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Distribution of alien species from Poaceae and Asteraceae families in the protected areas of Ukrainian forest-steppe

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Abstract: The current paper evaluates the abundance of alien species from Asteraceae and Poaceae families in different types of biotopes. We have discovered species exhibiting eurytopic properties and forming the ecological niches in three or more biotope types and recorded from only two biotope types, including anthropogenic ones. The majority of anthropophytes from Asteraceae family are eurytopes having the potential to move to other biotopes, due to their ecological amplitude and phytocoenotic strategy. Only five species of Poaceae family showed high exploration trend in different habitat types: *Setaria viridis* (L.) P.Beauv., *Bromus tectorum* L., *B. arvensis* L., *B. commutatus* Schrad., *Eragrostis minor* Host, and have the potential to further spread. It was found that in contrast to Asteraceae family, where eurytopic species prevail, the Poaceae family has only a third of eurytopes in its overall species composition. Alien species distribution for the protected areas of the Ukrainian forest-steppe by generic floristic spectrum revealed two times higher taxonomic diversity of Asteraceae family than the Poaceae one. Among Asteraceae there are such best-represented genera as *Artemisia* L., *Helianthus* L., *Xanthium* L. The analysis of taxonomic structure of the model protected areas and the evaluation of their participation in the formation of different habitat types suggest a low taxonomic diversity and quite uneven coenotic role of individual anthropophytic taxa. It should be noted that such genera as *Phalacroloma* Cass., *Sonchus* L., *Xanthium*, *Bromus* Scop. and *Setaria* P.Beauv. have a particular importance, having the leading

positions both concerning the wide spectrum of species, and concerning exploration of different biotope types. Geographical distribution analysis showed that the biotopes of protected areas of the central forest-steppe are highly explored by the alien members of Asteraceae and Poaceae families and are located in the floodplains of the Dnieper River. The representatives of Asteraceae family are least recorded in the eastern model floras, while Poaceae family are least recorded in eastern and southern model protected areas.

Keywords: alien species, Asteraceae, Poaceae, biotopes (habitats), protected nature areas, forest-steppe.

Introduction

The development of powerful intercontinental relations and communications caused global spread of anthropogenically induced biotic invasions, which is now a serious environmental problem (HOBS 2000, MONACO & GENOVESI 2013, LEWIS & POPE 2001, MILTON 2004, MOONEY et al. 2000, RICHARDSON et al. 2000, THEOHARIDES & DUKES 2007, WILLIAMSON 1996, WEBER 2003, 2013). Particularly dangerous are the pace and extent of alien species spread in natural communities during the last decade. There are predictions of more invasions in the future due to the globalization of markets, increasing of trade, tourism, use of natural resources and other economic activities. Climate change is also adding to the intensity of invasion processes. While most alien species are distributed mainly in anthropogenically disturbed ecotypes (roadsides, former peat fields, land reclamation canals, logged areas, grazing and arable lands), many of the alien species are actively spreading in farmlands and forests, sometimes entirely replacing native species and disrupting the structure and composition of natural communities (VINOGRADOVA et al. 2010, PYŠEK & RICHARDSON 2010). Even the protected areas are not completely resistant to the penetration of new alien species (BURDA 2007, MOROZOVA & TSAREVSKAYA 2010, FOXCROFT et al. 2013). For the implementation of the "European strategy on invasive alien species" the inventory of alien species in different localities and regions is crucially needed. There is also an urgent need to control the invasive species spread (GENOVESI & SHINE 2003) by the Standing Committee of the Berne Convention and adopt the rules and regulations on protected and invasive alien species (MONACO & GENOVESI 2013). The questions of integration areas of invasive species control and management in protected nature areas are now actively discussed in Ukraine (BURDA et al. 2015). Due to the high dynamics of alien component and the rapid dispersal of alien species, identification and control of potentially dangerous invasive species is becoming very topical and actual. For the forest-steppe zone of Ukraine the problem of alien species and invasions control is particularly relevant, given the continual zonal location and combination of different vegetation types on the area. Penetration of new species is taking place in different pathways: by land, air and water, which to some extent later

determines the development of new alien species habitats. To reduce biological contamination of the area the detailed monitoring studies to identify the spread strategy of alien species and their impacts on natural habitats should be carried out.

