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## PRELIMINARY CHECK-LIST OF INVASIVE ALIEN PLANT SPECIES (IAS) IN CROATIA

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Boršić, I., Milović, M., Dujmović, I., Bogdanović, S., Cigić, P., Rešetnik, I., Nikolić, T. & Mitić, B.: Preliminary check-list of invasive alien plant species (IAS) in Croatia. *Nat. Croat.*, Vol. 17, No. 2., 55–71, 2008, Zagreb.

In this paper a preliminary check-list of invasive alien plant species (IAS) in Croatia is presented. It has been created on the basis of the literature and of field observations. The list consists of 64 taxa, with family, life-form and geographic origin assigned to each IAS. Analyses according to family affiliation, life-form and origin were made. Out of 27 families the majority (24 families) belong to the dicotyledons. The most numerous family is *Asteraceae*, and genera with the highest number of IAS are *Conyza*, *Erigeron* and *Impatiens*. Life-form analysis showed the predominance of the therophytes but also presence of hemicryptophytes, phanaerophytes and geophytes. In the origin analysis, IAS from the Americas predominated, followed by those from Asia and Africa.

**Key words:** invasive alien plant species (plant IAS), alien flora, introduced flora, Croatia

Boršić, I., Milović, M., Dujmović, I., Bogdanović, S., Cigić, P., Rešetnik, I., Nikolić, T. & Mitić, B.: Preliminarni popis invazivnih stranih biljnih vrsta (IAS) u Hrvatskoj. *Nat. Croat.*, Vol. 17, No. 2., 55–71, 2008, Zagreb.

U radu je predstavljen preliminarni popis invazivnih stranih biljnih vrsta (IAS) u Hrvatskoj. Izrađen je na temelju literaturnih podataka i opažanja na terenu. Popis se sastoji od 64 svojte, kojima je pridružena pripadajuća porodica, životni oblik i geografsko podrijetlo. Izvršene su analize prema pripadnosti porodicama, životnom obliku i podrijetlu. Od 27 porodica većina (24 porodice) pripada dvosupnicama. Najbrojnija porodica je porodica *Asteraceae* dok su rodovi *Conyza*, *Erigeron* i *Impatiens* zastupljeni s najvećim brojem svojti. Analiza životnih oblika pokazala je dominaciju terofita, ali i prisutnost hemikriptofita, fanerofita i geofita. Po podrijetlu dominiraju invazivne svojte iz obiju Amerika, a slijede ih one iz Azije te Afrike.

**Ključne riječi:** invazivne strane biljne vrste, strana flora, alohtona flora, Hrvatska

## INTRODUCTION

Alien species are considered to be »species introduced and growing outside of their natural distribution« (MITIĆ *et al.*, 2008). Their spread was enabled and in the last decades considerably enhanced by long-distance trade, travel and tourism. Although Europe has mostly been a source of taxa in these processes (CROSBY, 1986), it has also received a great number of alien plants from other parts of the world. Until recently, just a few European countries had exhaustive information regarding their alien floras while for most of them at least some data on alien plant species existed (cf. PYŠEK *et al.*, 2002). This situation has positively improved with the DAISIE project which included 49 countries/regions in its inventory of alien plant species at the European level (LAMBTON *et al.*, 2008).

According to the proposed categorisation of alien (non-native) flora in Croatia, plant invasive alien species (IAS) are defined as »naturalized plants that produce reproductive offspring, often in very large numbers and at considerable distances from the parent plants and thus have the potential to spread over large areas (produce reproductive offspring more than 100 m in less than 50 years through generative reproduction and/or more than 6 m in three years through vegetative reproduction)« (RICHARDSON *et al.*, 2000; MITIĆ *et al.*, 2008). Thus, it is necessary for the naturalized species to overcome environmental barriers as well as to spread successfully into new areas in order to become effective invaders (cf. RICHARDSON *et al.*, 2000). The habitats they mostly invade are disturbed, human-made or semi-natural.

