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Preliminary list of plant invaders in Montenegro

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***Abstract*:**
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Due to the fact that Invasive alien species (IAS) are considered to be the second cause of global biodiversity loss after direct habitat destruction and have adverse environmental, economic and social impacts from the local level upwards, in last decades investigations of alien flora of Montenegro are intensified. In this paper we are presenting a preliminary list of IAS, with the aim to provide a basic data on IAS in Montenegro, to enable future monitoring and to draw attention on the problems which expansion of IAS is bringing with itself. The list consists of 50 plant taxa species and supspecies level.

Key words: invasive alien plants, Montenegro

Abbrevations: IAS- invasive alien species, P- phanaerophytes, Ch- chamaephytes, H- hemicriptophytes, T- therophytes, G- geophytes, NAM- North America, SAM- South America, CAM & SAM- Central and South America, AS- Asia, AFR- Africa, EAS-Euroasia.

Introduction

Unlike some worldwide regions where invasive ecology is well developed, in Montenegro the interest for this a rather new field in ecology, that study a human mediate transfer of organisms to areas outside their natural dispersal range and the consequences of such transfer, has appeared in last few years: Stešević & Jovanović (2005, 2008), Stešević (2005), Stešević & Jogan (2006, 2007), Tomović & Stešević (2007), Stešević et al. (2009).

Due to the concept of Richardson et al. (2000), later supplemented by Pyšek et al. (2004), Richardson & Pyšek (2004), plants taxa in a given area whose presence there is due to intentional or unintentational human involvement, or which have arrived there without the help of people from an area in which they are alien are known as alien plants (exotic, non-native, non-indigenous). Invasive plants are naturalized plants that produce reproductive offspring often in very large numbers, at considerable distance from parent plants (approximate scales: > 100m; <50 years for taxa spreading by seeds and other propagules; > 6m/3 years for taxa spreading by roots, rhizomes, stolons, or creeping stem) and thus have a potential to spread over considerable area.

On global level invasive species are recognized as a major factor of environmental change, and are considered one of the most important causes of biodiversity loss worldwide (Walker & Steffen, 1997; McNeely, 1999, 2001, ISSG 2000, Millennium Ecosystem Assessment 2005 etc.). These species have invaded and affected native biota in virtually every ecosystem type on Earth and ecological cost is the irretrievable loss of native species and ecosystems. It is estimated that the direct economic cost of alien invasive species runs into many billions of dollars annually (ISSG 2000). Beside mentioned impacts, invasive alien plants sometimes have a negative impact on humans health, such as *Ambrosia artemisiifolia, Heracleum mantegazzianum* etc.

Considering habitat types, many invasive species seem to do best in urban und urban-fringe environments where long histories of human disturbance have created vacant niches and abundant bare ground. Cities also tend to be the focal points of the global economy and the entry points for many invasives (Kowarik 1990).

Pathways, as the process by which alien species are introduced from one location to another are different and it is possible to distinguish six ways: i) deliberate release, ii) escape (from gardens, aquaculture), iii) contamination, iv) stowaway, v) corridor (transportation infrastructure), vi) unaided from neighboring countries (the natural spread of an alien species from another region where it is not native) (Hulme et al. 2008). Compared to the other pathways ornamental horticulture is therefore the main pathway for plant invasions worldwide (Hulme et al. 2008), although its importance compared to other pathways has found the attention of ecologists rather late (Mack 1991; Reichard & White 2001; Mack & Erneberg 2002).

According to Jenkins (1996); Levine & D'Antonio (2003) an increasing amount of species inadvertently introduced into areas outside their natural range is directly linked with increases in trade. Due to specific history, long period of isolation, low level of industrial and economic development, bad road infrastructure as well as international commerce and travel, Montenegro for a long time hesitated to introduction of alien species. But, in last last decade fast urban, trade and tourism development facilitated their spread.

Although alien flora of Montenegro has never been systematically explored, first records of some alien species dates from the beginning of XIX Century (Pančić, 1875, Pantoczek, 1874 etc.). These historical notes consist only of information about the presence of a species, so population size or ecological impact of its spreading on natural communities was not documented. During the field excursions conducted in last decade, some interesting results in monitoring of selected alien species are obtained. In this paper we are presenting these results and giving an overview of a species that should be considered as invasive in Montenegro. In addition we are giving taxonomic, biologic and geographic analysis of invasive alien flora.

Material and methods

Preliminary check list of invasive alien species (IAS) is mainly created according to authors own field observations, while the list of alien species is extracted from: Rohlena (1942), Pulević (2005) and Stešević et al. (2008).