Floristic analysis of anthropogenic flora fraction on the protected areas of Ukrainian forest-steppe showed that the most important role is played by Asteraceae and Poaceae families. The purpose and objective of the research was to reveal the nature of alien plants distribution in the specially protected areas of Ukrainian forest-steppe and to assess the invasion success in different biotope types.

Material and methods

Species distribution features were determined through analyzing the species presence data in different types of biotopes and phytosociological relevés of biotope communities containing anthropophytes. Also the published scientific papers as well as the chronicles of nature reserves and national parks were critically considered in our research (BURDA et al. 2015).

In our study we have selected 13 protected areas (PA) of the highest conservation rank in the forest-steppe zone of Ukraine which represent the overall flora of the forest-steppe zone (Fig 1). In the Left-bank flatland part of

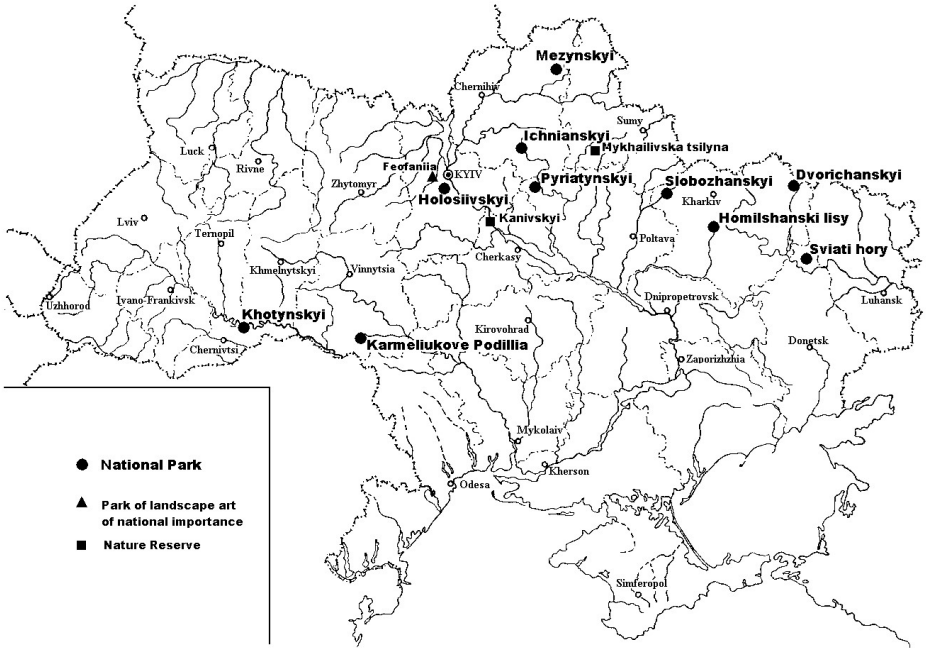

Fig. 1. Location of model protected areas of the Ukrainian forest steppe.

Ukraine are situated: nature reserve (NR) Mykhailivska tsilyna, national park (NP) Ichnianskyi, NP Pyriatynskyi, NP Slobozhanskyi, NP Dvorichanskyi, NP Homilshanski lisy. In the central and southern parts of Right-bank Ukraine: NR Kanivskyi, NP Holosiivskyi, NP Khotynskyi, NP Karmeliukove Podillia and park of landscape art of national importance Feofaniia. For a better comparative analysis and assessment of alien species expansion trends from neighboring PA we have also included in our research the northern areas of forest-steppe - NP Mezynskyi (fragment of forest-steppe landscape from Polissia) and NP Sviati hory in the south (Donetsk forest-steppe).

Selected 13 PA have been analyzed in terms of distribution of alien species in 6 natural and 1 anthropogenic types of habitats. Habitat types are listed according to the classification DIDUKH et al. (2011): continental water habitats – *type C*; wet habitats of grassy – *type D*; grassland habitats (grasslands, steppes and wasteland) – *type E*; chamaephytes and nanophanerophytes – *type F*; habitats dominated by phanerophytes – *type G*; habitats, whose development is caused by geomorphologic and accumulative processes – *type H*; habitats shaped by human activity – *type I*.