The problem of IAS has become one of the most important issues in conservation biology during the last decades. Invasive species are nowadays recognized as the second most important cause of biodiversity loss, just after direct habitat destruction (GENOVESI & SHINE, 2003). For example, VILA *et al.* (2006) have shown that invasion of *Carpobrotus* species, *Ailanthus altissima* (Mill.) Swingle and *Oxalis pes-caprae* L. considerably decreased species richness on Mediterranean islands and altered environmental conditions. Apart from being deleterious from the conservational and environmental point of view, IAS have a strong negative economic impact (PIMENTEL, 2002). In addition to that, some species pose a great problem to public health (e. g. allergenic plant *Ambrosia artemisifolia* L.; PETERNEL *et al.*, 2005).

Compared to the generally rich history of floristic research in the territory of Croatia, the bibliography on alien plant taxa in Croatia is not abundant. While, for example, alien plant taxa were systematically recorded from the beginning of the 20<sup>th</sup> century in what is now the Czech Republic (PYŠEK *et al.*, 2002), in Croatia only sporadic and in many cases accidental records concerning adventive/neophyte plant taxa exist. They mostly concern the first records of new alien plant taxa for Croatia (e.g. ILIJANIĆ, 1990; BOGDANOVIĆ *et al.*, 2006). Only a minority of articles deal with the distribution and spread of neophyte species in Croatia (e.g. FRANJIĆ *et al.*, 1998; SMITAL *et al.*, 1998).

The first more or less comprehensive list of alien species in Croatia with analyses regarding their life forms and origins was presented in DOBROVIĆ *et al.* (2005). The list comprised casuals, naturalized non-invasive and naturalized invasive alien spe-

cies while cultivated species and archaeophytes were not included. Out of 206 plant taxa on the list, 48 were considered invasive. Apart from this data, there is also an unpublished document of Starmühler that mentions 157 alien taxa for Croatia. This list was used in the inventory of alien species in the framework of the DAISIE project, where Croatia was represented only by this total number of alien plants. As Croatian botanists were not involved in that project, other data on alien and/or neophyte species were not included (LAMBTON *et al.*, 2008). With regard to invasive alien species only, DOBROVIĆ *et al.* (2006) reported 58 taxa on their preliminary list.

As a result of few national projects carried out during last years in Croatia (STANČIĆ, 2007; NIKOLIĆ, 2008), the module »Allochthonous plants« was especially developed and integrated in the already existing Flora Croatica Database (NIKOLIĆ, 2008) as a national standard, and a list of neophytes and the corresponding habitats has been produced (STANČIĆ, 2007).

As can be seen from the above, there has been no systematic research into either alien or invasive plant taxa in Croatia and no comprehensive check-list of alien flora exists. Categorisation has only recently been proposed for alien flora (MITIĆ *et al.*, 2008). Based on this categorisation, this is one of the first attempts to determine which alien plant taxa could be considered a threat to the native flora and should therefore be treated as invasive alien plant species in Croatia.

## MATERIAL AND METHODS

A preliminary check-list of invasive alien plant species in Croatia was created on the basis of two different procedures. Primarily, a survey of the literature was made. All relevant literature concerning non-native species, their first records and their spread on the territory of Croatia was examined. For the sake of completeness, the whole list of references is given, even though some of them are not cited in the text (see References). The articles were mostly from *Acta Botanica Croatica* (e.g. ILIJA-NIĆ & TOPIĆ, 1986), *Natura Croatica* (e.g. BOGDANOVIĆ *et al.*, 2003) and *Fragmenta phytomedica et herbologica* (e.g. GAŽI-BASKOVA & ŠEGULJA, 1978b). Especial consideration was given to the weeds from HULINA (1998a). As a second source, our own field observations were used.

The nomenclature of plant invasive alien species follows the Croatian Flora Check-list (NIKOLIĆ, 2008).

Life-form and origin were attributed to each IAS given on the check-list. The life-forms were interpreted according to Raunkier's system (RAUNKIER, 1934) as presented by ELLENBERG *et al.* (1991) and OBERDORFER (2001) and were denoted with the following abbreviations: **P** – Phanaerophytes, **Ch** – Chamaephytes, **H** – Hemipterophytes, **T** – Therophytes, **G** – Geophytes, **Hy** – Hydrophytes. For the IAS not listed in ELLENBERG *et al.* (1991) and OBERDORFER (2001), available literature (see References) was mostly used.

