant \cdot m^{-2}$; S-1, 5 ± 0.2 $plant \cdot m^{-2}$ and D-3, 4 ± 0.2 $plant \cdot m^{-2}$.

The calculations showed, that in the population S-1 average number of seeds per one individual was 1,092.2 thousand pieces, in Z-2, 470.5 thousand pieces, and in the population D-3, 3,536.6 thousand pieces. Taking into account the average density of *S. canadensis* individuals in the studied populations, potential stock of seeds was in population S-1, 5.24 million $seeds \cdot m^{-2}$; Z-2, 1.87 million $seeds \cdot m^{-2}$ and D-3 – 15.7 million $seeds \cdot m^{-2}$.

Conclusion. Huge seed productivity of *S. canadensis* and its significant allelopathic activity (Yuan et al., 2013) promote manifestation of this species as a transformer, which is able to capture quickly new territories and biotops in Ukrainian Polesie.

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DISTRIBUTION PROPERTIES OF THE SPECIES OF *IRIS* L. GENUS (*IRIS* L., IRIDACEAE JUSS.) IN UZBEKISTAN

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Introduction. The genus *Iris* (Iridaceae Juss) includes 280 species common in temperate regions of the northern hemisphere. The representatives of this category are geophytic plants that can be found in different ecological conditions, in swamps, deserts, steppes, hills and mountainous areas (Wilson at al., 2016).

This species, like many other plants, is of economic importance due to its medicinal properties and the beauty of its flowers. The geophyte organs of the genus are systematized based on morphological features such as hairs on the outer petals. Currently, the *Iris* series is divided into 6 subcategories, 12 sections (Ikinci at al., 2011).

Central Asia is the center of a number of species of the Iris family. Currently, 47 species of this genus are found in the flora of Uzbekistan.

36 of the species found in the Western Tianshan and the Pamir-Alay mountain ranges in Uzbekistan are endemic (Khassanov at al., 2012).

As a result of scientific research, *I. austrotschatkalica* was found in the Chatkal ridge of the Fergana Valley, *I. khassanovi* in the Gissar ridge (Tadjibayev at al., 2014), *I. rudolphii* and *I. victoris* (Khassanov at al., 2013) in the Kelif-Sherabad ridge. Therefore, this study covers the distribution of Iris species on the territory of Uzbekistan, on the basis of 1,608 herbarium specimens stored in the National Herbarium of Uzbekistan (TASH) and the materials collected during field research.

Materials and methods. The distribution of the species in the botanical and geographical regions of Uzbekistan is studied based on the system of Sh. Tojibaev et al. (Tojibaev at al., 2016). The information was aggregated according to the data stored in the TASH fund, given in the herbarium labels. The accepted scientific names of the taxa are listed in accordance with POWO (http://www.plantsoftheworldonline.org). The International Plants Names Index, the Catalog of Life and other international electronic resources were also used. The main purpose of the research is to shed light on the distribution of the subgenus *Iris*, *Limniris* and *Scorpiris* in the botanical and geographical regions of Uzbekistan.

Results. In the flora of Uzbekistan, the representatives of the subfamily *Iris* comprise 11 %, *Hermodactyloides* – 4 %, *Limniris* – 11 %, *Scorpiris* – 71 %. The distribution of species within the botanical and geographical regions of Uzbekistan depends on a number of abiotic factors, such as climate, relief, soil composition, length of the day.

The representatives of *Limniris* and *Iris* subgenus *I. loczyi* Kanitz are found in mountainous areas at altitudes of 1,000 to 3,000 m above the sea level in the Western Tien-Shan, Fergana-Alay, West-Gissar and Gissar-Darvaz districts.

I. songarica Schrenk species is found in the Western Tien Shan, Kuhiston, Western Gissar, Nurata, Bukhara, the Kyzylkum, the Southern Aral Sea and the Ustyurt regions at altitudes from 100 to 1,500 m above sea level, in the desert, hills and lower mountains. *I. longiscapa* Ledeb is distributed in Western Gissar, Nurata, Bukhara, the Kyzylkum, the South Aral Sea and the Middle Syrdarya regions at the height of 60 to 300 m below sea level compared to other species. *I. falcifolia* Bunge species is distributed in the Western Gissar, Bukhara and the Kyzylkum regions and can be seen in the range of 300–700 m above sea level. *I. alberti* Regel species is distributed in the foothills of the Western Tien Shan and Fergana regions at the altitude of 700–800 m, *I. korolkowii* Regel species can be found only at the altitude of 1,500 m in the botanical geographical areas of the Western Tien Shan region of Uzbekistan. *I. stolonifera* Maxim species is found at the altitudes of 900–2,500 m in the botanical geographical regions of

Kuhiston, Western Gissar, Gissar-Darvaz, the Pyanj region. *I. ruthenica* Kre Gawl. species is distributed in the northern part of the Mirzachul district, at the exit of the Syrdarya river from the territory of Uzbekistan, at the altitude of about 250 m. *I. sogdiana* Bunge occurs at the altitudes of 500–2,500 m in Bunge Chimgan, Qurama (Ahangaran), South Chatkal, Chorkesar, Urgut, Kashkadarya, Sangardak-Tupalang, Boysun regions. The representatives of *I. oxypetala* Bunge species are found in the Eastern Alay, Eastern Fergana and Kayrakkum-Yazyavon regions, in the foothills at the altitude of 800–1,500 m.

The geophyte organs of the subspecies *Scorpiris* differ from those of the remaining subspecies by the presence of bulbs and other morphological features. The species of the genus are mainly distributed in the foothills and high mountain regions. *I. austrotschatkalica* Tojibaev, F. Karimov & Turgunov species are found on the slopes of the Southern Chatkal region at the altitude of 1,200–1,300 m. The spicies *I. fedtschenkoi* F.O. Khass. & N. Rakhimova, *I. pseudocapnoides* Rukšāns, *I. orchioides* Carriere, *I. winkleri* Regel, *I. kolpakowskiana* Regel, *I. capnoides* (Vved.) T. Hall & Seisums are observed in Ugam-Pskom, Tashkent pre-districts. The spicies *I. tubergeniana* Foster, *I. wilmottiana* Foster are observed in Chimgan, Qurama, Ahangaran, North Turkestan and Tashkent prefectures. *I. hippolyti* is found in the Kokchatog mountains in the Kyzylkum region of western Uzbekistan. *I. rudolphii* F. O. Khass., Esankulov occur in Boysun Sangardak-Tupalang, Kuhitang, Bobotog region. & N. Rakhimova, *I. vvedenskiy* Nevski ex Popov, *I. petri* F. O. Khass., & N. Rakhimova, *I. victoris* F. O. Khass., Esankulov. & N. Rakhimova, *I. bucharica* Foster, *I. khassanovi* Tojibaev Komil & Turginov Orzimat, *I. narbuti* O. Fedtsch, *I. vicaria* (Vved.) T. Hall & Seisums, *I. nicolai* Vved. species *I. maracandica* Vved, *I. warleyensis* Foster, *I. tadshikorum* Vved. species are distributed in North Turkestan, Urgut, Nurata regions.

Conclusion. Based on the above, it can be seen that the main distribution centers of the subspecies Iris, Scorpiris and Limniris of the genus actually belong to the Western Tien Shan and the Pamir Alay mountain ranges. Also *I. songarica* Schrenk, *I. narbuti* O. Fedtsch. and *I. longiscapa* Ledeb species differ from the remaining species in their prevalence compared to other species and in the breadth of their distribution area. The area of distribution of the species *I. winkleri* Regel, *I. magnifica* (Vved.) F.O. Khass. & Rakhimova, *I. orchioides* Carrière, *I. hippolyti* (Vved.) Kamelin, *I. svetlanae* (Vved.) F.O. Khass., *I. victoris* F.O. Khass. et al. is very narrow.

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VASCULAR PLANTS – TRANSFORMERS OF THE OMSK OBLAST

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Introduction. According to preliminary data, there are at least 90 invasive and potentially invasive species of vascular plants in the flora of the Omsk oblast (Plikina & Efremov, 2017). Among actively settling and naturalizing in disturbed, semi-natural and natural habitats there are *Amaranthus retroflexus* L., *Amelanchier spicata* (Lam.) K. Koch, *Axyris amaranthoides* L., *Erigeron canadensis* L., *Echinochloa crus-galli* (L.) P. Beauv., *Echinocystis lobata* (Michx.) Torr. & A. Gray, *Epilobium adenocaulon* Hausskn., *Malus baccata* (L.) Borkh., *Medicago sativa* L., *Melilotus officinalis* (L.) Pall., *Plantago lanceolate* L., *Setaria viridis* (L.) P. Beauv., *Tripleurospermum inodorum* (L.) Sch.Bip. The most environmentally and economically damaging transformers are *Acer negundo* L., *Elodea canadensis* Michx. and *Hordeum jubatum* L. The purpose of this publication is the assessment of the nature and current status of these species in the region.

Materials and methods. The assessment of the distribution characteristics of transformer species is based on the results of analysis of literary sources of the XIX–XXI centuries (*q.v.* Plikina & Efremov, 2017) and regional herbarium collections. Distribution patterns and environmental features were specified by authors' field studies in various biotopes between 2000 and 2020. To characterize the invasive component of flora, we adopted a scale, based on the assessment of the level of aggressiveness of invasive species and the features of their distribution (Notov, Vinogradova & Mayrov, 2010).

Results. *Acer negundo* was unknown in the region before the XX century (Ebel et al., 2016). The distribution of this species in the Omsk oblast is associated with the creation of a system of state forest protection belts in the 1960–1970s. Currently, *A. negundo* is widely found in the south of Western Siberia, growing in forest belts, parks, garden plots, garbage dumps, widely distributed along ravines and river valleys, in the undergrowth of birch outliers (Ebel et al., 2016). In the Omsk oblast, the species is found everywhere in disturbed and natural biotopes (as part of the undergrowth of birch outliers, along river valleys and ravines). The species is more common and abundant for the forest-steppe zone, in the forest zone it grows mainly in disturbed habitation.

The exact time of appearance of *Elodea canadensis* is unknown, probably it was repeatedly imported. In July 1962 scientists of Omsk Agricultural Institute intoduced *E. canadensis* into the ponds of the Institute educational farm (Omsk) and Lake Goreloye (Tyakalinsk district) in order to increase the fodder base of water bodies for duck breeding. Despite systematic studies of hydromacrophytes in the region from the late 1990s up to 2006, the species had not been found (Ebel et al., 2016). Currently, *E. canadensis* may be occasionally found in the forest-steppe zone (especially in the south subarea) and in the steppe zone, less frequently in the forest zone. It is mainly found in the valley of the Irtysh River, less frequently found in the valley of the Om River. It occurs both in monodominant communities and in phytocenoses with the dominance of *Ceratophyllum demersum* L., *Stratiotes aloides* L., *Phragmites australis* (Cav.) Trin. ex Steud. In case of widespread distribution, it can have a general negative impact on aquatic ecosystems, as it displaces aboriginal species, changes lighting conditions and chemical composition of water, contributes to the development of overseas phenomena, impedes navigation.

Hordeum jubatum was discovered in the Omsk oblast in the early 1930s (Borisovsky district, village Borisovka, 90 km west of the city of Omsk, marshy lake shore, 3–20.VII.1933,

M. Elizarieva, TK) (Ebel et al., 2016). At the end of the XX century in Omsk oblast it was considered an ordinary species of weeds (Bekisheva, 1999). Currently, the invasion is threatening the southern part of the region (central and southern forest-steppe, steppe). The species has less partial activity in the forest zone. *Hordeum jubatum*, being an edificator, it forms monodominant communities occupying vast areas in wastelands, diggings, near buildings, along roads and railways, alkaline meadows (Sviridenko, 1999). In semi-natural and natural habitats it may be found together with *Poa pratensis* L., *P. annua* L., *Juncus gerardii* Loisel., *Festuca pseudovina* Hack. ex Wiesb. In the first few years of *H. jubatum* the projective cover is 10–20 %, in 2–3 years it can reach 50–80 %. Resistance to mechanical effects and salinization, tolerance to habitat conditions, spreading along roads, high seed productivity largely determine the effectiveness of invasion. The most active settlement of *H. jubatum* in the region began in 1990–2000. Currently there is an expansion of the northern distribution border.

It is worthwhile to mention a group of species that have not currently overcome the reproductive barrier in the region, but are able to be grow in places of importation, sometimes for decades, often bloom and bear fruit profusely. This group includes such cultivated woody plants as *Acer tataricum* L., *A. ginnala* Maxim., *Cerasus tomentosa* (Thunb.) Wall., *Elaeagnus commutata* Bernh. ex Rydb., *Pyrus ussuriensis* Maxim., *Ulmus laevis* Pall.

Conclusion. All transformer species in the Omsk oblast come from North America, and currently, their distribution to the north continues. It is necessary to organize a regional system of monitoring to track the dissemination and control the biological invasion.

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PREDICTIVE MODELING OF *HERACLEUM SOSNOWSKYI* MANDEN. DISTRIBUTION IN THE VOLGA-KAMA REGION IN A CHANGING CLIMATE

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Introduction. Currently, the secondary range of caucasian *Heracleum sosnowskyi* covers the forest zone of European Russia, Ukraine, Belarus, the Baltic States, Finland, Denmark, Germany, Poland, the Czech Republic, Slovakia, Hungary and Romania. The species continues to expand its range in the east and southwest directions. Since 2005, the species has been actively settling in Altai, since 2007 in Tomsk, and since 2010 in Novosibirsk regions. In 2016 it was recorded in Serbia, in 2017 in Bulgaria.