Results

According to the research results we have created a checklist, containing 56 Asteraceae and 28 Poaceae species, common in model protected areas of the Ukrainian forest-steppe. It represents 16 % and 8% respectively of the total number of alien species in the overall flora of the Ukrainian forest-steppe zone (Fig. 2).

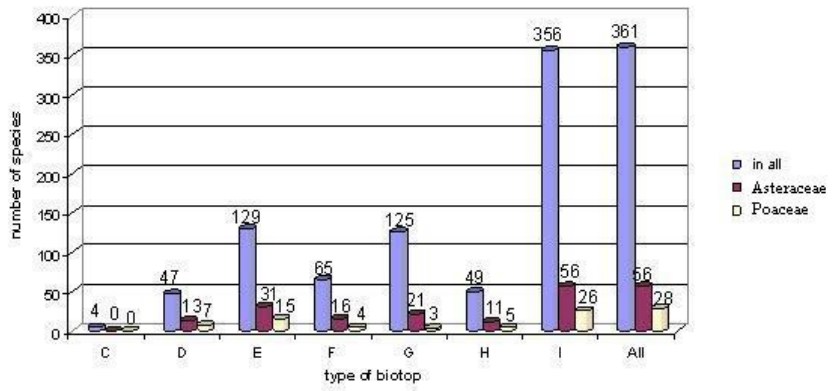

Fig. 2. Distribution of alien species Asteraceae та Poaceae in protected area habitats of the Ukrainian forest steppe, where type *C* – continental water habitats; type *D* – wet habitats of grassy; type *E* – grassland habitats (grasslands, steppes and wasteland); type *F* – chamaephytes and nanophanerophytes; type *G* – habitats dominated by phanerophytes; type *H* – habitats, whose development is caused by geomorphologic and accumulative processes; type *I* – habitats shaped by human activity.

It was established that all anthropophytes occur in type I biotope. There was no alien species found to be commonly present in all 13 model floras. In 12 of the PA *Artemisia absinthium* L., *Cichorium intybus* L., *Conyza canadensis* (L.) Cronquist, *Sonchus arvensis* L. were present and widespread, and *Ambrosia artemisiifolia* L., *Cyclachaena xanthiifolia* (Nutt.) Fresen. were shown to be present and abundant in 11 PA.

Among the natural habitats, most of Asteraceae species are common in grassland habitats (type E) - 31 species, representing just over half (55%) of family members in the flora of the Ukrainian forest-steppe. In one model flora there were recorded from 6 to 18 species of this family in the current habitat. *Ambrosia artemisiifolia* L., *Artemisia absinthium*, *Cichorium intybus*, *Conyza canadensis*, *Cyclachaena xanthiifolia*, *Matricaria recutita* L., *Phalacroloma annuum* Dumort., *Solidago canadensis* L., *Tripleurospermum inodorum* (L.) Sch. Bip. are the most common and abundant species.

In the biotopes of phanerophytes (G-type) - from 1 to 12 species of anthropophytic species are recorded in one model flora. In general, in forest and shrub habitats occur 21 alien and adventive species of Asteraceae, *which* represents 8 % of all alien species of Ukrainian forest-steppe flora. The most common species are *Conyza canadensis, Lactuca serriola* L., *Phalacroloma annuum*, *Sonchus arvensis, S. oleraceus* L.

F-type biotopes contain 16 anthropophytic species of Asteraceae in their floristic composition, covering 29% of the total family representatives in the forest-steppe zone, from 2 to 8 species in the model PA. This type of shrub communities are recorded in nine protected model sites, mostly located in the central and western parts of the forest-steppe. Alien species with the highest permanence status, such as *Artemisia absinthium, Conyza canadensis*, *Cyclachaena xanthiifolia, Lactuca serriola, Phalacroloma annuum*, *Sonchus asper* (L.) Hill occurs in no more than 3-6 of the total 13 studied PA. (Fig. 3).

Slightly lower share of alien Asteraceae species was observed in Type *D* and *H* habitats: 13 and 11 species, representing 23% and 20% respectively. Waterlogged habitats hosted from 1 to 7 alien species of the family. In most cases the most common species in these habitats were *Ambrosia artemisiifolia*, *Artemisia abrotanum* L., *Bidens frondosa* L., *Cyclachaena xanthiifolia*, *Galinsoga parviflora* Cav., *Matricaria suaveolens* L., *Xanthium albinum* (Widder) Scholz & Sukopp, *X. strumarium* L.