Geographic origins of IAS were attributed only in general terms (at the continental level except for Mediterranean species) and were assigned with the following

abbreviations: **Am** – the Americas (North and South), **As** – Asia, **Af** – Africa, **EA** – Eurasia, **M** – Mediterranean. Data on origin were taken mostly from the available literature (see References).

Basic statistic analyses were carried out to show the relative abundance of IAS according to the family affiliation, life-form and geographic origin. Taxa that originate from two different continents were considered as representatives for each of them in the origin analysis.

## RESULTS AND DISCUSSION

The preliminary check-list of invasive alien plant species in Croatia consists of 64 taxa and is presented in Table 1. There are neither pteridophytes nor gymnosperms on the list although alien representatives of these two groups exist in the flora of Croatia (cf. NIKOLIĆ, 2008). The species *Pinus nigra* Arnold is considered by SUŠIĆ & RADEK (2008) to be invasive on the island of Cres. It was often used for forestation because of its resistance and fast-growth, as was the case on the island of Cres. We did not include it on our list because it is a native species in Croatia, naturally distributed on Grobničko polje, near Senj, on Mala Kapela, Velebit (Paklenica) and Biokovo mountains, on the islands of Brač, Hvar and Korčula as well as on the Pelješac peninsula (LIBER, 2000). However, this species is also considered to be a transformer on rocky grasslands in Hungary (TÖRÖK *et al.*, 2003) and should therefore be monitored outside its native range.

The check-list presented here contains six more taxa, added on the basis of newer field observations, than the previous list of IAS produced by DOBROVIĆ *et al.* (2006). These added taxa are: *Cenchrus incertus* M. A. Curtis, *Duchesnea indica* (Andrews) Focke, *Nicotiana glauca* Graham and *Parthenocissus quinquefolia* (L.) Planchon. We have also included three subspecies in the checklist: *Erigeron annuus* (L.) Pers. subsp. *annuus*, *E. annuus* subsp. *septentrionalis* (Fernald et Wiegand) Wagenitz and *E. annuus* subsp. *strigosus* (Mühlenb. ex Willd.) Wagenitz, instead of the species *Erigeron annuus* (L.) Pers. which was on the list of DOBROVIĆ *et al.* (2006).

The list consists of invasive alien plant species that belong to 27 families (Tab. 2) of angiosperms, the majority of which (24 families with 55 taxa) belong to dicotyledons. Monocotyledons are represented by only three families with nine taxa. It is approximately the same ratio of dicotyledon and monocotyledon families as in the Croatian vascular flora in general (cf. NIKOLIĆ, 2001). The family with the highest number of IAS is *Asteraceae*, which is the second biggest family of the entire Croatian flora (with 448 taxa; NIKOLIĆ, 2001). It includes 22 invasive taxa, which account for more than one third of all IAS in Croatia. Other families with a considerable number of invasive taxa are *Poaceae*, *Solanaceae* and *Balsaminaceae*. Out of them, only *Poaceae* is among the 15 biggest families of Croatian vascular flora (6% of all taxa; NIKOLIĆ, 2001). The family *Solanaceae* with 41 taxa (NIKOLIĆ, 2008) accounts for less than 0.8% of Croatian vascular flora, while four invasive taxa belonging to this family total 6.3% of all IAS. The family *Balsaminaceae* is represented in the flora of Croatia by only five species (NIKOLIĆ, 2008), out of which a full three are consid-