Invasiveness of species is estimated according to Richardson et al. (2000).

Life forms follows Raunkier's system (Raunkier, 1943, Ellenberg et al., 1967), while origin of species is given according to Pignatti (1982), Pyšek et al. (2002), Tutin et al. (1964-1980, 1993).

Results and disscusion

Due to the to the sheme proposed by Richardson et al. (2000), Pyšek et al. (2004), Pyšek & Richardson (2004), 50 taxa of alien plants of Montenegro can be classified as invasive. The list of IAS is given in **table 1**, while one taxa from the list *Carpobrotus edulis* is for the first time reported for alien flora of Montenegro. First finding of this species dates from 2006, when rather poor population was noted near the side shore in Bijela (Boka Kotorka Bay). In the meantime species is recorded on numerous locations near the coast, where compose rather dense patches.

The list of IAS of Montenegro consists of 50 species and subspecies belonging to 36 genera and 20 families.

Majority of families (18), genera (31) and species/subspecies (42) belongs to *Dicotyledons*, while other representative belongs to *Monocotyledons*.

It is not surprising that two of the largest families worldwide *Poaceae* and *Asteraceae* (Heywood, 1993) provide the highest number of invasive alien species in Montenegro: *Asteracee* (16), *Poaceae* (7) (**tab.2**). Similar to the world's list of leading invaders families (see Crawley, 1987, Weber, 1997, Pyšek, 1998) *Fabaceae* and *Brassicaceae* are near to the top. Due to Cronquist (1981) *Asteraceae* is considered as one of the evolutionarily most advanced families. Possessing a number of features advantageous in the invasion process, e.g. high reproductive rate, specialized dispersal structures, diversity of metabolic products providing protection from grazing, high level of apomixes etc. (Heywood, 1989, Pyšek, 1997). Similarly, successful dispersal mechanisms in *Poaceae* and *Fabaceae*, together with a highly evolved inflorescence in the former, and an ability to fix atmospheric nitrogen as well as remarkably successful pollination system in the latter may serve to explain why these families among the world's leading invaders. Advanced features that might be considered as a clue for successful invasion are: high reproductive rate, long

Table 1. List of IAS in Montenegro: taxonomy, biology, origin, first record and habitat type. Legend: P- phanaerophytes, Ch- chamaephytes, H- hemicriptophytes, T- therophytes, G- geophytes, NAM- North America, SAM- South America, CAM & SAM- Central and South America, AS- Asia, AFR- Africa, EAS- Euroasia.