To control Sosnovsky's hogweed, an urgent problem is to identify the places of its growth and predict its distribution in the future. Due to global climate change, the areas of many organisms will change their outlines; therefore, the long-term dynamics of the distribution of *H. sosnowskyi* is also of interest. The aim of the research is to identify the distribution of the *H. sosnowskyi* in the Volga-Kama region and to predict its dispersal taking into account climate change.

A number of studies have shown that the northern boundary of the distribution of this species is determined by the isotherm of the sum of active temperatures (SAT) equal to 800 to 1,000°C (Chadin et al., 2017). The southern boundary of the secondary range corresponds to the isoline of the hydrothermal coefficient equal to 1.25 (Afonin et al., 2017).

The development of spatial models for the purpose of predicting the distribution of this invasive species and identifying its dependence on climate was undertaken by a number of researchers for the Ukrainian Carpathians, the Komi Republic and southern European Russia.

The study area covers the Volga-Kama region – a territory located in the east of the Russian Plain approximately between the meridians of Nizhny Novgorod and Ufa and the parallels of Kirov and Orenburg. The southern border of the secondary range of Sosnovsky hogweed runs along the territory of the region.

Materials and methods. The materials for this work were our own observations, data from the “Flora of Russia” project on the iNaturalist platform (Seregin et al., 2020) and records from the “Flora” database (Prokhorov, Rogova & Kozhevnikova, 2017) – a total of 4,114 identified locations.

The Maxent method was used to model potential habitats (Phillips, Anderson & Schapire, 2006).

WorldClim climatic variables, SoilGrids soil data and TerraNorte landcover were used as a model predictors. For predictive models, averaged data from 9 different climatic models was used (BCC-CSM1-1, CCSM4, GISS-E2-R, HadGEM2-AO, HadGEM2-ES, MIROC5, MIROC-ESM, MIROC-ESM-CHEM, NorESM1-M) for two climate change scenarios (RCP2.6 and RCP8.5) and two time periods (2050 and 2070).

After carrying out the correlation analysis, 17 predictors were selected for creating a model. To reduce the sampling bias, the observations were spatially filtered, as a result of which the number of observations was reduced by almost 10 times to 420.

Results. Most of the observations of *H. sosnowskyi* in the Volga-Kama region are recorded in the forest zone (taiga and mixed forests); in the forest-steppe zone hogweed is found scattered, reaching in its distribution the northern border of the steppes.

Pre-simulation with MaxEnt showed good results (AUCtest = 0.824). The landcover (38 %), maximum July temperature (18 %) and altitude (12 %) have the largest contribution to the model. Together, these three factors explain more than two thirds (68 %) in the distribution of hogweed. When analyzing the response curves of the model, it turned out that Sosnovsky's hogweed prefers urbanized areas, meadows and swamps, maximum July temperatures in the range of +20 ... + 21 °C, and altitudes of about 100 m above sea level.

As a result of the final data processing, a spatial model of the potential habitats of the *H. sosnowskyi* was built. In the northern part of the Volga-Kama region, a high probability of occurrence is associated with both river valleys and watersheds, while in the central and southern parts, the hogweed selects habitats with increased moisture exclusively along river valleys.

Conclusion. The area of the potential range of *H. sosnowskyi* in the Volga-Kama region is currently estimated at 141,000 sq. km, which is 23.3 % of the entire territory. According to the climate change scenario RCP 2.6, by 2050 its area will be 31,000 sq. km (5.2 %), and by 2070 it will reach 50,000 sq. km (8.3 %). If the RCP 8.5 maximum warming scenario is realized by 2050, the potential range of hogweed will occupy 27,000 sq. km (4.4 %), and by 2070 there will be no suitable habitats for this species.

Thus, according to our model, as a result of climate change, the area of habitats suitable for Sosnovsky hogweed in the Volga-Kama region will significantly decrease (almost five times by 2050). In the event of the development of the most unfavorable scenario of climatic changes (RCP 8.5), Sosnovsky's hogweed will completely extinct in the region.

This work was carried out with the financial support of the RFBR and the Government of the Republic of Tatarstan, project № 18-44-160021.

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INATURALIST VS. PL@NTNET: ACCELERATING DATA COLLECTING ON ALIEN PLANTS OF RUSSIA IN REAL-TIME MODE

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Modern technologies make it possible to collect information on the distribution of living organisms with unprecedented speed and efficiency. Thus, 60 % of records in Global Biodiversity Information Facility (https://www.gbif.org/) on dated records of living organisms were made in the last ten years (2011–2021) during field research. In most cases, researchers are now collecting data in electronic form directly in the field using various gadgets. This information is rapidly entering the global data circulation, using GBIF platform as a rule.

A special role in the collection of big data on biodiversity is assigned to non-professional researchers who generate electronic datasets on records of various plants, animals and fungi using simple public platforms like ebird, iNaturalist, Pl@ntNet, Naturgucker and many others. Over the past two years, both iNaturalist website and app have gained unprecedented popularity in Russia, largely due to the emergence of our project “Flora of Russia” in early 2019 (https://www.inaturalist.org/projects/flora-of-russia). Currently, it has over 910,000 observations based on photos from 11,000 users.

Large datasets from non-professional researchers are of particular value when compared with other available e-data on plants of Russia, i.e. published sources and herbarium collections. At the moment, data from iNaturalist and Pl@ntNet form the main source of information (as of January 27, 2021) on alien species which rapidly expanding their ranges.

Number of GBIF-mediated records for ten most widely distributed invasive species of Russia for all years are given below.

1) *Heracleum sosnowskyi* – GBIF: 14267; iNaturalist: 3027; Pl@ntNet: n/a; both: 21.2 %.
2) *Acer negundo* – GBIF: 6989; iNaturalist: 5032; Pl@ntNet: 1200; both: 89.2 %.
3) *Erigeron canadensis* – GBIF: 3732; iNaturalist: 2445; Pl@ntNet: n/a; both: 65.5 %.
4) *Impatiens glandulifera* – GBIF: 3694; iNaturalist: 1785; Pl@ntNet: 1654; both: 93.1 %.
5) *Matricaria discoidea* – GBIF: 3328; iNaturalist: 1594; Pl@ntNet: 184; both: 53.4 %.
6) *Impatiens parviflora* – GBIF: 3053; iNaturalist: 1944; Pl@ntNet: 719; both: 87.2 %.
7) *Lupinus polyphyllus* – GBIF: 2896; iNaturalist: 1882; Pl@ntNet: 475; both: 81.4 %.
8) *Bidens frondosa* – GBIF: 1868; iNaturalist: 1289; Pl@ntNet: 2; both: 69.1 %.
9) *Erigeron annuus* – GBIF: 1828; iNaturalist: 1454; Pl@ntNet: 9; both: 80.0 %.
10) *Solidago canadensis* – GBIF: 1699; iNaturalist: 1399; Pl@ntNet: 26; both: 83.9 %.

The same figures restricted to the data collected in 2019–2021 are as follows.

1) *Heracleum sosnowskyi* – GBIF: 2748; iNaturalist: 2744; Pl@ntNet: n/a; both: 99.9 %.
2) *Acer negundo* – GBIF: 5697; iNaturalist: 4572; Pl@ntNet: 1080; both: 99. 2 %.
3) *Erigeron canadensis* – GBIF: 2331; iNaturalist: 2302; Pl@ntNet: n/a; both: 98.8 %.
4) *Impatiens glandulifera* – GBIF: 3165; iNaturalist: 1551; Pl@ntNet: 1562; both: 98.4 %.
5) *Matricaria discoidea* – GBIF: 1724; iNaturalist: 1522; Pl@ntNet: 179; both: 98.7 %.
6) *Impatiens parviflora* – GBIF: 2557; iNaturalist: 1811; Pl@ntNet: 682; both: 97.5 %.
7) *Lupinus polyphyllus* – GBIF: 2082; iNaturalist: 1616; Pl@ntNet: 426; both: 98.1 %.
8) *Bidens frondosa* – GBIF: 1186; iNaturalist: 1164; Pl@ntNet: 2; both: 98.3 %.
9) *Erigeron annuus* – GBIF: 1409; iNaturalist: 1372; Pl@ntNet: 9; both: 98.0 %.
10) *Solidago canadensis* – GBIF: 1318; iNaturalist: 1284; Pl@ntNet: 26; both: 99.4 %.

The proportion of these two crowdsourcing platforms for the ten most common invasive species of the Russian flora ranges from 21 to 89 %. At the same time, the latest data on localities of these species (collected in 2019–2021) are by 97.5–99.9 % supported by records from iNaturalist and Pl@ntNet.

Pl@ntNet is the main competitor to iNaturalist among automatic plant recognition mobile apps and as a GBIF publisher of citizen science data on plants. Below we discuss the main differences between the two platforms.

1) In Pl@ntNet (France), you can upload photos of vascular plants only, whereas iNaturalist (USA) enables to upload all living organisms. Four photos per single observation is the limit of Pl@ntNet, and iNaturalist has twenty photo limit.

2) In Pl@ntNet, one can create projects, but only by contacting the head office. In iNaturalist, creation and administration of projects is available to any user through a web interface. The strength of iNaturalist is its huge community of experts who are checking identifications.

3) Pl@ntNet does not have a common entry point to a single base, i.e. the "Explore" button is available on project pages only. iNaturalist has a common access point for all observations (https://www.inaturalist.org/observations).

4) In Pl@ntNet, any data on geography is hidden on the observation page, but available through GBIF, if the observation is there. To what extent this location is coarse remains unclear. In iNaturalist, all geo data are available, except when they are hidden on purpose by the user in the settings (or coarsened by iNaturalist for vulnerable species).

5) In general, observation on Pl@ntNet contains very little information: photo, taxon name, function of anonymous identification, rough assessment of data quality (for/against), author, and date. Also, there is a tab with a discussion of the records. The functionality and details of the observations available on iNaturalist are much wider.

6) The web version of Pl@ntNet is available in three languages, with no plant names in Russian. iNaturalist has a web interface available in dozens of languages and has very detailed databases of national names. In the apps, the choice of languages for both platforms is approximately equal.

7) To identify something on Pl@ntNet, one needs to select a species and slide through the photos. The correct name can be inserted on observation page only. There are no geographic filters in searching the records. iNaturalist has a special interface for identification with a detailed filter system.

8) Cultivated and wild plants in Pl@ntNet are mixed, and it is impossible to separate one from the other. On the contrary, a clear distinction between cultural and natural species is one of the fundamental requirements of iNaturalist.

9) Pl@ntNet data transferred to GBIF as two datasets: https://doi.org/10.15468/gtebaa (794K observations with photos) and https://doi.org/10.15468/mma2ec (9.6M automatically identified snapshots without photos). iNaturalist has a single dataset in GBIF available at https://doi.org/10.15468/ab3s5x (23.4M records with photos, incl. 8.7M records of vascular plants).

10) In Pl@ntNet, the probability of automatic suggestions (as a percentage) is available for the user. If it's high, no other options are offered. On iNaturalist, for instance, the following disclaimer is available: "This is most likely the genus *Adoxa*" with *Adoxa moschatellina* as the first option, and in addition seven other unnecessary species. This point is definitely better worked out on Pl@ntNet. However, the suggestion of a genus, family or tribe on iNaturalist is a very strong feature useful for identification of species unknown to AI. Full taxonomic names on Pl@ntNet contain taxonomic authors, whereas iNaturalist does not provide this data.

Additionally, Pl@ntNet has no project with journals and discussions, logs (dashboards), forum, user's statistics, csv uploads, shapefile uploads, calendar, profile, notification and dashboard, opportunity for bulk uploads, bioblitzes. All this is on iNaturalist.

Citizen science platforms like iNaturalist, Pl@ntNet and others as well as GBIF with freely available data rapidly change the way we study plants, their geography, phenology and ecology. For many alien species – a case in point is Russia – they are merely the only source of reliable modern data.

THE COMPOSITION OF INVASIVE PLANTS IN URBANIZED TERRITORIES ON THE EXAMPLE OF THE RECREATIONAL ZONE OF BREST

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Introduction. As part of the adventive component of flora, invasive plants are the most aggressive alien species that displace local, native plants. A factor contributing to the activation of invasions may also be modern climate changes, such as warming, which promotes naturalization and viable reproduction of more heat-loving drought-resistant alien species. In recent decades, the boundaries of agroclimatic zones have changed on the territory of Belarus, including the formation of a new, warmer zone in the south of Polesie.

236 species of adventitious plants with negative impact on the diversity of the native flora fraction and the structure of phytocenoses were found in the natural ecotopes of Brest Polesie, including forest communities. Studies outside the urbanized areas of Brest Polesie showed the presence of 17 invasive species that pose a certain threat to the native biodiversity of the region (Savchuk, 2012). The purpose of this study was to identify the types of urbanized territory and classify a group of particularly dangerous invasive plants in Belarus on the example of the Park of Soldiers-Internationalists in Brest.