**Tab. 1.** List of plant invasive alien species in Croatia.

Taxon	Family	Life form	Origin
<i>Abutilon theophrasti</i> Medik.	Malvaceae	T	EA Af
<i>Acer negundo</i> L.	Aceraceae	P	Am
<i>Ailanthus altissima</i> (Mill.) Swingle	Simaroubaceae	P	As
<i>Amaranthus retroflexus</i> L.	Amaranthaceae	T	Am
<i>Ambrosia artemisiifolia</i> L.	Asteraceae	T	Am
<i>Amorpha fruticosa</i> L.	Fabaceae	P	Am
<i>Angelica archangelica</i> L. subsp. <i>archangelica</i>	Apiaceae	H	EA
<i>Artemisia annua</i> L.	Asteraceae	T	EA
<i>Artemisia verlotiorum</i> Lamotte	Asteraceae	G	As
<i>Asclepias syriaca</i> L.	Asclepiadaceae	G	Am
<i>Aster squamatus</i> (Spreng.) Hieron.	Asteraceae	T	Am
<i>Bidens frondosa</i> L.	Asteraceae	T	Am
<i>Bidens subalternans</i> DC.	Asteraceae	T	Am
<i>Broussonetia papyrifera</i> (L.) Vent.	Moraceae	P	As
<i>Carpobrotus edulis</i> (L.) N.E.Br. in Phillips	Aizoaceae	Ch	Af
<i>Cenchrus incertus</i> M.A.Curtis	Poaceae	T	Am
<i>Chamomilla suaveolens</i> (Pursh) Rydb.	Asteraceae	T	As Am
<i>Chenopodium ambrosioides</i> L.	Chenopodiaceae	T	Am
<i>Conyza bonariensis</i> (L.) Cronquist	Asteraceae	T	Am
<i>Conyza canadensis</i> (L.) Cronquist	Asteraceae	T	Am
<i>Conyza sumatrensis</i> (Retz.) E.Walker	Asteraceae	T	Am
<i>Cuscuta campestris</i> Yuncker	Cuscutaceae	T	Am
<i>Datura innoxia</i> Mill.	Solanaceae	T	Am
<i>Datura stramonium</i> L.	Solanaceae	T	Am
<i>Diptotaxis erucoides</i> (L.) DC.	Brassicaceae	T	M
<i>Duchesnea indica</i> (Andrews) Focke	Rosaceae	H	As
<i>Echinocystis lobata</i> (Michx.) Torr. et Gray	Cucurbitaceae	T	Am
<i>Eleusine indica</i> (L.) Gaertn.	Poaceae	T	As
<i>Elodea canadensis</i> Michx.	Hydrocharitaceae	Hy	Am
<i>Epilobium ciliatum</i> Raf.	Onagraceae	H	Am
<i>Erigeron annuus</i> (L.) Pers. subsp. <i>annuus</i>	Asteraceae	T	Am
<i>Erigeron annuus</i> (L.) Pers. subsp. <i>septentrionalis</i> (Fernald et Wiegand) Wagenitz	Asteraceae	T	Am
<i>Erigeron annuus</i> (L.) Pers. subsp. <i>strigosus</i> (Mühlenb. ex Willd.) Wagenitz	Asteraceae	T	Am
<i>Euphorbia maculata</i> L.	Euphorbiaceae	T	Am
<i>Euphorbia prostrata</i> Aiton	Euphorbiaceae	T	Am
<i>Galinsoga ciliata</i> (Raf.) S.F.Blake	Asteraceae	T	Am