In three PA this type of habitats was not explored by alien species. This indicates a stable communities structure as well as an optimal protection regime, although adventive alien species belonging to other families are still recorded.

Biotopes of hasmophytic and psammophytic vegetation (type H biotopes) were detected only in four national parks: Mezynskiy, Dvorichansky, Gomilshanski Forests, and Svyati Gory. For these biotope types constant processes of substrate degradation under the influence of abiotic factors are common (weathering, erosion etc.). Xero-, mesophytes and mesoxerophytes such as *Artemisia absinthium*, *Carduus acanthoides* L., *Cichorium intybus*, *Conyza canadensis*, *Onopordum acanthium* L., *Ambrosia artemisiifolia*, *Cyclachaena*

xanthiifolia, *Grindelia squarrosa* (Pursh) Dunal are the most widespread in these type of biotopes. However, in the northernmost Mezynskiy national nature park, mesophytes such as *Phalacroloma annuum*, *Cyclachaena xanthiifolia, Sonchus arvensis* and *S. oleraceus* have the highest permanence rate.

Fig. 3. a - *Phalacroloma annuum* in the forest (NP Karmeliukove Podillia), b - *Cyclachaena xanthiifolia* on the lake shore (NP Mezynskiy).

The analysis of Poaceae species participation in PAs showed that *Panicum capillare* L. and *Secale cereale* L. were observed in only one national nature park - Pyryatynskiy and *Zizania latifolia* Turcz. ex Stapf was recorded solely in the territory of Kanivskiy nature reserve. The highest numbers of alien species belonging to Poaceae family - 19 species entered the PA of Pyryatynskiy and Holosiyivskiy national nature parks. *Bromus tectorum* L., *Setaria viridis* (L.) P.Beauv are commonly observed in different types of biotopes – this species grow in 11 model PA.

In type I biotopes there were recorded 4 - 23 anthropophytes of the family in the different model floras with 26 alien grass species. Only this type of habitat was explored by 10 species: *Avena sativa* L., *Bromus secalinus* L., *B. scoparius* L., *B. squarrosus* L., *Digitaria sanguinalis* (L.) Scop., *Hordeum murinum* L., *H. vulgare* L., *Panicum capillare*, *Secale cereale*, *Setaria verticillata* (L.) P.Beauv., *Zea mays* L.

The representatives of Poaceae family in the habitats of *E*-type count from 1 to 11 species in PAs. Most of them are registered in Holosiyivskiy national nature park, which is partly located in Kyiv city vicinity and has direct proximity to the routes of communication. *Bromus tectorum* and *Setaria viridis* are among the alien grasses, which often explore grassland habitats.

In the biotopes of riparian and aquatic vegetation of type *D* there are 7 alien species revealed. Among them there are two species of "wild rice" (*Zizania aquatica* L., *Z. latifolia*) forming thickets along the water front, under optimal biotopic conditions. Other grasses occurring in this type of habitat are often ephemeric species like *Bromus commutatus* Schrad., *Digitaria ischaemum* (Schreb.) Muhl., *Echinochloa crusgalli* (L.) P.Beauv., *Eragrostis minor* Host, *Setaria viridis*.

Only five anthropophytes are observed in H-type biotopes and all of them are very widespread*: Bromus tectorum, B. arvensis* L.*, Eragrostis minor, Pennisetum glaucum* (L.) R.Br.*, Setaria viridis.* A similar situation is observed with the exploration of *F* and *G* biotopes by alien adventive species. These species are mostly annuals, explerents and xeromesophytes with rather wide ecological amplitude.

We have also studied the distribution of the model species as for generic floristic spectra. Conducted analysis of taxonomic structure of PAs' alien fractions indicates higher taxonomic diversity of Asteraceae family. It is established that the alien fraction of the forest-steppe model area of Asteraceae family is represented by 30 genera (Fig. 4). The most numerous are *Artemisia* L., *Helianthus* L., *Xanthium* L., but the species number of each genus does not exceed five species. Poaceae family has 14 genera, the most numerous of which is *Bromus* Scop. (5 species).