Materials and methods. However, the most invasive are industrial habitats, arable soils, parks and gardens. In this regard, urbanized areas, where cultural or semi-natural plant communities are concentrated, are of particular interest in regard of search for invasive species. On the territory of Brest, in Vostok microdistrict, there is a territory called the Park of Soldiers-Internationalists. This is a natural and cultural-educational complex, in which the park area smoothly turnes into forests and meadow phytocenoses. The park territory is surrounded by birch and pine communities of artificial origin, former agricultural land, as well as communities that were formed during the reclamation of disturbed lands, sand pits near the bed of the Mukhavets River, country roads. To classify a species as invasive for the Republic of Belarus, we were guided by the data of Belarusian researchers (Dubovik et al., 2017; Dubovik et al., 2020).

Results. According to the results of the study, the list of aggressive invasive plants of land-air habitats of the recreational zone of the Park of Soldiers-Internationalists in Brest includes 22 species.

The tree-shrub forms are represented by nine species: *Acer negundo* L., *Robinia pseudoacacia* L., *Quercus rubra* L., *Populus alba* L., *Sambucus nigra* L., *Parthenocissus quinquefolia* (L.) Plach., *Cornus alba* (L.) Opiz, *Sarothamnus scoparius* (L.) Koch., *Hippophae rhamnoides* L. 13 species of invasive plant were represented by annuals or perennial grasses. The species *Oenothera biennis* L., *Phalacroloma appiim* (L.) Dumort., *Conyza canadensis* (L.) Cronq., *Solidago canadensis* L., *Rumex confertus* Willd. are already familiar to Brest region. *Echinocystis lobata* (Michl. ex Willd.) Britt. and *Impatiens glandulifera* Royle are common for depressions with more moist fertile soil, overgrown with alder, ruderal habitats, in riverine shrub phytocenoses. Under the canopy of pine forests *Impatiens parviflora* DC formed numerous monodominant communities. Sand along country roads, abandoned sand dumps near the Mukhavets riverbed and other disturbed habitats are inhabited by *Helianthus tuberosus* L. and *Xanthium albinum* (Widder.) H. Scholz. *Galinsoga parviflora* Cav. is also recorded everywhere in disturbed habitats and agrocenoses.

Thus, representatives of 13 families were identified in the study area. In the context of families, the largest number of invasive species is distinctive for Asteraceae family (6 species). Fabaceae and Balsaminaceae families are represented by three and two species, respectively. One species was identified from each of the families Aceraceae, Fagaceae, Caprifoliaceae, Vitaceae, Cornaceae, Salicaceae, Elaeagnaceae, Onagraceae, Polygonaceae, Cucurbitaceae.

According to the degree of naturalization, most of the identified species can be classified as agriophytes, since they have successfully introduced themselves into natural communities. The group of apecophytes found only in anthropogenic habitats includes *Galinsoga parviflora* Cav., *Helianthus tuberosus* L., *Xanthium albinum* (Widder.) H. Scholz., *Impatiens glandulifera* Royle, *Hippophae rhamnoides* L.

By way of introduction of identified invasive species, adventive component of flora in general is dominated by ergasiophytes. The xenophytes include *Impatiens parviflora* DC., *Conyza canadensis* (L.) Cronq., *Galinsoga parviflora* Cav., *Rumex confertus* Willd., *Xanthium albinum* (Widder.) H. Scholz., since they appeared on the territory of Belarus accidentally as a result of natural migration or human economic activity.

According to the time of introduction to the territory of Belarus, the identified species can be divided into neophytes and superneophytes. Among neophytes, the earliest time of introduction is distinctive for *Sambucus nigra* L., which probably entered the territory of Belarus at the end of the XVII century, and *Sambucus nigra* L. which became naturalized at the end of the XVII century. The group of superneophytes, whose penetration into the territory of Belarus and naturalization occurred in the XX century, is quite numerous: *Cornus albus* (L.) Opiz, *Phalacroloma annuum* (L.) Dumort., *Solidago canadensis* L., *Xanthium albinum* (Widder.) H. Scholz, *Impatiens glandulifera* Royle, *Impatiens parviflora* DC., *Echinocystis lobata* (Michl. ex Willd.) Britt., *Lupinus polyphyllus* Lindl., *Quercus rubra* L., *Rumex confertus* Willd. (Dubovik et al., 2017).

The primary area of most of the identified species (11 species) is North America, which is explained by the similarity of natural and climatic conditions that contribute to the naturalization and distribution of species in the secondary area. *Galinsoga parviflora* and *Xanthium albinum* (Widder.) H. Scholz originated from Central and South America. *Cornus albus* (L.) Opiz, *Impatiens glandulifera* Royle, *Impatiens parviflora* DC., *Hippophae rhamnoides* L. have Asian origin. Species *Rumex confertus* Willd., *Populus alba* L., *Sambucus nigra* L. entered the flora of Belarus from more southern and western parts of Europe.

Conclusion. Thus, the invasive plants that constitute a part the adventive fraction of the flora of Brest are characterized by a high degree of naturalization, mainly cultural origin and generally came from North America. Among the identified invasive species there are neophytes and superneophytes, which is mainly due to the fact, that most of them were introduced on the territory of Belarus in the XIX–XX centuries.

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INVASIVE PLANTS OF THE BELARUSIAN-LITHUANIAN BORDER

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Introduction. During implementation of the project "Reduction of Negative Impact of Alien Invasive Plant Species on Ecosystems and Human Wellbeing in Cross-border Region of Lithuania-Belarus" ENI-LLB-1-207 an inventory of 8 target invasive plant species (*Acer negundo*, *Asclepias syriaca*, *Echinocystis lobata*, *Heracleum sosnowskyi*, *Heracleum mantegazzianum*, *Impatiens grandulifera*, *Solidago canadensis*, *Solidago gigantean)* and their mapping in the Belarusian-Lithuanian border area were carried out.

Materials and methods. Field studies covered an area of 1,555 km^2: part of Grodno and Shchuchin districts, including the republican landscape reserves "Kotra", "Oziory" and the right bank of the reserve "Grodnenskaya Pushcha". In the field work, we used space images with objects applied to them, with the help of which the growing areas of target alien invasive plant species (AIPS) were determined. The fieldwork was based on a grid method (2.4 km by 3.4 km rectangles (n = 241)). Sample: 518 questionnaires were filled in, 634 species records were drawn up (this indicator is more than the number of questionnaires due to the presence of several target species in some of the questionnaires), information on 658 habitats of the target species was entered (234 points, 140 lines, 284 areas). The research did not cover the territory of Gozha military training ground. Field surveys were carried out in each rectangle. For each alien invasive plant species (AIPS) found, a special form (questionnaire) was drawn up, with indication of the location, habitat and other necessary information. On the printed map, the location of the invasive plant species was marked with a marker, indicating the type of cartographic unit: point, line (tape) or area. All completed forms and maps were scanned and then entered in the database. A special application for smartphones has been developed and implemented into practice, which allowed mapping and entering descriptions of the populations. It automatically records location coordinates and saves a photographic image of the spicies found. Implementation: the cartographic and analytical part of the work was implemented on the geoinformation platform ArcGIS.

Results. Collected field data are combined into a single geographic database, which enables to store and manage both spatial (points, lines and polygons) data and attribute data. The digital map served as the basis for an interactive web application that was developed within the framework of the project, and is available to all interested organizations and citizens for further adding of the information about the places where alien plant species grow and about the measures taken to combat them (https://bit.ly/2S1UxLa).

During inventory of the project area (Belarusian part), from the target list (8 plant species) 6 species revealed: *Acer negundo*, *Echinocystis lobata*, *Heracleum sosnowskyi*, *Impatiens grandulifera*, *Solidago canadensis*, *S. gigantea*. The total area occupied by the target species is less than 1 % of the project area. The areas of *Asclepias syriaca* and *Heracleum mantegazzianum* growth were not identified.

The distribution of the identified species (according to the mapping results) reflects the main patterns of the secondary AIPS habitat formation: the habitats and their greatest concentration falls on settlements and their environs, as well as on highways (road and rail transport). In general, the largest number of habitats within the project area (Belarusian segment) was identified in southern part of the project area which is most economically developed. A direct relationship between the total area occupied by a species and the number of localities was noted, which makes it possible to rank the identified species according to these two indicators. The largest area with the largest number of localities among the target species is occupied by

Acer negundo (~ 43 % of the total area occupied by the target species). *Solidago canadensis* also belongs to the group with the largest occupied area and number of habitats. The group of the target species with an average proportion of occupied area includes *Solidago gigantea* and *Echinocystis lobata*: more than 100 and less than 250 ha. The group with the smallest occupied area includes *Heracleum sosnowskyi* and *Impatiens grandulifera.* The minimal presence of *Heracleum sosnowskyi* is the evidence of effectiveness of the government measures to eliminate this aggressive species.

The study showed, that among alien goldenrods (*Solidago canadensis*, *S. gigantea*), the most dangerous is *Solidago gigantea*, as it completely displaces all other plant species in places of its growth.

Only four species (*Acer negundo*, *Heracleum sosnowskyi*, *Solidago canadensis*, *Solidago gigantean)* occupy habitats with signs of aggressive species destruction. The territories, where measures are being taken to eradicate this aggressive plant species, occupy only 3 % of their total habitats. This is not sufficient for effective biosafety work.

The accompanying AIPS are most often found with *Acer negundo* and *Solidago canadensis* (~ 60–80 habitats, more than 200 ha). The species commonly associated with AIPS and often characterized by high abundance are *Erigeron annuus*, *Rosa rugosa*, *Robinia pseudoacacia*, and *Impatiens parviflora*.

Conclusion. *Acer negundo* and *Echinocystis lobata* are the most dangerous species for ecosystems and economics in the project area. It is predicted, that invasive species areas and number of its habitats will expand, in particular those that are not subject to systematic control and struggle: *Acer negundo*, *Echinocystis lobata*, *Solidago gigantea*, as well as accompanying AIPS (*Bidens frondosa*, *Erigeron annuus*, *Robinia pseudoacacia*, etc.).

The high level of natural habitat, as well as intensive agriculture and forestry, reduce the risks of AIPS invasion.

The created GIS provides the authorities and reserves administrations with up-to-date information for taking reasonable actions to prevent further spread of invasive plants.

The ENI-LLB-1-207 project is funded by the European Union.

CRYPTIC INVASION OR NATIVE SPECIATION? THE CASE OF PHRAGMITES IN BELARUS

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Introduction. Biological invasions are currently one of the most pressing problems facing humanity. The ecological consequences of the introduction of alien species can be dramatic, but the regulation and prevention of negative impacts is often hampered by the presence of cryptic species – species that are practically indistinguishable in morphological characteristics, but have significant differences at the genetic level (Morais & Reichard, 2018; Jarić et al., 2019). The problem of cryptic species and cryptic invasions has become especially urgent recently in connection with the development of molecular genetic methods and the possibility of reliable identification of such taxa. Cryptic invasions require a lot of attention, since, like any other invasions, they can cause changes in the functioning and productivity of ecosystems, but at the same time they go unnoticed, as a result, their monitoring becomes much more difficult.

The genus *Phragmites* Adans. is practically cosmopolitan in distribution, its species are distributed from the tropics to the cold temperate regions of the northern and southern hemispheres of the Earth, which makes it a good subject for research. Most of the species of this genus demonstrate high phenotypic, cytological and genetic variability and, as recent studies show, are complexes of cryptic species. The number of species of the genus *Phragmites* has not yet been unambiguously established. According to various researchers, the genus contains from 4–7 to 11–12 species. According to N.N. Tsvelev, the real number of reed species can reach 20 species (Tsvelov, 2011).

Study of the genetic diversity of *P. australis* s.l. showed a very wide range of general genotypic variability and allelic polymorphisms. As a result of these studies, the monophilia and independence of *P. japonicus* and *P. americanus* were confirmed. In addition, the AFLP analysis showed a significant difference at the genetic level between the Eurasian tetraploid plants and the Australo-East Asian octoploids (Lambertini et al., 2006). Therefore, instead of *P. australis* s.str. (the species described from Australia) we use the name *P. communis* Trin for the widespread Eurasian tetraploids.

Species of the genus *Phragmites* are one of the best studied examples of cryptic invasions among higher plants. In North America, a detailed study of the displacement of the native *P. americnus* by the invasive European *P. communis* is being carried out (Saltonstall, Peterson & Soreng, 2004). It has been convincingly shown that the cryptic invasion of *P. communis* in North America is comparable in scale (if not more) to other easily detectable invasions (*Lythrum salicaria*, *Tamarix* sp., etc.) (Saltonstall, 2002). Unfortunately, in Europe this issue has hardly been studied.

For the territory of Belarus, most sources provide only one reed species – *P. australis* (Cav.) Trin. ex Steud. (syn. *P. communis* Trin.). In the second volume of "Flora of Belarus" DI Tretyakov mentions two more invasive species – *P. altissimus* (Benth.) Mabille and *P. chrysanthus* Mabille (Tret'yakov, 2013). In addition, we found *P. americanus* (Saltonstall, P.M. Peterson, & Soreng) A. Haines (*P. australis* ssp. *americanus* Saltonstall, P.M. Peterson, & Soreng) in Belarus. For the territory of Belarus and Europe as a whole, this species is presented for the first time (Nobis et al., 2019).

In addition to the mentioned species, we found populations of reeds that are very close phenotypically to the invasive *P. altissimus*, but differ from it in the pubescence of leaves and flower scales, as well as in the seasonal rhythm of development, and so morphologically correspond to *P. communis* var. *pseudodonax* Rabenh. Nosov et al. suggested that this taxon was formed as a result of the ancient hybridization of *P. communis* and *P. altissimus* (Nosov et al., 2020). In order to confirm this assumption, we assessed the genetic polymorphism of the *Phragmites* species using ISSR analysis.