Taxon	Family	Life form	Origin	1st record/author	Habitat type
Acer negundo L.	*Aceraceae*	P	NAM	2005 (Stešević&Jovanović)	Riverine forest, Ruderalis/mainly waste places
Ailanthus altissima (Mill.) Swingle	*Simaroubaceae*	P	AS	1971 (Popović & Sterniša)	Ruderalis/widespread, Vegetation near the road sides, railways, waste places etc., Shrubland of *Carpinus orientalis*, Rocklands
Alcea rosea L.	*Malvaceae*	H	AS	1900 (Baldacci)	Ruderalis/vegetation near the road sides, railways, waste places, etc.
Amaranthus hybridus L.	*Amaranthaceae*	T	NAM	2005 (Stešević&Jovanović)	City lawns, Ruderalis/vegetation near the road sides, waste placeas, cultivated soils
Amaranthus retroflexus L.	*Amaranthaceae*	T	NAM	1875 (Pančić)	Ruderalis/wate places, vegetation near the road sides, cultivated land , city lawns …
Ambrosia artemisiifolia L.	*Asteraceae*	T	NAM	2009 (Stešević)	Ruderalis/vegetation near the road sides, gravely river banks, city lawns
Amorpha fruticosa L.	*Fabaceae*	P	NAM	1973 (Pulević)	River banks, sandy dunes
Artemisia verlotiorum Lamotte	*Asteraceae*	G	AS	2006 (Stešević & Jogan)	Ruderalis/ vegetation near the road sides, railways, waste places ….
Asclepias syriaca L.	*Asclepiadaceae*	G	AS	2005 (Stešević&Jovanović)	Wet meadows
Aster squamatus (Spreng.) Hieron	*Asteraceae*	T	CAM, SAM	2004 (Hadžiablahović)	Ruderalis/ vegetation near the road sides and railways, waste places..
Broussonetia papyrifera (L.) Vent.	*Moraceae*	P	AS	2005 (Stešević&Jovanović)	Ruderalis/ waste places, vegetation near the road sides, roofs …
Bidens subalternans DC.	*Asteraceae*	T	SAM	1993 (Trinajstić)	Ruderalis/ waste places, vegetation near the road sides, railways etc.
Bidens frondosa L.	*Asteraceae*	T	NAM	2005 (Stešević&Jovanović)	River banks, Rudelralis
Carpobrotus edulis (L.) N.E.Br.	*Aizoaceae*	Ch	AFR	2006 Stešević (leg.)	Ruderalis/Vegetation near road side, Costal rocks
Commelina communis L.	*Commelinaceae*	H	AS	1997 (Karaman)	Ruderalis/ waste places, city lawns
Chamomilla suaveolens (Pursh.) Rydb.	*Asteraceae*	T	AS	1986 (Vasić)	Ruderalis, Vegetation near the road sides
Conyza albida Willd.	*Asteraceae*	T	SAM	2005 (Stešević&Jovanović)	Ruderalis/ widespread
Conyza bonariensis (L.) Cronq.	*Asteraceae*	T	SAM	2005 (Stešević&Jovanović)	Ruderalis/ widespread
Conyza canadensis (L.) Cronq.	*Asteraceae*	T	NAM	1874 (Pantoczek)	Ruderalis/ widespread
Cuscuta caesattiana Bertol.	*Cuscutaceae*	T	NAM	1949 (Černjavski et al.)	Ruderalis, (sub)mediterranean shrublands and rocklands
Cuscuta campestris Yuncker.	*Cuscutaceae*	T	NAM	1997 (Karaman)	Ruderalis, (sub)mediterranean shrublands and rocklands
Datura stramonium L.	*Solanaceae*	T	NAM	1875 (Pančić)	Ruderalis, widespread
Eleusine indica (L.) Gaertn.	*Poaceae*	T	AFR	1959/1960 (Hodak)	Ruderalis/ vegetation near the road sides, trampled habitats, city lawns etc.
Eleusine tristachya (Lam.) Lam.	*Poaceae*	T	SAM	1998 (Lakušić)	Ruderalis/ trampled habitats, city lawns
Erigeron annuus (L.) Pers.	*Asteraceae*	T	NAM	1972 Stanković-Tomić	Ruderalis/widespread, seminatiral habitats, meadows, shurbalnd
Erigeron annuus subsp. serpentionalis	*Asteraceae*	T	NAM	2005 (Stešević&Jovanović)	Ruderalis/widespread, seminatiral habitats, meadows, shurbalnd
Euphorbia maculata L.	*Euphorbiaceae*	T	NAM	1979 (Obradović & Budak)	Ruderalis/ trampled habitats
Euphorbia prostrata Aiton.	*Euphorbiaceae*	T	NAM	1984 (Pulević)	Ruderalis/trampled habitats
Galinsoga parviflora Cav.	*Asteraceae*	T	NAM	1968 (Blečić)	Ruderalis, widespread
Helianthus xlaetiflorus Pers.	*Asteraceae*	G	NAM	1980 (Obradović)	Ruderalis/waste places, river banks

Helianthus tuberosus L.	*Asteraceae*	G	NAM	2005 (Stešević&Jovanović)	Ruderalis/waste places, river banks
Impatiens parviflora DC.	*Balsaminaceae*	T	AS	2010 (Stešević & Drescher)	River bank
Lepidium virginiacum L.	*Brassicaceae*	T	SAM	1936 (Rohlena)	Ruderalis/ vegetation near the road sides and railways, roofs
Medicago sativa L.	*Fabaceae*	H	AS	1874 (Pantoczek)	Widespread
Oenothera biennis L.	*Onagraceae*	H	NAM	1976 (Pulević)	Ruderalis
Oenothera glazioviana Micheli	*Onagraceae*	H	NAM	2008 (Rakaj & Krzysztof)	Sandy dunes, ruderalis
Oenothera fallax Renner et Rostanski	*Onagraceae*	H	NAM	2008 (Rakaj & Krzysztof)	Sandy dunes, ruderalis
Opuntia vulgaris Mill.	*Cactaceae*	H	NAM	1930 (in Pulević 2005)	Mediterannean rocklands, vegetation near the roadside
Paspalum dilatatum Poir.	*Poaceae*	H	SAM	1986 (Ilijanić & Topić)	Ruderalis,/trampled habitats, lawns, wet meadows
Paspalum paspaloides (Michx.) Schribn.	*Poaceae*	H	CAM, SAM	1949 (Černjavski et al.)	Ruderalis, city lawns, wet meadows
Reynoutria japonica Houtt.	*Polygonaceae*	G	AS	2005 (Stešević&Jovanović)	Natural forests, river banks, ruderalis/vegetation near the road sites
Robinia pseudacacia L.	*Fabaceae*	P	NAM	1911 (Rohlena)	Natural forests, river banks, ruderalis/vegetation near the road sites
Solanum elaeagnifolium Cav.	*Solanaceae*	H	SAM	2003 (Hadžiablahović et al.)	Ruderalis, wet meadows
Sorghum halepense (L.) Pers.	*Poaceae*	H	EAS	1874 (Pantoczek)	Widespread
Sporobolus poirettii (R.et S.) Hitche	*Poaceae*	H	NAM	1998 (Niketić in Greuter)	Ruderalis, vegetation near the road sides, city lawns
Sporobolus vaginiiflorus (Torrey) Wood	*Poaceae*	T	NAM	2006 (Stešević & Jogan)	Ruderalis/ vegetation near the road sides, city lawns
Tamarix dalmatica Baum.	*Tamaricaceae*	P	AFR	1942 (Rohlena)	River banks, Sandy dunes
Veronica persica Poir.	*Scrophulariaceae*	T	AS	1900 (Baldacci)	Widespred
Xanthium strumarium L. *italicum* (Moretti) D.Löve	*Asteraceae*	T	NAM	1900 (Horak)	Ruderalis, sandy dunes
Xanthium spinosum L.	*Asteraceae*	T	SAM	1874 (Pantoczek)	Ruderalis, widespread