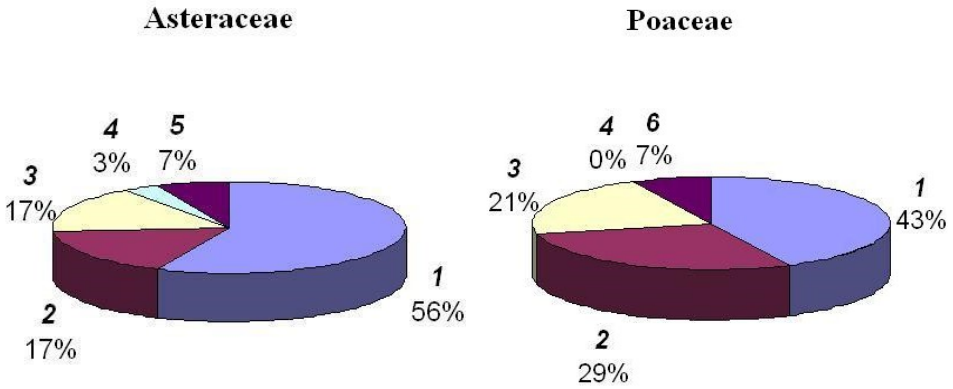

Fig. 4. Generic spectrum *of* Asteraceae and Poaceae families of the alien fraction in Ukrainian forest-steppe model protected areas, where *1 - 5* is the number of species and percentage share (%) of the genera within the family.

It was found that according to the geographic distribution, biotopes the most explored by the members of both families are located on the PA of the central part of Ukrainian forest-steppe, namely in Holosiyivskiy, Pyryatynskiy national nature parks, park-monument of landscape art "Feofaniya" and Kanivskiy nature reserve, located in the floodplain of the Dnieper River. Representatives of Asteraceae family are least represented in the eastern model PA (NP Khotynskyi, NP Karmeliukove Podillia), and representatives of Poaceae family - in the eastern and southern PA (Fig. 5).

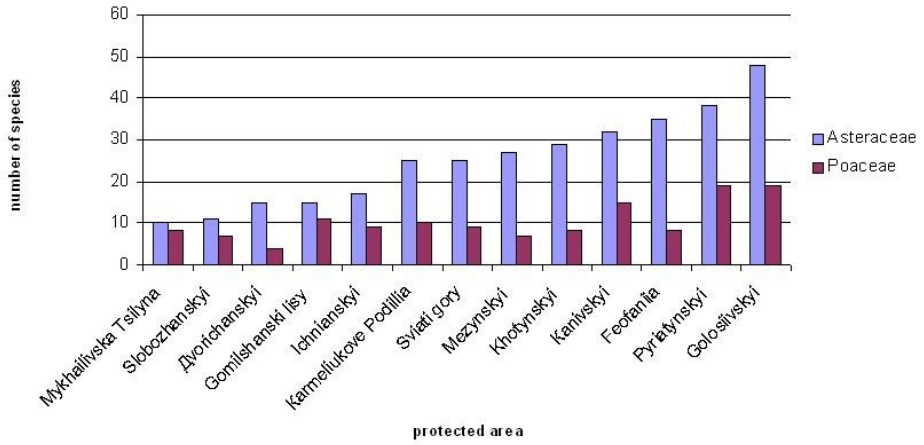

Fig. 5. Alien species distribution belonging to the leading families Asteraceae and Poaceae in the protected areas.

Discussion

Alien species are found in all taxonomic groups and most habitat type, in any region of the world has been affected to some extent. In protected areas impacts from alien species consist in impact on ecosystem function and structure, furthermore at the level of species communities or habitats as well as at the level of species (BRAUN et al. 2016, WEBER 2003). On world and regional levels there is not a systematic quantitative review of invasion alien species, defiant problems in protected areas (PAGAD et al. 2007). In the early studies of alien species, attention was focused on descriptive studies of the extent to which they invaded. In the last decade, much work has focused on understanding the impact of intrusions. One of the most thorough analyzes of 24 islands, tropical, coastal and arid reserves, states that in terms of taxonomy, large species-rich families are best represented, but only Fabaceae, Poaceae, Asteraceae and Myrtacea. As very widespread invaders that have large global distributions was marked *Poa annua* L. (*Poaceae*), and *Leucanthemum vulgare* Lam. (*Asteracea*), which are natural species in Ukraine (FOXCROFT et al. 2017). For protected areas in Central Europe the most widely managed species were *Reynoutria japonica* Houtt.,