Materials and methods. Populations of *Phragmites* from various habitats in Belarus (Brest, Minsk, Gomel, Vitebsk and Grodno regions) were taken as objects for assessing intra- and interspecific polymorphism.

Eight di-, tri-, and tetranucleotide microsatellite sequences were used for the analysis (ISSR-04, ISSR-09, ISSR-09a, ISSR-10, ISSR-17, ISSR-22, ISSR-23, ISSR-24), which showed high efficiency according to the results of preliminary studies.

Results. The dendrogram was constructed using the neighbor-joining method (Saitou & Nei, 1987), the probability of the dendrogram topology is supported by the bootstrap values in the cluster nodes. The calculation of distances and the construction of a dendrogram of phylogenetic relationships between the samples were carried out using the TREECON for Windows v.1.3b program (Van de Peer & De Wachter, 1994).

The average level of ISSR markers polymorphism for the *Phragmites* populations was 90.4 %. Polymorphic ISSR markers were used to construct a phylogenetic dendrogram of the *Phragmites* species, shown in the figure.

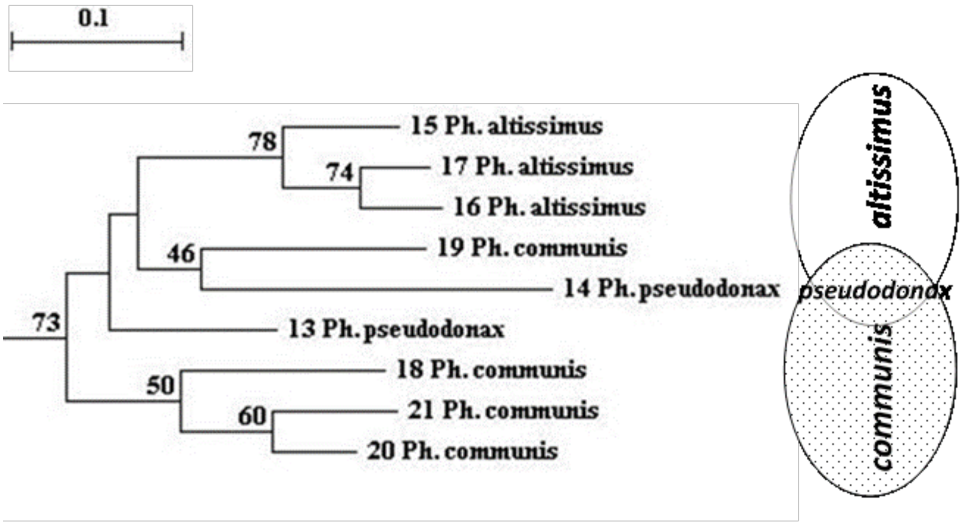

Fig. Dendrogram of genetic similarity of the populations *P. communis, P. altissimus* and *P. communis* var. *pseudodonax*, constructed by the NJ method (Saitou & Nei, 1987) based on ISSR markers polymorphism.
Top scale – genetic distances by Nei (bootstrap values are indicated in cluster nodes)

Analysis of ISSR polymorphism of plants from different *Phragmites* populations showed that they are grouped into several clusters, which correspond to the phenotypic clusters of *P. communis*, *P. communis* var. *pseudodonax* and *P. altissimus*. Moreover, *P. communis* var. *pseudodonax* forms a subcluster included in the cluster of *P. altissimus*. This character of the genetic variability is a feature of the hybrid nature of the taxa. Thus, we confirm the hypothesis of the origin of *P. communis* var. *pseudodonax* as a result of hybridization of northern (*P. communis*) and southern (*P. altissimus*) races (Nosov et al., 2020).

Conclusion. The data about the hybrid origin of *P. communis* var. *pseudodonax* can be interpreted as a modern hybridization of invasive *P. altissimus* and native *P. communis*, or as an ancient (most likely postglacial or even earlier) hybridization of parental species and further independent evolution of the formed hybrid taxon. Considering that the invasion of *P. altissimus* in Eastern Europe (including Belarus) has been observed only since the 1990s–2000s (Tret'yakov, 2013; Papchenkov, 2008), and herbarium collections of *P. communis* var. *pseudodonax* from the territory of the republic have been known since the middle of the 19th century; the fact that in the weather conditions of Belarus *P. communis* var. *pseudodonax* blooms very early and bears fruit well, unlike *P. altissimus*, which blooms very late and does not have time to form fruits, as well as the confinement of this taxon to the Baltic Sea basin (Tsvelov, 2011), it can be assumed with a high degree of confidence that that *P. communis* var. *pseudodonax* should be considered as a result of the ancient hybridization of *P. communis* and *P. altissimus*. Currently, this species is spreading independently of the parental species and is native to Belarus.

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THE FIRST FINDING OF *SPERMOTHAMNION STRICTUM* (RHODOPHYTA) AT ZERNOV'S PHYLLOPHORA FIELD (BLACK SEA, UKRAINE)

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Introduction. "Zernov's Phyllophora field" (ZPF) is a unique habitat located in the northwestern part of the Black Sea. One of the main characteristics of ZPF is dense clusters of agarophytes (red algae) and a high diversity of associated fauna.

The first finding of *Spermothamnion strictum* (C. Agardh) Ardissone, 1883 (*Spermothamnion* Areschoug, 1847 Ceramiales, Florideophyceae, Rhodophyta) in the area of the ZPF was noted in the summer of 2016. We can say with a confidence that this species settled in the area after 2012. In 2012 a full-scale survey (over than 50 stations) was carried out in this area. The species was not found.

Spermothamnion strictum is considered as a lower boreal species with a common habitat in Northwestern region of the Black Sea, the Crimea, the Caucasus, Romania. Thallus of *Spermothamnion strictum* is thin filamentous, segmented, without a bark, with a sprawling thread-like base. It uses suckers to attach to the substrate. Vertical shoots rise lopsided, opposite or alternately branched from the sprawling filaments. It forms tufts of 0.5–1.5 cm in height. Vertical shoots are 45–52 μ thick at the base and 25–28 μ thick in the middle. The ends of the branches are very thin and pointed.

Nowadays, a significant change in a biodiversity of macrophytes in the Black Sea and this area in particular is expected due to increased eutrophication and climate changes. Therefore, the detection in the area of the ZPF a warm water (lower boreal) small filamentous species with higher specific surface values is quite naturally.

Materials and methods. In this work materials from the research expeditions on the research vessel Mare Nigrum, Romania (May 2016, April, July, August 2017, August 2019) within the project "Improving Environmental Monitoring in the Black Sea" (EMBLAS) were used. Underwater video filming and sampling with a 20 × 20 cm periphyton frame were carried out by the biologist-diver Kurakin A.P. (IMB) (Minicheva, Afanasyev & Kurakin, 2014). The guide (Zinova, 1967) was used to identify algae.

Results. In 2016, this alga was detected at all stations in the ZPF area. It was an epiphyte on *Phyllophora crispa* and *Coccotylus truncatus* and grew on mussel shells. At most stations 70–80 % of the coverage consists of made up of *Spermothamnion*. Currently, the species is ubiquitous and the third-dominant species among biomass abundance at ZPF. As a result of observations, it was found that the species is distributed at depths from 18.5 to 42 m. The temperature in the bottom layers in the area ranged from 5.0 to 6.5 °C in April, from 8.1 to 9.1 °C in July and from 8.4 to 8.8 °C at the end of August. The was observed throughout the growing season.

Conclusion. Changes in the biodiversity of the Black Sea macrophytes is obvious due to an increased anthropogenic load and climatic changes. The concentration of nutrients inside of the bottom sediments at the northwestern shelf is one order of magnitude higher than in the water column. Washing out nutrients from the bottom sediments into the bottom layers of water is the main reason for overgrowing of *Phyllophora crispa* and *Coccotylus truncatus* by small filamentous algae (Minicheva, Kosenko & Shvets, 2009). The confirmation of that is the active growth of *Spermothamnion* in the area of the field.

According to the latest revision, *Spermothamnion strictum* is distributed in the coastal waters of Ukraine, Russia, Georgia and Romania. One of the ways of dispersal of new species occurs in the direction of the main Black Sea water current (Milchakova, 2004). The water area closest to ZPF, where this species was recorded, is Karkinitsky Bay (the Crimea) (Sadogurskiy, Belich & Sadogurskaya, 2019). Therefore, it is most likely that *Spermothamnion strictum* is spreading in the region from Karkinitsky Bay.

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HALOSIPHON TOMENTOSUS (OCHROPHYTA) IN THE DNIESTER REGION OF THE BLACK SEA

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Introduction. The first invasion of the species *Halosiphon tomentosus* (Lyngbye) Jaasund, 1957 (*Halosiphon* Jaasund, 1957, Tilopteridales, Phaeophyceae, Ochrophyta) was discovered in May 2016 in the Dniester region. It is the second case of important finding of this species in the Black sea ecosystem.

Halosiphon tomentosus is a subarctic species which is widespread in the Arctic Ocean and northern parts of the Atlantic Ocean (Zinova, 1953). This species is littoral or sublittoral, dark brown to almost black in colour, cartilaginous, firm, densely covered with dark green hairs. The size is 10–30 cm long for littoral, and about 50–135 cm long for sublittoral species (Jaasund, 1957, p. 212–213).

Materials and methods. The materals used in this work were taken from research expeditions on the research vessel Mare Nigrum, Romania (May, 2016) within the project "Improving Environmental Monitoring in the Black Sea" (EMBLAS).

The procedure of macrophytobenthos collection and its processing was prepared within the EMBLAS I project and approved by the Black Sea Environmental Commission (Minicheva, Afanasyev & Kurakin, 2015). Samples of macrophytobenthos were collected by a Van Veen grab with the surface of 0.13 m^2. Identification books were used to verify algae (Zinova, 1953, p. 144–146; Jaasund, 1957).

Results. In May 17, 2016, several thalli *Halosiphon tomentosus* (=*Chorda tomentosa*) were found on sandy and shelly substratum at the station with coordinates 45°59.393 (45.9899) N 030°42.667 (30.7111) E (Dniester region) at a depth of 18.5 m and temperature of 6 °C. The height of thallus was about 10 cm.

First detection of sporophytic phase of the brown algae *Halosiphon tomentosus* was on sandy and shelly substratum at a depth of 5–8 m and temperature of 9 °C at Cape Bolshoi Fontan (the north-western Black Sea, Ukraine, Odessa Bay: 46° 22.469 N 30°45.249 E) on April 30, 2015, during an underwater survey. The height of thallus in the population is 50 to 80 cm in average (the maximum height was 85 cm) (Minicheva, 2015).

According to Jaasund (Jaasund, 1957), with increasing depths, the dimensions of the Chord should also increase. Apparently, the specimens found in 2016 were in a depressed state.

Conclusion. Finding of *Halosiphon tomentosus* within the EMBLAS project is the second official discovery of this species in the Black sea. It can be assumed that the reproductive material of this species was brought with ballast waters to the area of Odessa bay and the Dniester region, where it found acceptable conditions for development. Further distribution of the species can be traced in case of special monitoring.

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THE FIRST CASE OF ALIEN RED ALGAE *CHONDRIA CAPILLARIS* IN ODESSA BAY

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Introduction. *Chondria capillaris* (Hudson) M.J.Wynne, 1991 (*Chondria* C.Agardh, 1817, Ceramiales, Florideophyceae, Rhodophyta**)** was first discovered in the fall of 2020 during the annual monitoring of UkrSCES in Odessa Bay at the open beach Luzanovka. *Chondria capillaris* is a boreal tropical species common for the Northwest region, Crimea, the Caucasus, Romania, Bulgaria. It forms bushes of 5–20 cm tall. Thallus is brownish-red colour and branched. The main axis is usually distinguished with 0.5–1 mm thickness at the base and tapering towards the top. Branches are rod-shaped with short additional branches of 1–10 mm long and 120–300 μ thick. Young branches have bunches of hair at the top. It grows on rocks, stones, shells and algae, at a depth of up to 28 m in summer and autumn (Zinova, 1967).

Materials and methods. Luzanovka beach practically has no solid substrates. Therefore, qualitative samples of macrophytes were collected manually from storm remains on the beach and algae floated in the water column according to the standard method approved in marine phytocenology. Identification books were used to verify algae (Zinova, 1967).

Results. A significant number of thalli were found on Luzanovka beach at two points with the coordinates 46°33,18 (46,553) N, 030°40,14 (30,769) E and 46°32,94 (46,549) N, 030°45,48 (30,758) E.

According to the latest revision *Chondria capillaris* is distributed throughout the Black Sea. In Ukraine, it is noted in phytocenoses of the southeastern coast of the Crimea, in Karkinitsky Bay (Sadogurskiy, Belich & Sadogurskaya, 2019), in the western part of Dzharylgach Bay (Skrebovska & Shaposhnikova, 2016). It is often found as an epiphyte on thalli of Charales in Tendrovsky and Yagorlytsky bays (Korolesova, 2015). *Chondria capillaris* is a part of the phytocenoses of *Cystoseira barbata* in Tiligul Estuary (Tkachenko & Maslov, 2014).

Conclusion. Due to absence of breakwaters and piers, Luzanovka beach is characterized by powerful currents. In our opinion, the finding of *Chondria* at two points of the beach is not an accidental phenomenon. The development of the population began on solid substrates in Odessa Bay. Climate changes lead to the development of thermophilic macrophyte species. Further distribution of the species can be traced in case of special monitoring.