viability of seeds or C4 photosynthetic pathways-like in *Amaranthaceae* (Cronquist, 1981, Heywood, 1989). Majority of families (13) are represented with only one species (**tab. 2**).

Genera represented with highest number of IAS are *Conyza* (3) *Oenothera* (3), *Erigeron* (2), *Euphorbia* (2), *Amaranthus* (2), *Bidens* (2), *Xanthium* (2), *Eleusine* (2), *Paspalum* (2), *Sporobolus* (2). Up to now only two subspecies of *Erigeron annuus* are recorded in the flora of Montenegro: ssp. *annuua* and ssp. *serpentionalis*, but considering the fact that third ssp. *strigosus* is reported for the flora of neighboring countries (Croatia- Nikolić (2010), Serbia- Jovanović (1994)) we expect to find it soon, so taxonomic spectrum of genera will look a bit different.

As it was expected considering life forms therophytes shows predominance with 26 species fig. 1. They are followed by hemicriptophytes (12), than phanaerophytes (6), geophytes (5) and chamaephytes (1). Hydrophytes are not present at all. Feature that are enabling therophytes to become very successful invaders are short life cycle (annuals), high reproductive rate, easily dispersed seeds etc.

Due to its native range, exactly half of IAS originates from North America (25), while second dominant are Asian (11) (fig.2). These species were mainly introduced as ornamental plants (*Robinia pseudoacacia, Acer negundo, Ailanthus altissima, Reynoutria japonica,* etc.) and very soon they started to escape into the wild, invading native ecosystems with disastrous results and become invasive species. From the other side, greatly improved transport that enables traders to move goods from distant destinations provided ideal opportunities for the accidental introduction of AIS (*Paspalum* spp., *Eleusine* spp.).

Considering the patterns of habitat invasion, our results are similar to Chytrý et al. (2008). Despite large differences in species, it is possible to notice regularity in the patterns of habitat invasion. A general trend is: in harsh climatic conditions and nutrient-poor habitats, invasion levels are low. Alien

plants tend to thrive in nutrient-rich and man-made habitats. Mountains, cliffs, bogs, dry grasslands and coniferous woodlands tend to resist alien invasion, while coastal and riverine habitats, where nutrient availability and disturbance can be high, are more prone to invasion by alien plants. Human made habitats such as farmland and urban landscapes also facilitate the spread of alien plants.

Table 2. Taxomonic spectrum of families of IAS in Montenegro

Family	No of taxa	%
Asteraceae	16	32
Poaceae	7	14
Fabaceae	3	6
Brassicaceae	3	6
Onagraceae	3	6
Amaranthaceae	2	4
Cuscutaceae	2	4
Euphorbiaceae	2	4
Aceraceae	1	2.0
Aizoaceae	1	2.0
Asclepiadaceae	1	2.0
Balsaminaceae	1	2.0
Cactaceae	1	2.0
Commelinaceae	1	2.0
Malvaceae	1	2.0
Moraceae	1	2.0
Polygonaceae	1	2.0
Scrophulariaceae	1	2.0
Simaroubaceae	1	2.0
Solanaceae	1	2.0
Tamaricaceae	1	2.0