Tab. 1. continued

Taxon	Family	Life form	Origin
<i>Galinsoga parviflora</i> Cav.	Asteraceae	T	Am
<i>Helianthus tuberosus</i> L.	Asteraceae	G	Am
<i>Impatiens balfourii</i> Hooker f.	Balsaminaceae	T	As
<i>Impatiens glandulifera</i> Royle	Balsaminaceae	T	As
<i>Impatiens parviflora</i> DC.	Balsaminaceae	T	As
<i>Juncus tenuis</i> Willd.	Juncaceae	H	Am
<i>Lepidium virginicum</i> L.	Brassicaceae	T	Am
<i>Nicotiana glauca</i> Graham	Solanaceae	P	Am
<i>Oenothera biennis</i> L.	Onagraceae	H	Am
<i>Oxalis pes-caprae</i> L.	Oxalidaceae	G	Af
<i>Panicum capillare</i> L.	Poaceae	T	Am
<i>Panicum dichotomiflorum</i> Michx.	Poaceae	T	Am
<i>Parthenocissus quinquefolia</i> (L.) Planchon	Vitaceae	P	Am
<i>Paspalum dilatatum</i> Poir.	Poaceae	H	Am
<i>Paspalum paspalodes</i> (Michx.) Scribn.	Poaceae	H	Am
<i>Phytolacca americana</i> L.	Phytolaccaceae	H	Am
<i>Reynoutria japonica</i> Houtt.	Polygonaceae	G	As
<i>Reynoutria sachalinensis</i> (F.S.Petrop.) Nakai in T. Mori	Polygonaceae	G	As
<i>Robinia pseudoacacia</i> L.	Fabaceae	P	Am
<i>Rudbeckia laciniata</i> L.	Asteraceae	G	Am
<i>Solanum eleagnifolium</i> Cav.	Solanaceae	H	Am
<i>Solidago canadensis</i> L.y	Asteraceae	H	Am
<i>Solidago gigantea</i> Aiton	Asteraceae	H	Am
<i>Sorghum halepense</i> (L.) Pers.	Poaceae	H	Af As
<i>Tagetes minuta</i> L.	Asteraceae	T	Am
<i>Veronica persica</i> Poir.	Scrophulariaceae	T	As
<i>Xanthium spinosum</i> L.	Asteraceae	T	Am
<i>Xanthium strumarium</i> L. subsp. <i>italicum</i> (Moretti) D.Löve	Asteraceae	T	Am

ered invasive. There are no representatives of the families *Phytolaccaceae* and *Simroubaceae* in the Croatian flora other than the invasive *Phytolacca americana* L. and *Ailanthus altissima* (Mill.) Swingle, respectively. Genera with the highest number of IAS are *Conyza*, *Erigeron* and *Impatiens*.

The list of neophytes compiled by STANČIĆ (2007) contains among other data information on the status (naturalized/casual) and abundance (from rare to very frequent) of the taxa. The invasive status of the species is not indicated but most of the naturalized and at the same time frequent neophytes are included in our list as well.

**Tab. 2.** Family analysis of plant invasive alien species in Croatia.

Family	Number of taxa	%
Asteraceae	22	34.4
Poaceae	7	10.9
Solanaceae	4	6.3
Balsaminaceae	3	4.7
Brassicaceae	2	3.1
Euphorbiaceae	2	3.1
Fabaceae	2	3.1
Onagraceae	2	3.1
Polygonaceae	2	3.1
Aceraceae	1	1.6
Aizoaceae	1	1.6
Amaranthaceae	1	1.6
Apiaceae	1	1.6
Asclepiadaceae	1	1.6
Chenopodiaceae	1	1.6
Cucurbitaceae	1	1.6
Cuscutaceae	1	1.6
Hydrocharitaceae	1	1.6
Juncaceae	1	1.6
Malvaceae	1	1.6
Moraceae	1	1.6
Oxalidaceae	1	1.6
Phytolaccaceae	1	1.6
Rosaceae	1	1.6
Scrophulariaceae	1	1.6
Simaroubaceae	1	1.6
Vitaceae	1	1.6

Life-form analysis showed the predominance of therophytes (Fig. 1). They include 36 taxa which account for 56.3% of all IAS. The second share goes to hemi-cryptophytes with 12 taxa (18.7%). Phanaerophytes and geophytes are represented by seven taxa (10.9%) each. There is just one hydrophyte (*Elodea canadensis* Michx.) and one chamaephyte (*Carpobrotus edulis* (L.) N. E. Br. in Phillips). These results and especially the high percentage of therophytes were expected because therophytes (annual plants), with their short life cycle and production of many, easily dispersed seeds, are very effective as invasive plants. Moreover, weeds are generally also therophytes.