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Section 3. Invasive And Alien Fungi Species

RECORDS OF THE DOTHISTROMA NEEDLE BLIGHT PATHOGENS IN BELARUS

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Introduction. Red band needle blight, or Dothistroma needle blight is one of the most common and harmful diseases of pine. The causative agents of the disease are pathogenic micromycetes *Dothistroma septosporum* (Dorogin) M. Morelet. and *Dothistroma pini* Hulbary. Dothistroma needle blight has already become widespread in the neighboring countries of Belarus (Poland, Baltic countries, Ukraine, Russia). Red band needle blight was first detected in Belarus in 2012, but till now information about this disease in the country is fragmentary. The aim of this research was to conduct a pine trees survey in botanical gardens, arboretums, urban territories and ornamental tree nurseries in Belarus to detect Dothistroma needle blight and estimate potential risks, caused by of *Dothistroma septosporum* blight for pines in the country.

Material and methods. Phytopathological inspection of trees of both exotic (*Pinus sibirica, P. mugo, P. strobus, P. pallasiana, P. banksiana, P. nigra, P. peuce, P. ponderosa, P. pumila, P. rigida, P. cembra, P. korainensis, P. hamata, P. contorta, P. kochiana*) and aborigen (*P. sylvestris*) for Belarus pine species from more than 30 localities was being carried out during 2016–2020. Symptomatic needles were initially examined under light microscope by standard mycological methods. The identification of the species, that was the disease causative agent, has been confirmed by molecular genetic assay.

Results. In this study we updated information about the current prevalence of Dothistroma needle blight in botanical gardens, arboretums, urban territories and ornamental tree nurseries in Belarus. Dothistroma needle blight was diagnosed in individual trees of *Pinus mugo*, *P. nigra* and *P. ponderosa* in the stands of the Central Botanical Garden of NAS of Belarus, arboretum of the State experimental forestry establishment “Glubokskij experimental forestry enterprise”, nurseries of ornamental plants in the Grodno and Minsk regions. The invasive species *Dothistroma septosporum* was identified. The pathogen caused needle blight and premature defoliation. In infected needles, symptoms initially appear in late autumn and are represented by spots that turn brown to reddish-brown color, gradually enlarge and form bands around the needles. Warm and wet weather favours needle blight, as under moist conditions frutting bodies produce spores. Twigs of heavily infected pines typically have only last year's needles. Mostly, 2- and 3-year old needles tend to shed.

Conclusion. Currently, the incidence of *Dothistroma septosporum* is low (4.8–7.2 %). The portion of observation sites, where this disease was detected was at 60 %. According to the research, Dothistroma needle blight is a chronic disease in urban green spaces and botanical gardens. In ornamental tree nurseries, Dothistroma needle blight was detected, mainly, on planting material imported from abroad, that indicates a transboundary route of *D. septosporum* entering to the country. Analysis of literary sources and the research results indicate the potential danger of red band needle blight for pine stands in the country, which in turn requires to organize regular monitoring of the disease appearance and develop the methods to limit the spread of *D. septosporum*. The pathogen from exotic to aborigen (*Pinus sylvestris*) pine species is worth special attention and caution.

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THE OCCURENCE OF INVASIVE FUNGI *ERYSIPHE FLEXUOSA* AND *PHYLLOSTICTA PAVIA* ON THE HORSE CHESTNUT IN THE REPUBLIC OF BELARUS

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Introduction. Based on the results of long-term monitoring of the spread of alien species of pathogenic fungi (2005–2020), an analysis of the occurrence and harmfulness of the pathogens of powdery mildew (*E. flexuosa*) and brown leaf spot (*Ph. paviae*) in horse chestnut (*Aesculus hippocastanum* L.) plantations in the territory of the Republic Belarus was made.

Materials and methods. The plantings of the horse chestnut in different categories of urban green spaces (parks, squares, boulevards, streets, yards) and nurseries of the republic were examined. The degree of damage to chestnut crowns caused by powdery mildew and brown leaf spot was assessed on a 5-point scale: point 0 means zero, no damage done; point 1 means little damage, up to 10 % of the crown is affected; score 2, medium, 10–50 % of the crown is affected; point 3, extensive damage, more than 50 % of the crown is affected; score 4 is complete damage, the entire crown is affected. The weighted average score of crowns infestation was calculated (Mamedov, 2011).

Results. Powdery mildew and brown leaf spot in plantations of the horse chestnut were noted in all regions of the Republic of Belarus. First observations of the disease appearance date back to 2018–2020: powdery mildew appeared in the – 1st–3rd decades of May, brown spot, in the 1st decade of May, which indicates an increase in the harmfulness of fungi *E. flexuosa* and *Ph. paviae*. Powdery mildew and brown spot leaf infection continues until the end of September. In case of 10 % lesion of horse chestnut trees, their decorativeness and vitality are significantly reduced, with the development of diseases up to 50 % or more mature trees pass into the category of severely weakened. Development of powdery mildew and brown spot in nurseries lead to stunted growth and development of chestnut seedlings which greatly affects the quality of planting material. It was noted that leaves, which were largely covered by the mycelium of the fungus *E. flexuosa*, were not damaged by the chestnut moth. However, powdery mildew infestation of leaves damaged by chestnut moth (many mines on the leaf blade) was noted with late plant infection in August-September. In the categories of urban plantations with a less pronounced degree of air pollution (parks) and presence of litterfall, there is a significant distribution of powdery mildew on horse chestnuts. Under favorable conditions for the development of the fungus, a high degree of plant damage is observed. The lesion of the leaves with powdery mildew leads to premature leaf fall (1.5 months ahead of schedule) and a decrease in the decorative effect of plants.

The occurrence of powdery mildew is quite high in all regions of the republic and varies depending on the category of plantings (0.2–1.0). The weighted average score of powdery mildew affection of horse chestnut tree crowns is higher in plantations of the Minsk, Mogilev and Gomel regions. According to the results of the examination of horse chestnut in different categories of urban plantings and the analysis of the occurrence of fungi-causative agents of powdery mildew and brown leaf spot, the species of green plantations that are most vulnerable to invasion of pathogens were identified. In anthropogenically transformed phytocenoses of urban plantations, all categories of chestnut plantations and plants in nurseries located in urban areas are vulnerable to the invasion of *E. flexuosa*. Within the boundaries of cities, chestnut grows on boulevards, squares, parks, i.e. locations where a large number of trees are concentrated in a limited area, which makes them more vulnerable (frequency of occurrence is 1.0) to invasion. Within street plantings, the frequency of occurrence of the pathogen varies greatly (0.4–1.0), reaching high values (1.0) on streets with heavy traffic, where trees are weakened by the influence of various abiotic factors.

The degree of powdery mildew damage to the crowns of horse chestnut trees in urban plantings depends on the type of tree planting. In parks and squares, the weighted average score of tree crowns infestation with powdery mildew is higher in single-row planting of trees along paths (1.4–2.5), compared to group planting on the lawn (0.8–1.1). Within chestnut plantations on boulevards, along highways and streets with heavy traffic, trees in a double-row planting are more affected (the weighted average score on boulevards is up to 1.4; along highways and streets, up to 1.2 points), compared with a single-row planting (on boulevards, along highways and streets it comprises up to 0.4 points). In courtyard areas in single and group plantings of horse chestnut, the occurrence of powdery mildew varies from medium to high (0.5–1.0) with a weighted average score of 0.1–1.3. Less vulnerable (frequency of occurrence equal to 0.01–0.3) to infestations of the fungus *E. flexuosa* are seedlings of chestnut plants in nursery plantings located far from urban areas, due to the lack of nearby sources of infection. An increase in the prevalence and harmfulness of powdery mildew on horse chestnut on the territory of the republic is noted every year.

The damage of chestnut caused by brown spot was noted in different categories of urban plantings in all regions. The occurrence of the fungus *Ph. paviae* is high (0.2–0.9) in the plantations of the Mogilev, Vitebsk, Gomel, Brest regions with a high degree of damage (up to 4 points). In urban plantations of the Minsk and Grodno regions, the frequency of occurrence of the pathogen is low (0.1–0.3) with the weighted average score of 1–2 crowns. In 2017–2020 in urban plantings, a decreasing or moderate desease development was noted, because of a low level of occurrence (0.2–0.9) of the causative agent of brown leaf spot with an average or high level of severity (weighted average score of crown infestation equal to 1.0–4.0). In recent years, there has been an increase in the incidence of the fungus *Ph. paviae* affecting chestnut leaves. In nurseries, an epiphytotic development of brown spot on seedlings is observed annually – high occurrence (1.0) of the pathogen with a high level of severity (weighted average score of crown infestation is 2.5–3.4).

The expansion of the range of affected host plants has been revealed. For the first time the infection of powdery mildew and brown spotting was noted in *Aesculus carnea* (Grodno – 2016; Brest, Minsk – 2017), which were considered resistant to these diseases.

Conclusion. Based on the results of the survey of chestnut plantations and analysis of the occurrence of invasive fungi *E. flexuosa* and *Ph. paviae*, maps of the fungi distribution on the territory of the Republic of Belarus were compiled. A rapid spread of alien pathogenic fungi, earlier infection of plants, expansion of the range of affected host plants, and high harmfulness indicate an increase in the aggressiveness of pathogens and good adaptation to new habitat conditions. Pathogenic fungi *E. flexuosa* and *Ph. paviae* have high invasive potential for chestnut plantations in the country. It is necessary to develop measures to limit the spread of alien pathogens in the plantings of the republic and tighten measures to control the phytosanitary quality of planting material.

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Section 4. Ecology Of Invasive And Alien Species

ECOLOGICAL STRUCTURE OF PHYTOPHAGES-INVIDERS COMPLEXES IN URBAN GREEN PLANTS OF THE GRODNO NEMAN RIVER REGION (BELARUS)

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Introduction. Phytophagous arthropods invasive species make up a significant part in the ornamental greenery pests complexes. The importance of studying and predicting the consequences of invasive processes for the Grodno Neman River region urbancoenoses is associated with the fact, that these territories are one of the main corridors for the penetration of alien species and potentially possible invasions in Belarus.

Materials and methods. The work is based on the materials of entomo-phytopathological surveys of urban green plants of the Grodno Neman River region, carried out from May to October 2016–2020 on the territory of Grodno, Skidel, Mosty, Lida and Porozovo. In general use plantation of all the settlements sample plots were organized with the total number of 18. The material was collected in the course of visual inspection of trees and shrubs. Plant fragments with phytophages and injuries were subsequently analyzed in laboratory conditions. Herbarization was carried out according to the appropriate methods (Geltman, 1995). The material is stored in the Invertebrate Laboratory of the Department of Zoology and Human and Animal Physiology. Identification of the taxonomic status of arthropods was carried out using (http://www.bladmineerders.nl.; http://www.leafmines.co.uk.), the phytophages ecological indicators were refined according to (https://www.gbif.org/ru/species/; Nickel, 2003). Classification of invasive phytophages ecological groups was carried out according to such criteria as: trophic specialization breadth, topical confinement and localization on a fodder plant, phytobiontic groups, the nature of damage, including teratogenicity.

Results. During the study, 42 phytophagous invaders species were found on urban green plants of the Grodno Neman River region. They belong to 6 orders, 10 families and 2 classes, which is 21 % of arthropod phytophages species abundance in this territory. The Hemiptera order includes 27 species, while each the Thysanoptera and Diptera insects are represented by single species. The Aphididae (22 species, 52 % of their total number) and Eriophyidae (7 species, 17 % of their total number) families dominate by species number.

According to trophic specialization, the majority of urban plantations in the Grodno Neman River region, are monophages, and number 28 species. Among them *Aceria cephalonea, Aceria erinea, Aceria pseudoplatani, Aceria tristriata, Aculus hippocastani, Adelges laricis, Appendiseta robiniae, Brachycaudus divaricatae, Cameraria ohridella, Chromaphis juglandicola, Cryptomyzus ribis, Drepanosiphum platanoidis, Eriophyes exilis, Hinatara recta, Hyadaphis tataricae, Myzocallis walshii, Myzus cerasi, Myzus ligustri, Myzus pruniavium, Macrosaccus robiniella, Nematus tibialis, Obolodiplosis robiniae, Panaphis juglandis, Parthenolecanium fletcheri, Phyllonorycter issikii, Parectopa robiniella, Psylla buxi, Vasates quadripedes*. Oligophages are represented by 9 species: *Acyrthosiphon caraganae, Brachycaudus spiraeae, Capitophorus elaeagni, Capitophorus hippophaes, Adelges (Cholodkovskya) viridana, Pemphigus bursarius, Pemphigus spyrothecae, Tinocallis saltans, Therioaphis tenera*. Polyphages include *Aphis craccivora, Aphis gossypii, Aphis spiraecola, Dendrothrips ornatus* and *Stictocephala bisonia.*

The majority of invader phytophages overwinter in the stage of eggs (22 species, 54 % of their total number) or larvae (11 species, 27 % of their total number). The green citrus aphid (*A. spiraecola*) hibernates in the egg or larva stages (in anolocyclic forms). The linden speckled moth (*Ph. issikii*) hibernates in the imago stage, the white acacia lower-sided speckled moth (*M. robiniella*) hibernates in the pupa or imago stage, females of the lime thrips (*D. ornatus*) also hibernate, while the wintering stage of the maple leaf-mining sawfly bubbly (*H. recta*) has not yet been established.