Due to the favorable climate and higher level of disturbance Mediterranean part of the country hosted significantly higher number of invasive species than continental-mountainous. IAS typical for Mediterranean part of the country are: *Carpobrotus edulis, Opuntia vulgaris, Oenothera glazioviana, O. fallax, Conyza bonariensis, C. albida, Aster squamatus, Asclepias syriaca, Acer negundo, Amaranthus hybridus, Lepidium virginicum, Bidens subalternans, Helianthus tuberosus, H. laetiflorus, Xanthium spinosum, Eleusine indica, E. tristachya, Sporobolus poiretti, S. vaginiiflorus, Commelina communis, Solanum elaeagnifloium, Tamarix dalmatica, Amorpha fruticosa, Paspalum paspaloides, P. dilatatum.*

Up to now only one species (*Impatiens parviflora*) has distribution restricted only to continental part of the country (riverine forests). This is explained by its ecological preferences of species: very susceptible to water stress and a shade tolerant, mostly found at 5-40% relative daylight, prefer nitrogen rich stands, with pH range between 4.5 and 7.6 (C o m b e , 1956).

Fig. 1. Structure of invasive alien flora with respect to life forms.

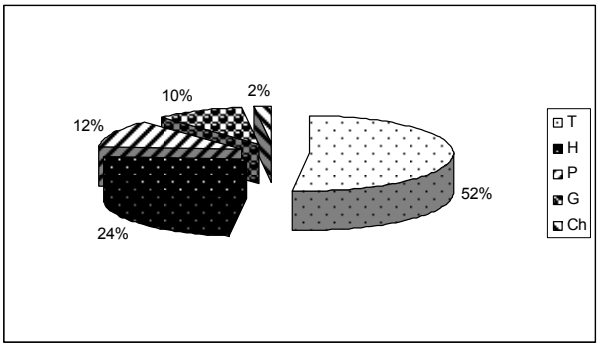
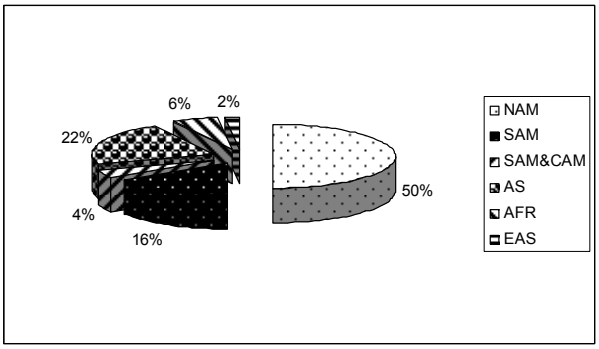


Fig. 2. Structure of invasive alien flora with respect to origin.



Other species, such as *Robinia pseudoacacia, Erigeron annuus, Amaranthus retroflexus, Veronica persica, Xanthium strumarium* ssp. *italicum, Ailanthus altissima, Reynoutria japonica* are distributed in both part of the country.

Considering *Ailanthus* and *Reynoutria*, at the beginning of our field study we noticed that first species mainly invaded mediterannean part of the country, while the second one is restricted to continental part. But during the last year both species started to move its borders. Along the roadsides *Ailanthus* moved towards the north and *Reynoutria* along roadsides and riverbanks towards the south. Success of this "movement" is strongly supported by increase of a disturbance.

As it can be seen in table 1, majority of IAS are for the first time recorded in our flora in last few decades, but we can't exactly state when these species were really introduced, by which pathways and when expansion of its populations has really started. With this study we intended to do a zero stage for a future monitoring of IAS, but also to draw attention to the problems which expansion of IAS is bringing with itself.

Majority of species listed above are also recognized as invasive in our first neighboring Mediterranean country- Croatia (B o r š i ć , 2008).

Conclusion

Preliminary list of IAS in Montenegro consists of 50 flowering plants belonging to 36 genera, 20 families and 2 classes. *Carpobrotus edulis* is for the first time reported for Montenegro.

The highest number of IAS has families *Asteraceae* and *Poaceae*, while between genera dominant are *Conyza* and *Oenothera.*

In the spectrum of life forms therophytes are prevailing, while due to its native range, majority of IAS has North American and Asian origin.

Considering the patterns of habitat invasion, highly disturbed, man made and nutrient rich habits are more prone to invasion by alien plants than natural and nutrient-poor habitats.

Due to the favorable climate and higher level of disturbance Mediterranean part of the country is more favorable for plant invaders than continental-mountainous.

The aim of this study was to provide a basic data on IAS in Montenegro, to enable future monitoring and to draw attention on the problems which expansion of IAS is bringing with itself.

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