Heracleum mantegazzianum Sommier & Levier and *Impatiens glandulifera* Royle (BRAUN et al. 2016), though for Ukrainian reserves these species do not have high average value. The inventory of the alien flora of Slovakia (MEDVECKÁ et al. 2012), showed the highest diversity of alien taxa are of synanthropic vegetation (more than 50%), which forms a habitat type *I* and there are relatively high numbers of alien taxa in some of the semi-natural alliances *Aegopodion podagrariae*, *Chenopodion glauci*, *Arrhenatherion elatioris*, *Senecionion fluviatilis*, *Festucion valesiacae* (mostly type *E*) and natural vegetation, such as *Alnion incanae*, *Carpinion betuli* (type *G)* and *Festucion valesiacae* or *Cynosurion cristati* (type *E*).

Among the representatives of Asteraceae family, following species showed the highest exploration rate in different biotopes - *Ambrosia artemisiifolia*, *Conyza canadensis*, *Phalacroloma annuum, Sonchus arvensis* present in six biotope types*, Artemisia absinthium, Bidens frondosa*, *Cyclachaena xanthiifolia*, *Lactuca serriola*, *Sonchus oleraceus, Xanthium strumarium, X. spinosum* L. - five biotope types*, Artemisia annua* L.*, Carduus acanthoides, Centaurea diffusa* Lam., *Onopordum acanthium*, *Senecio vulgaris* L. present in four biotope*, Carduus nutans* L., *Cichorium intybus*, *Galinsoga parviflora*, *Grindelia squarrosa*, *Matricaria suaveolens, Solidago canadensis, S. gigantea* Aiton*, Xanthium albinum* present in three different biotope types and showing eurytopic properties in the secondary range*. Anthemis arvensis* L., *A. cotula* L., *Matricaria chamomilla* L., *Tanacetum parthenium* (L.) Sch. Bip., *Tripleurospermum inodorum*, besides anthropogenically altered habitats of I type, were recorded in grassland biotopes of type *E,* and Symphyotrichum novae-angliae (L.) G.L. Nesom was also recorded in *F*-type biotopes*.* Thus, the most of anthropophytic members of Asteraceae family are eurytopic species (can develop within three or more biotope types), and have the potential of spreading to other habitats, due to their wide ecological amplitude and appropriate phytocoenotic strategy.

We have revealed only five species of Poaceae family showing the greatest activity and potential in developing within different biotope types. For instance*, Setaria viridis* is recorded in six biotope types*, Bromus tectorum, B. arvensis* - in five*, Eragrostis minor, Bromus commutatus* - in four and *Digitaria ischaemum, Echinochloa crusgalli, Pennisetum glaucum* - in three biotope types having the distinct potential of further spread. Other species, apart from type *I* biotopes (biotopes formed as a result of human activity), entered the grassland (meadows, steppes) and riparian communities. It was found that in contrast to Asteraceae family, dominated by eurytopic species, Poaceae family is represented by only a third of eurytopic species from its overall species composition.

Alien species distribution in the model PA of Ukrainian forest-steppe as for generic floristic spectrum reflected twice higher taxonomic variety of family Asteraceae than Poaceae*,* among which the best-represented genus are *Artemisia*, *Helianthus*, *Xanthium*, *Bromus.*

The taxonomic structure analysis of the PA and evaluation of species participation in different habitat types suggest a low taxonomic diversity and

uneven coenotic role of individual anthropophyte taxa of the leading families. It should be noted that such genera as *Phalacroloma* Cass., *Sonchus* L., *Xanthium*, *Bromus*, *Setaria* P.Beauv*,* are of particular importance, characterized by the leading positions both as for species spectra and exploration rate in different biotope types.

It should be stressed that the territory of Ukraine, and especially its forest-steppe part, is an active acceptor of alien species because of its appropriate geographical location and cross-border nature of river basins. This all means that invasion processes and alien species spread will continue and intensify in future.

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