Representatives of the dendrobiont phytobiont group (24 species, 57 % of their total number) predominate among urban green plants of the Grodno Neman River region. Tamnobionts (6 species, 14 %) and dendrochortobionts (6 species, 14 %) are less numerous. The rest of the representatives of the invasive species complex belong to dendrotamnobionts, tamnochortobionts and dendrotamnochortobionts. Each or these ecological groups include 2 species.

Phylobiontic forms dominate within the complex of invasive phytophagous species, and amount to 35 species out of 42 (83 %). Phyllobiont species live on leaf blades of woody and shrub plants. Meristemophilous forms, gravitating to the tops of growing shoots and other places of meristems localization, are represented by 6 species. Carpophilia is very typical for the large caragan aphid (*A. caraganae*) – massive development of colonies was observed on green fruits of *C. arborescens*.

Gall formation is typical for 13 invasive phytophage species. These terata, as a rule, are clearly visible, represented by felty or brush-like erineums, or single- or multi-chambered closed or open galls on various parts of forage plants (leaf petioles, along the main vein of the leaf). The loss of decorativeness in most cases has a long-term character and cannot be compensated during one growing season.

The demages caused by feeding of a number of aphid species (such as *A. craccivora*, *A. gossypii*, *A. spiraecola*, *B. divaricatae*, *H. tataricae*, *M. cerasi*, *M. ligustri*, *M. pruniavium*) and the buffalo leafhopper (*S. bisonia*) leads to disordered deformation of of growing shoots leaf blades in fodder plants.

The complex of phytophages insects and invasive species of mites of woody-shrub plants is devided into 2 main groups in terms of lifestyle: open-living (22 species, 52 % of their total number) and hidden (20 species, 48 %) forms. Miners (5 species), inhabitants of open (4 species) and closed (5 species) galls, as well as eryneum mites (6 species) belong to the hidden forms.

Conclusion. Based on the results of the study carried out in 2016–2020, 42 invasive phytophagous arthropods species were identified in urban communities of the Grodno Neman River region. Hemiptera insects from the family Aphididae and Eriophyidae mites predominate. The majority of invasive species are monophages, hibernating in the stage of eggs or larvae. Usually they are representatives of the dendrobiont phytobiont group and phylobiontic forms. According to the nature of their lifestyle, they are devided into two group: open-living and hidden-living forms.

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TAXONOMIC COMPOSITION OF APOIDEA VISITORS OF SOLIDAGO INFLORESCENCES IN DIFFERENT BIOTOPES IN MINSK

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Introduction. The increasing spread of invasive alien species can lead to significant changes in the functioning of natural ecosystems. Most flowering plants are entomophilous and require insects for successful cross-pollination. Seed production and genetic variation are also influenced by the amount of pollen transferred from flower to flower. Invasive species can decrease native plant density and disrupt already established interactions between native plants and their pollinators (Sun, Montgomery & Li, 2013, p. 2165–2177). The introduction of invasive species into natural biocenoses can lead to significant changes in the species composition of the anthophilic insects complexes. Such an impact on the biodiversity of biocenoses has been proven in many works published in recent years (van Hengstum et al., 2014, p. 4–11).

Among the most active invasive plants are North American species of goldenrod (Solidago). About 20 species of goldenrod are cultivated and able to spread beyond the cultivation areas, naturalize and quickly form dense thickets. Despite good melliferousness and decorative attractiveness, goldenrods are malicious weeds and rather aggressive invaders, characterized by high seed fertility and capability of rapid colonization and transformation of large territories (Moron, 2009).

Rich species composition of goldenrods' visitors may confirm the fact that goldenrods are an attractive food source for a wide range of Apoidea.

Materials and methods. The collection of material was carried out in the summer-autumn period of 2018–2019 from various biotopes in the Minsk region. The insects were collected by hand and fixed in plastic tubes filled with 70 % ethanol. The taxonomic identification of the collected specimens was carried out according to the key for the European part of USSR (Ponomareva, Osychnuk & Panfilov, 1978).

Results. On the goldenrod inflorescences we registered 51 species of Apoidea, belonging to 5 families:

Apidae family: *Apis mellifera* (Linnaeus, 1758), *Bombus lapidarius* (Linnaeus, 1758), *B. laesus* (Morawitz, 1875), *B. terrestris* (Linnaeus, 1758), *B. ruderarius* (Müller, 1776), *B. humilis* (Illiger, 1806), *B. hypnorum* (Linnaeus, 1758), *B. lucorum* (Linnaeus, 1761), *B. semenoviellus* (Skorikov, 1910), *B. pratorum* (Linnaeus, 1761), *B. pascuorum* (Scopoli, 1763), *B. soroeensis* (Fabricius, 1776), *B. pomorum* (Panzer, 1805), *B. hypnorum* (Linnaeus, 1758), *Psithyrus vestalis* (Geoffroy, 1785), *P. rupestris* (Fabricius, 1793), *P. bohemicus* (Seidl, 1838), *P. barbutellus* (Kirby, 1802), *Epeolus variegatus* (Linnaeus, 1758), *E. cruciger* (Panzer, 1799);

Melittidae family: *Macropis europaea* (Warncke, 1973), *Dasypoda altercator* (Harris, 1780);

Colletidae family: *Colletes similis* (Schenck, 1853), *C. collaris* (Dours, 1872), *Hylaeus communis* (Nylander, 1852), *H. annularis* (Kirby, 1802), *H. gracilicornis* (Morawitz, 1867), *H. sigmatus* (Panzer, 1798);

Andrenidae family: *Andrena chrysopyga* (Schenck, 1853), *A. gallica* (Schmiedeknecht, 1883), *A. lepida* (Schenck, 1861), *A. pilipes* (Fabricius, 1781), *A. flavipes* (Panzer, 1799), *A. tarsata* (Nylander, 1848), *A. gravida* (Imhoff, 1832), *A. chrysopyga* (Schenck, 1853);

Megachilidae family: *Heriades truncorum* (Linnaeus, 1758), *Coelioxys inermis* (Kirby, 1802), *Megachile versicolor* (Smith, 1844), *Stelis punctulatissima* (Kirby, 1802);

Halictidae family: *Sphecodes puncticeps* (Thomson, 1870), *S. crassus* (Thomson, 1870), *Halictus quadricinctus* (Fabricius, 1776), *Lasioglossum albipes* (Fabricius, 1781), *L. morio* (Fabricius, 1793), *L. calceatum* (Scopoli, 1763), *L. leucopus* (Kirby, 1802), *H. tumulorum* (Linnaeus, 1758), *L. sexnotatulum* (Nylander, 1852), *L. costulatum* (Kriechbaumer, 1873), *H. maculatus* (Smith, 1848).

Andrena gallica Schmiedeknecht, *Andrena pilipes* F., *Bombus terrestris* L., *Bombus lapidarius* L., *Bombus ruderarius* Müller, *Macropis europaea* Warncke were previously registered on goldenrod inflorescences (Koroteeva, 2019). The rest of these species have been registered as visitors of goldenrods in Belarus for the first time.

Conclusion. On the inflorescences of goldenrods we have registered 51 species of Apoidea belonging to 5 families. Significant richness of species of visitors of goldenrod inflorescences indicates that these plants are extremely attractive source of nectar and pollen for a wide range of Apoidea pollinators.

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SIZE STRUCTURE OF THE DREISSENA POLYMORPHA POPULATION OF LAKE MYASTRO

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Introduction. *Dreissena polymorpha* (Pallas, 1771) is an actively spreading bivalve mollusk. In Lake Myastro dreissena was first discovered in 1984 (Burlakova, Karatayev & Padilla, 2006). Since then, the mollusk population has firmly established itself in the lake. With the massive distribution of dreissena, it began to have a serious impact on the ecosystem of the water body. Dreissena accelerates bentification processes (Mayer et al., 2014) and affects the development of populations of other species, i.e. actively inhibits the development of large bivalve molluscs by overgrowing their shells (Panko, Kryuk & Zhukava, 2019). The development of the *D. polymorpha* population in water bodies should be monitored. The last work describing in detail the structure of the population of *D. polymorpha* in the lakes of Naroch group was published in 2006 (Burlakova, Karatayev & Padilla, 2006). In addition, there are no published works describing the size structure of the *D. polymorpha* population in Lake Myastro. In this work, we briefly describe the size structure of the population of *D. polymorpha* at the present stage of evolution in Lake Myastro.

Materials and methods. The studies have been carried out in Lake Myastro on the premises of the Educational and Research Centre "Naroch Biological Station named after G.G. Vinberg" in July 2017. *D. polymorpha* samples were collected by hands (with the help of divers at big depths) from four littoral and seven pelagic sites, 0.25 m^2 at each site. Sizes of the mollusks (length, width, height) were measured by calipers.

Results. The average length (±Sd) of dreissena shells sampled at different stations of the pelagic zone of the lake varies from (9.62 ± 1.55) to (16.14 ± 6.13) cm. The average shell width varies from (4.10 ± 0.80) to (12.2 ± 7.34) cm. The indicators of the average shell height vary from station to station in the range from (4.90 ± 3.82) to (9.30 ± 2.76) cm. The smallest specimens were found at the stations near Kochergi campground (N 54 50.755 / E 026 54.541) at a depth of 3.1 m and near the village of Minchaki (N 54 52.952 / E 026 53.694) at a depth of 1.9 m. The largest specimens were found at the station located near autocamping Kochergi (N 54 51.601 / E 026 53.932) at a depth of 4 m.

The average length of shells at different stations of the littoral ranged from (14.25 ± 6.03) to (17.52 ± 7.27) cm. The average width of zebra mussels in the littoral varied from (6.78 ± 3.17) to (8.77 ± 4.13) cm. The average height varied from (6.68 ± 2.62) to (8.28 ± 3.10) cm. The smallest specimens were found in the littoral of the lake at the station near Gatovichi village (N 54 51.448 / E 026 52.387). The bottom substrate at the station is silty sand. The largest specimens were recorded at the station near Nikoltsy village (N 54 52.835 / E 026 52.096). The substrate at this station is coarse sand and stones.

Conclusion. Thus, it can be concluded that in Myastro Lake the average size of Dreissena individuals is larger in the littoral zone. However, the size of the zebra mussel does not strongly interdepend with the depth in the pelagic zone of the lake. There is a significant interrelation between size characteristics of dreissena and substrate type. The smallest individuals taken from pelagic stations were found mainly at sampling sites located in bays. The largest individuals, on the contrary, were found in the central parts of the lake, which also allows us to conclude that the indicators of the zebra mussel size are sensitive to the intensity of the hydrodynamic of water mass in the habitat.

According to the results of the study of the size structure of the *D. polymorpha* population in lakes Naroch and Myastro in 2016–2017, it can be stated that the population of dreissena inhabiting Lake Myastro on average is larger in size, comparing to that in Lake Naroch

(Panko, Kryuk & Zhukava, 2017). This is probably due to the presence of a food base (planktonic algae development).

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OCCURRENCE OF LEAF GALLS FORMED BY GALL MIDGE *OBOLODIPLOSIS ROBINIAE* LARVAE ON BLACK LOCUST IN GREEN AREAS OF MINSK AND LIDA (BELARUS)

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Introduction. The gall midge, *Obolodiplosis robiniae* (Haldeman, 1847) (Diptera: Cecidomyiidae), is a Nearctic species, damaging the black locust (*Robinia pseudoacacia* L.) (Fabaceae) (Skuhravá, Skuhravý & Csoka, 2007). It was first observed in Italy in 2003 (Navone & Tavella, 2004) and has spread during short period in Europe (Skuhravá, Skuhravý & Csoka, 2007) and East Asia (Yang et al., 2006). In Belarus *O. robiniae* was registered for the first time in 2000s (Petrov, 2019), and at present it is common in all regions of the country where *R. pseudoacacia* grows. The black locust leaf gall midge is a single species of Cecidomyiidae in "Black book of invasive animal species in Belarus" (Alekhnovich et al., 2016).

Gregarious feeding of larvae results in thickening of the margins of the leaflets and their bending downwards, forming the characteristic leaf margin roll galls. They are green in the beginning, but subsequently turn yellow or pink and may darken and dry up. Leaf damage depends on the number of larvae living in the galls; high infestation can cause serious defoliation of trees.

Materials and methods. For each location (yard plantings, linear sidewalk plantings, forest belt green plantings) samples of leaves were randomly collected and placed into plastic bags. The collected samples were taken to the laboratory and analyzed. The total number of leaflets and the number of infested leaflets were counted for each leaf in the sample. Based on this data, obtained during vegetation season in 2020, the infestation ratio for each leaf from each location was estimated as the ratio of infested compound leaves to the total number of compound leaves. The overall ratio of the black locust trees infestation by *O. robiniae* at each location was estimated as a mean infestation ratio of all leaves in the sample from the location.

Results. The infestation ratio of compound leaves of *R. pseudoacacia* varied from 1.75 % to 35.00 %. Within four locations in Minsk, studied during the period of July–August, the infestation ratio of the black locust compound leaves accounted for 2.53–3.85 % (linear sidewalk plantings), 5.20–12.50 %, and 5.88–7.14 % (yard plantings), 1.75–3.57 % (forest belt plantings). In general, the ratio of black locust compound leaves infestation by *O. robiniae* was higher during the period of July–August, and has been declining slightly up to September.