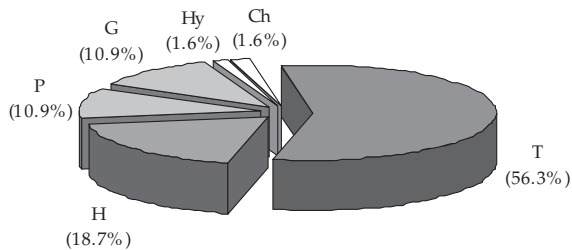


Fig. 1. Life-form analysis of invasive alien plant species in Croatia.

According to the results of geographic origin analysis (Fig. 2), most of the IAS in Croatia originate from the Americas (71.9%). They contain aliens from both North and South America. As much as 20.3% of invasive plant taxa in Croatia are native to Asia and 6.3% originate from Africa. Eurasian taxa account for 4.7% of all the IAS while there is only one species (1.6%) that originates in the Mediterranean (*Diploptaxis eruroides* (L.) DC.). The small percentage of invasive plants of Eurasian and Mediterranean origin could be explained by the fact that these taxa are likely archaeophytes and are by now a constitutive part of the natural vegetation. On the other hand, plants from the Americas have been spreading more vigorously during the last decades.

Comparing different countries regarding their plant invasive alien species in a quantitative and a qualitative sense is difficult because of the different terminology used. Also, different alien plants invade different habitat types. On the other hand, invasion history, data on invasiveness and effects of alien species observed in other (neighbouring) countries and areas are quite informative and therefore should be used for considering potentially invasive species. In comparison with the Slovenian list of IAS which does not include weeds, out of 42 plant taxa (JOGAN, 2006), 21 are also found on our list. These are mainly some of the most widespread alien species in Europe, such as *Acer negundo* L., *Ailanthus altissima* Desf., *Elodea canadensis* Michx., *Helianthus tuberosus* L., *Reynoutria japonica* Houtt., *Solidago* species etc. (cf. LAMBTON *et al.*, 2008). A list of invasive and transformer (invasive plants that change the character, condition, form or nature of plant communities and/or ecosystems; MITIĆ *et al.*, 2008) plant species occurring in major habitat types in Hungary also contains

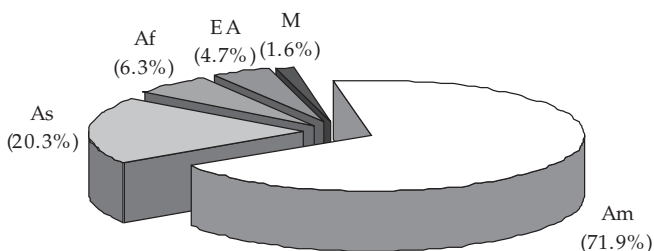


Fig. 2. Origin analysis of invasive alien plant species in Croatia.



most of the species that are believed to be invasive in Croatia (cf. TÖRÖK *et al.*, 2003). According to ESSL & RABITSCH (2002), 17 vascular plant species are considered invasive and 18 potentially invasive in Austria. Most of them are included in our list as well. STEŠEVIĆ (2005) cites eight major plant invaders in Montenegro, out of which only *Chenopodium album* L. and *Cardaria draba* (L.) Desv. are not included in our list. No data regarding invasive alien plant species were available to us for Serbia and Bosnia and Herzegovina.

The list presented in this article (Tab. 1) is one of our first attempts to define which alien plant species are invasive in Croatia. Strict nomination of some taxa as invasive according to the definition (see above) is hindered by the fact that the real data on their dispersal, accurate distribution, spreading dynamics etc., are mostly unknown. This list should not be considered either definite or complete, hence the attribute preliminary. The taxa from the list should constantly be monitored and the list should continuously be revised and updated depending on newly obtained data and field observations. It is recommended that the updates are done through the new module »Allochthonous plants« of the Flora Croatica Database (NIKOLIĆ, 2008; MITIĆ *et al.*, 2008) which is officially recognized as the national database by the responsible government department.

Although we have compiled much information regarding alien and especially invasive plant species in Croatia and are still working on it, there are yet many important data that need to be obtained, such as mode and year of introduction, accurate distribution data, velocity of spreading and invaded habitat types. In spite of that, we have decided to present our current results and thereby draw attention to the problem of invasive alien species in Croatia as well as contribute to this concerning issue.

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