Within four locations in Lida (a major city of the Grodno administrative region), studied during the period of July–August, the infestation ratio of the black locust compound leaves accounted for 3.85–9.43 % (linear sidewalk plantings), 21.62–35.00 %, and 20.00–23.33 % (yard plantings), 3.45–8.33 % (parks).

Conclusion. The black locust leaf gall midge (*Obolodiplosis robiniae* (Haldeman, 1847)) is currently a common alien species of gall-forming insects. In green areas of Minsk and Lida the infestation ratio of compound leaves of the black locust (*Robinia pseudoacacia* L.) varied from 1.75 % to 35.00 % during July–August 2020 in different types of green plantings, such as linear sidewalk plantings, yards, parks or forest belts.

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ASSESSMENT OF THE DAMAGE TO LEAF BLADES BY *PARECTOPA ROBINIELLA* LARVAE IN THE BREST REGION

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Introduction. Many alien species are characterized by plasticity that allows them to be introduced into new ecosystems. The high rate of reproduction makes it possible to increase the number quickly and occupy the territory, many of the alien species have increased competitiveness, leading to the suppression or displacement of native species (Semenchenko & Pugachevsky, 2006). Some of the dangerous invasive insects in Europe are representatives of the Gracillariidae family. Among the representatives of this family, *Parectopa robiniella* is actively exploring new territories.

This phytophage poses a threat to black locusts in green areas because outbreaks of mass reproduction can lead to a significant loss of decorative effect by plants (Gninenko & Rakov, 2011). Today, the species is listed in the Black Book of invasive animal species of Belarus (category: A2) (Semenchenko et al., 2020).

Material and Methods. The research was carried out in the Brest region in 2015–2020. The assessment of the population of *P. robiniella* larvae on the lower crown of plants (the percentage of damaged leaf blades among 100 randomly selected) was carried out. Damaged leaf blades of *Robinia sp*. were herbarized and then scanned using the Epson Perfection 4180 Photo (300 dpi resolution). The ImageJ program was used to determine the areas of *Robinia* leaves damaged by *P. robiniella* larvae.

Results. As a result of the studies, regional features of the population of the lower crown of plants (3–71 %) and the relative damage (no more than 5 %) of the leaf blades of *Robinia pseudoacacia* L. by the larvae of an invasive miner in the green stands of the Brest region were noted. It has been established that autumn foliage harvesting can significantly reduce the pest density in green stands. Among forage plants, *Robinia hispida* L. is the most inclined to damage by phytophagous larvae.

Conclusion. In green plantings, *P. robiniella* is classified as a phytophagous pest with an average level of harmfulness. However, in some years there have been outbreaks of mass reproduction of *P. robiniella*, which leads to early defoliation of black locusts.

Acknowledgements. The research was carried out with the financial support of the Belarusian Republican Foundation for Basic Research (B19M-078).

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FIRST EVIDENCE OF *PLANKTOTHRIX AGARDHII* (CYANOPROKARYOTA) IN THE UKRAINIAN MARINE COASTAL WATER

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Introduction. In 2020, *Plantothrix agardhii* (Gomont) Anagnostidis & Komárek, 1988 (synonyms: *Oscillatoria agardhii* Gomont) was noticed in the coastal marine phytoplankton at the northwestern part of the Black Sea. *P. agardhii* is a widespread freshwater cyanobacterial species which is common for the temperate and tropical zones. It is a cosmopolitan and β-mezosaprob. The species is a filamentous phytoplankton without trichomes, that can rarely be found in benthos communities. *P. agardhii* creates harmful algae blooms in freshwaters waterbodies, but it can also grow in high biomass in brackish waters (Tsarenko, Wasser & Nevo, 2006; Churro, Azevedo, Vasconcelos & Silva, 2017). It produces microcystins, type of hepatotoxins. That means they have a toxic effect on hepatocytes of the liver and muscle cells (Chorus & Bartram, 1999).

Planktothrix sp. in Ukrainian marine water was first reported in 2010, when it was found in summer-autumn phytoplankton communities at the Danube region (Terenko & Nesterova, 2015). However, it was identified only to the genus name.

The aim of this study is to show the evidence of new freshwater cyanobacteria, which settled a stable population in the autumn-winter phytoplankton of 2020. Adjacent conditions for its growth and distribution will be also discussed.

Materials and methods. Phytoplankton samples were collected at the northwestern part of the Black Sea in October–December 2020. The reverse filtration method was used to concentrate water samples (1.5–2L) using nucleopore filters with a pore size of 1.5 µm. All samples were condensed to 30–45 mL and then fixed with a 40 % solution of neutralized formaldehyde to the final concentration of 4 %. The identification of cyanobacteria was performed in fresh, not fixed samples in vivo. Quantitative count of *Planktothrix* filaments was carried out in a Nagotte counting chamber with a volume of 0.05 mL using a light microscope "Mikmed-2" with 300–600 magnification. The average length of *Planktothrix* filaments (trichomes) of 139 µm was used for further calculations. Additionally, temperature, salinity, pH, concentrations of dissolved phosphorus, nitrogen and oxygen in water samples were measured by the standardized methods.

Results. The first finding of *P. agardhii* in the phytoplankton of the northwestern part of the Black Sea was on October 2, 2020, at the station (coordinates 31.174 E, 46.627 N), located under the influence of the Dnieper-Bug Estuary brackish water. The number of filaments was 57.61 x 10^3 filam·L^{-1} and biomass was 259.85 mg·m^{-3}. The water temperature and salinity were 20.00 °C and 13.86 ‰, respectively. Presumably, the Dnieper-Bug Estuary would be the source of this species because a small bloom of *P. agardhii* with the number of trichomes 167.01 x 10^3 filam·L^{-1} and biomass of 1.10 g·m^{-3} was observed on October 1, 2020, at the station located near its mouth.

Two months later, *P. agardhii* was again recorded in the coastal phytoplankton of Odessa Bay on December 23, 2020. The number of trichomes at the open coastal station with coordinates 30.768 E, 46.428 N was 69.30 x 10^3 filam·L^{-1}, associated with a biomass 159.00 mg·m^{-3}. At a semi-closed station (30.773 E, 46.441 N), where piers and breakwaters are installed, the number of trichomes was lower (1.69 x 10^3 filam·L^{-1}) associated with a biomass 3.84 mg·m^{-3}. The growth occurred at a seawater temperature of 3°C and salinity of 14.6 ‰. Both stations are monitored once a week on the year-round basis, that allowed us to analyze other environmental changes as well. *P. agardhii* biomass was higher at the open coastal area. The increase of all forms of phosphorus, nitrite-nitrogen, total nitrogen, and pH was observed from 16 to 23 of December. Only nitrate-nitrogen has dropped down twice from the previous week. Mineral nitrogen is one of the main components for the growth of *Plantothrix sp*., which has probably triggered its development. Moreover, during this period, we noticed the decrease in oxygen concentration at the open station to 78.1 %.

Conclusion. For the first time a population of freshwater species of cyanobacteria *P. agardhii* was registered in the autumn-winter phytoplankton in 2020. The presumable source of this species would be from the Dnieper-Bug Estuary, where massive development was observed at some moments earlier. The species can exist in a wide range of temperatures and sufficiently high salinity of marine environment. However, the number of works connecting to blooms of this species in high salinities is still rare. The population of the species found in the coastal recreational zone was influenced by rivers outflows. Based on the literature, this species carries toxins. Nearby this considered area, the Khadzhibey Estuary is an artificially closed region of the main part of the Black Sea. It has experienced new regular blooms of *P. agardhii* since April 2019. Our observations and analyses confirmed that this population is toxic and capable to produce microcystins (data not published yet). However, it is not sure that all these populations of *P. agardhii* in the Khadzhibey Estuary, the Dnieper-Bug Estuary and coastal water in Odessa have the same origin. Therefore, this shows the importance of a continuous monitoring program aimed at identification of toxic species of phytoplankton in marine coastal population and studing the mechanism of outflow influences on this region.

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MODELLING THE RANGE EXPANSION OF PUMPKINSEED *LEPOMIS GIBBOSUS* ACROSS EUROPE, WITH SPECIAL FOCUS ON LATVIA AND UKRAINE

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Introduction. The pumpkinseed *Lepomis gibbosus* (Linnaeus, 1758) is a North American sunfish (*Centrarchidae*) that has been introduced to Europe in the late 19th century, and established in at least 28 countries across Europe and Asia Minor, however considered invasive in part but not all of its introduced range (Copp & Fox, 2007). Currently the species is not considered to spread to more northerly latitudes (the northernmost known reproducing population is situated in southern Norway), however *L. gibbosus* is predicted to become invasive to these areas under conditions of climate warming (Britton et al., 2010). While more than a century has passed since its initial introduction to Europe, the range expansion of this fish has continued across the continent (Yavno et al., 2020). Exploring limiting environmental factors may help to understand the key drivers of the suggested range expansion of the species and may at the same time help to establish efficient monitoring programs including risk assessments of *L. gibbosus* invasion. Our objective was to predict the possible geographic range of the fish based on presence records and environmental variables likely to be associated with habitat suitability. Thus findings of this study can inform enhanced surveillance efforts in Latvia and Ukraine where *L. gibbosus* has not yet been recorded but where the environment appears to be favorable for its establishment. The basic approach applied here is based on species distribution models (SDMs) often called ecological niche models (ENMs), where species' presence or absence are correlated with environmental variables prevailing in the respective locations in order to project the potential distribution of a species under current and/or future climatic conditions. These projections are based on statistical and/or machine learning algorithms, aiming at the best estimation of the species-environment relationship.

Materials and methods. Occurrence data was collected from the literature, FishBase (http://www.fishbase.org/) and an extensive search of social media (Facebook, Twitter etc.), resulting in a total of 1,263 and 1,386 non-duplicate records across Europe and North America, respectively. To calculate sampling bias, we used the nearest neighbor distance (NND) method to narrow the data, where occurrence points that were ≤0.2 units away from each other were removed to avoid errors due to spatial autocorrelation. In this study, 82 climatic (http://www.worldclim.com/) and topographic variables (http://www.earthenv.org/) were analysed in order to identify key factors that discriminate areas, where *L. gibbosus* is present from those where the species is absent. Highly correlated (>0.7) predictors were removed using the 'virtualspecies' package in R, resulting in a selection of 16: aspect, BIO1 = annual mean temperature, BIO2 = mean diurnal range, BIO3 = isothermality, BIO5 = max temperature of the warmest month, BIO7 = annual temperature range, BIO12 = annual precipitation, BIO13 = precipitation of the wettest month, BIO14 = precipitation of the driest month, BIO18 = precipitation of the warmest quarter, BIO19 = precipitation of the coldest quarter, elevation, precipitation in July, solar radiation in January, solar radiation in July, terrain wetness index. Six SDM methods were employed using the 'sdm' and 'embarcadero' packages in R. The area under the receiver operating characteristic (ROC) curve (AUC) was used for assessing the discriminatory capacity of the models: AUC>0.8 is considered excellent. A final consideration is whether to restrict the model to one based on native range data or data from the invaded range, or include both. This is important because the assumption of niche conservatism over space is not always met: niches of invasive species can differ from their natives, especially if there has been a long historical distribution of a species in its invaded range, just as in the case of *L. gibbosus*. We compared both niches in environmental space using one-way ANOSIM (https://palaeo-electronica.org) and found moderate but statistically significant dissimilarities ($R = 0.24$. $p<0.05$). Therefore, to avoid this bias, capable of affecting transferability, only invaded range data was incorporated in the modelling.

Results. The most accurate technique was the Bayesian additive regression trees (BART) algorithm (AUC = 0.87), while the least accurate technique was 'bioclim' (AUC = 0.64). In terms of variable importance, the highest contributing variables appear to be annual mean temperature, annual temperature range (a proxy for continentality), solar radiation in January (a characteristic period with low position of the sun, and consequently, with low radiation intensity). The hump-shaped relationship of these temperature-related factors with the predicted habitat suitability suggests them to be limiting factors at their extremes. Amongst water-related factors, precipitation in June appears to be the most essential. Increasing altitudes accounted for a lower number of sites with better habitat suitability. One assumption is that lower altitudes can be associated with a stronger influence of land use and other human disturbances (Holcomb et al., 2016) of which invasive species can take advantage (Pollux & Korosi, 2006). According to an ensemble model, predicted habitat suitability in Ukraine ranges between 0.10 and 0.69, with south of the country being especially favourable for the species. Expansion is expected to occur in the Dnister catchment and to a lower extent in the Lower Pripyat and its tributaries further to the west. In Latvia conditions are far less satisfactory: habitat suitability ranges between 0.06 and 0.21, with the Kurzeme province being most promising.

Conclusion. Environmental niche modeling together with an updated record of *L. gibbosus* in Europe enable to characterize the environmental conditions relevant to its distribution within the invaded range, and may help to establish efficient monitoring programs including invasion risk assessments.

Acknowledgements. The research was partly supported by the project "Pond aquaculture production and ecosystem service innovative research with modelling of the climate impact to tackle horizontal challenges and improve aquaculture sustainability governance in Latvia" (lzp-2020/2-0070) financed by Fundamental and Applied Research Projects (FLPP).

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POSSIBLE CONSEQUENCES OF THE INVASION OF THE ALIEN MOLLUSK *ARCUATULA SENHOUSIA* (BIVALVIA, MYTILIDAE) IN THE BLACK SEA

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Recently, due to the development of commercial navigation, an intensive process of invasive penetration of alien species from various regions of the World Ocean into the Black Sea is taking place. Most of these organisms enter the sea at the larval stage of development together with the ballast water of ships. Likewise, in the XX century, representatives of bivalve mollusks *Mya arenaria* Linnaeus, 1758, and *Anadara kagoshimensis* (Tokunaga, 1906), as well as gastropods *Rapana thomasiana* Crosse, 1861, settled in the Black Sea. The first two species successfully passed the adaptation period and widely spread in benthic communities. *M. arenaria* has taken its niche among the burrowing shellfish, having no competitors in the Black Sea. *A. kagoshimensis* has adapted to living together with the native species *Cerastoderma glaucum* (Bruguiere, 1789). However, predatory *R. thomasiana*, which feeds on bivalve mollusks, significantly disrupted the structure of some benthic communities. In the XXI century the alien bivalve mollusk *Arcuatula senhousia* (Benson, 1842) was found in the Black Sea. The consequences of its introduction for the development of native species have yet to be assessed.

The material for the study was samples of fouling of solid substrates collected in 2017–2019 in the coastal zones of the northwestern part of the Black Sea, located in the Odessa region between the mouths of the Dnieper-Bug and the Sukhoi Limans. Samples were taken at a depth of 3 meters. The selected animals were identified to species, counted and weighed.

As a result of the research of the collected fouling samples, several living specimens of the invasive marine bivalve mollusk *Arcuatula senhousia* were found. One specimen of the mollusk was found on April 4, 2017, in the area located south of the mouth of the Grigorievsky Liman (near Yuzhny seaport) among a fouling community formed by the Black Sea mussel *Mytilus galloprovincialis* Lamarck, 1819. Two more living specimens were found in the same place on June 21, 2019. In the first case, the water temperature was 8.0 °C and the salinity was 14.7 ‰, and in the second case it was 25.6 °C and 13.7 ‰, respectively.

The bivalve mollusk *A. senhousia* or, as it is also called, the Asian date mussel belongs to the family Mytilidae, representatives of which are very common in seas and oceans. The native area of this Pacific Asiatic subtropical-low-boreal species is ranged in the South China Sea, the Yellow Sea and the Sea of Japan, as well as in the southern part of the Sea of Okhotsk. At the end of the XX century, with the oyster culture, this species was unintentionally introduced into the marine waters of New Zealand, Australia, the Pacific coast of North America and Europe (Mistri, 2002). This species then spread across the Mediterranean Sea.

In the Black Sea, it was first found at the beginning of the XXI century on hard substrate in the coastal waters of Romania near Constanta seaport (Micu, 2004). Then, in 2015, this species was found on the coast of the Crimea (Kovalev et al., 2017). In addition, in 2018, *A. senhousia* was found in the water area of the Sukhoi Liman, Odessa surroundings, where a large seaport is located (personal communication with Dr. Mikhail Son from the Institute of Marine Biology, Odessa).

The discovered bivalve mollusk *A. senhousia* has all the qualities of the opportunistic species. This relatively small invertebrate (the shell length of adults is about 30 mm) has a short life cycle (life-span is approximately 2 years). It is very fertile, has a long larval stage, during which the mollusk spreads over considerable distances. In addition, it grows rapidly, forming numerous settlements. This species can reach a high abundance and builds dense extensive mats of clams that are fastened together (Mistri, 2004). These properties help *A. senhousia* to capture new habitats quickly and successfully compete with native species.

These ecological features of the considered invasive mollusk pose a certain danger to native sedentary invertebrate species. Such characteristic features of *A. senhousia* as rapid growth and the ability to cover the substrate with a continuous carpet, under conditions of the Black Sea fouling community, can lead to complete isolation of edificator of this community bivalve mollusks *M. galloprovincialis*, as well as their subdominant *Mytilaster lineatus* (Gmelin, 1791) from the surrounding aquatic environment. A similar phenomenon has been reported for benthic species in San Diego Bay, California. In this water area relatively large organisms such as suspension-feeding bivalves can be inhibited by dense mats of *A. senhousia* (Crooks, 2002).

At present, the main obstacle for the wide distribution of this invasive species in the studied water area is relatively low salinity of the Black Sea. It is especially evident in its shallow northwestern part, which is influenced by the runoff of such large rivers as the Danube, Dnieper and Dniester. In this region, the salinity of water is half that in the native habitat of *A. senhousia*. This invertebrate needs a certain time to adapt to low salinity. So, for the predatory gastropod mollusk *R. thomasiana* that entered the Black Sea in the middle of the XX century, the period of adaptation to new conditions was about 50 years. About 20 years have passed since the first finding of *A. senhousia* in the Black Sea. During this period, the mollusk has not yet formed a stable Black Sea population. All its settlements have a local character.

As follows from the data presented, all individuals of the alien mollusk *A. senhousia* were found in the Black Sea near large ports, which indicates that possible routes of invasion of this species were associated with the development of navigation. Thus, at present, the invaded mollusk is undergoing the stage of adaptation to new conditions. If this stage is successfully completed, it can pose a serious threat to the representatives of the aboriginal Black Sea fauna.

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ALIEN AND POTENTIALLY INVASIVE SPECIES OF PHYTOPATHOGENIC FUNGI AND OOMYCETES IN PLANT COMMUNITIES OF BELARUS

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Introduction. Biological invasions are regarded today as one of the main threats to biodiversity. The main focus here is traditionally on plants and animals, but so far there are few studies on the distribution of phytopathogenic fungi [1, 2].

As a result of invasions of phytopathogens, epiphytotics of new diseases often occur in natural and artificial phytocenoses, causing enormous economic and environmental damage [3, 4].

All the more alarming is the fact that in recent decades there has been an exponential dynamics of the emergence of alien plant pathogens in Europe [5]. This problem is both regional and international, it is associated with human economic activities, transboundary flows, climate change, and the biology of pathogenic fungi and their hosts.

Materials and methods. Plants with symptoms of infection by phytopathogenic micromycetes were collected in various plant communities in Belarus. Identification was carried out according to keys and monographs.

Results. As a result of the research, 188 species and intraspecific taxa of alien phytopathogenic micromycetes were identified, which cause downy mildew and powdery mildew, rust, smut, various spots, rot and deformations of organs of wild and cultivated plants.

They belong to 44 genera, 13 families, 8 orders, 7 classes, 4 divisions (Oomycota, Ascomycota, Basidiomycota, Deuteromycota), 2 kingdoms (Stramenopila, Fungi). Among them, imperfect fungi dominate (104 species, 55.3%). All species belonged to the same ecological group - phylloplan micromycetes. The degree of commonality of phytopathogenic mycobiota for cultivated and wild plant species depends on the broad or narrow specialization of the pathogen.

The wider occurrence of the phytopathogen (score 2–5) is usually accompanied by a higher score of plant damage (3–4). Single finds of an alien species are characterized by insignificant damage to plants (score 1–2). With a fairly high score (3-4) of plant damage and more than a single occurrence, 75 out of 188 alien species of fungi (39.9 %) were recorded. They can be classified as potentially invasive species. Among them, only 15 species were recorded on wild plants and 60 species on cultivated plants. Thus, cultivated plants are obviously more susceptible to attack by invasive phytopathogens or, in the case of a highly specialized pathogenic fungus, are their vectors and spread vectors.

It is noted that the appearance in Belarus and the advancement of dangerous alien species of phytopathogenic fungi and oomycetes to new territories is associated with the spread of thermophilic species of mainly cultivated host plants against the background of observed climatic changes. Alien phytopathogenic micromycetes were recorded on cultivated and wild gymnosperms and angiosperms of 144 species, 123 genera, and 48 families. At the same time, almost three times fewer species were found on wild plants (54) than on cultivated plants. The degree of commonality of the phytopathogenic mycobiota for cultivated and wild plant species is generally small and depends on the broad or narrow specialization of the pathogen.

It seemed interesting to find out what types of phytopathogenic fungi have been developed on invasive plant species. According to the available data, 54 species and intraspecific taxa of phytopathogenic micromycetes were registered on 37 invasive species of wild plants included in the Black Book of the flora of Belarus (2020). Among them, almost half – 26 species (48.1 %) belong to aliens for Belarus.

The fact is that they are highly specialized and at present parasitize only on the indicated invasive plant species. The remaining 28 species (51.9%) affect both native and alien plants. Probably, these pathogens have expanded their trophic niche, moving from native to alien plants.

Indicators that determine the invasive activity of phytopathogenic fungi have been identified: distribution on the territory, frequency of occurrence and the degree of damage to host plants in a certain area, climatic phenomena and weather factors. A group of 75 potentially and actually invasive species was identified.

Conclusion. As a result of the research, a base of information was created on the distribution and degree of development of 188 alien species, including potentially invasive and invasive, phytopathogenic microscopic fungi and oomycetes. There are 12 maps of the distribution of the 30 most dangerous species have been compiled. It has been established that only a part of alien pathogens spread together with invasive species of host plants, the rest of alien pathogens enter the territory in connection with human economic activities and intentional or accidental introduction of the respective host plants.

It has been shown that alien and invasive phytopathogenic micromycetes as a by-product of Neolithic evolution have been spread over a specific territory depending on the degree of its anthropogenic transformation, the presence of a range of host plants and the respective climatic conditions. The results of the study make it possible to predict possible epiphytotics of new plant diseases.

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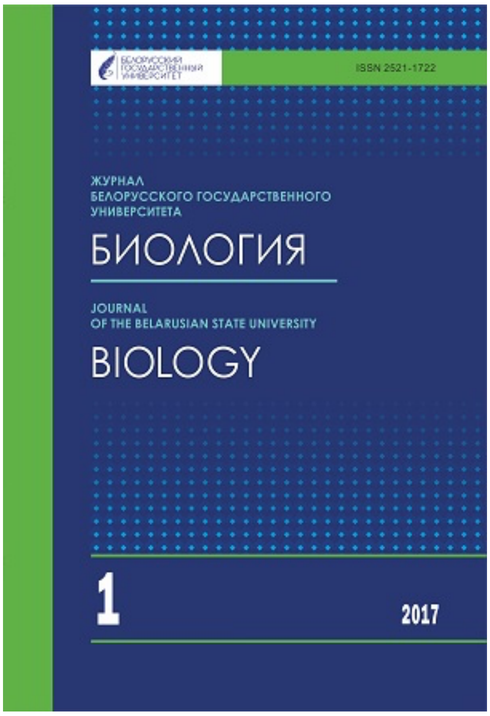

Editor-in-chief – Alexander V. Sidorov
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Publisher:

https://journals.bsu.by/index.php/biology

Languages – Russian, Belarusian and English.

Periodicity – 3 issues per year (February, June, October).

Print ISSN: 2521-1722
eISSN: 2617-3964

Abstracting & Indexing
Google Scholar, eLIBRARY, Science Index, Electronic Library System of the Publishing House «Lan», OpenAIRE, WorldCat, Open Archives Initiative, Bayerische StaatsBibliothek, Crossref, Higher Attestation Commission (Belarus), National Library of Belarus

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RUSSIAN JOURNAL OF BIOLOGICAL INVASIONS

PLEIADES PUBLISHING
Distributed by SPRINGER NATURE

Editor-in-chief: Yury Y. Dgebuadze
dgebuadze@sevin.ru

Publishers: Pleiades Publishing, Ltd. / Springer

http://www.sevin.ru/invasjour/index_eng.html

Languages – Russian and English.

Periodicity – 4 issues per year (February, May, August, November).

Print ISSN: 2075-1117
eISSN: 2075-1125

Abstracting & Indexing
AGRICOLA, BIOSIS, Biological Abstracts, CNKI, CNPIEC, Dimensions, EBSCO Discovery Service, Emerging Sources Citation Index, Geobase, Google Scholar, Japanese Science and Technology Agency (JST), Meta, Naver, OCLC WorldCat Discovery Service, ProQuest Agricultural & Environmental Science Database, ProQuest Biological Science Database, ProQuest Central, ProQuest Environmental Science, ProQuest Natural Science Collection, ProQuest SciTech Premium Collection, ProQuest-ExLibris Primo, ProQuest-ExLibris Summon, SCImago, SCOPUS, TD Net Discovery Service, UGC-CARE List (India).

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Научное издание

ALIEN SPECIES OF ANIMALS, FUNGI AND PLANTS IN BELARUS AND NEIGHBORING COUNTRIES

Book of Abstracts of the 1st International Scientific Conference
Minsk, Belarus, March 23, 2021

ЧУЖЕРОДНЫЕ ВИДЫ ЖИВОТНЫХ, ГРИБОВ И РАСТЕНИЙ В БЕЛАРУСИ И СОПРЕДЕЛЬНЫХ СТРАНАХ

Тезисы докладов 1-й Международной научной конференции
Беларусь, Минск, 23 марта 2021 г.

На английском языке

В авторской редакции

Ответственные за выпуск *Д. Г. Жоров, О. В. Синчук*
Компьютерная верстка *О. В. Синчук, Д. Г. Жоров*
Художественное оформление обложки *О. В. Синчук*

Подписано в печать 31.12.2021. Формат 60×84 1/8. Бумага офсетная.
Печать цифровая. Усл. печ. л. 13,95. Уч.-изд. л. 8,5.
Тираж экз. Заказ .

Белорусский государственный университет.
Свидетельство о государственной регистрации издателя,
изготовителя, распространителя печатных изданий №1/270 от 03.04.2014.
Пр. Независимости, 4, 220030, Минск

Отпечатано с оригинал-макета заказчика