Overview of the Invasive Alien Species in Croatia

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Abstract
Because of the increasing trends in the global movement of people and goods, IAS pose a growing problem in the conservation of biodiversity, and are a threat to many socio-economic interests. Croatia is particularly vulnerable to biological invasions, because of both the geographical context and the biogeographical specifics. It is known that over 350 alien species occur in the country. Many IAS related projects have been carried out in the last years in Croatia. Such projects concern both plants and animals, and focus on either acquisition of knowledge or implementation of concrete management measures.

Keywords
Invasive alien species, Croatia, nature protection

Introduction

Historically, problems with invasive alien species (IAS) in Croatia have been known beginning in 1910 when 11 specimens of mongoose *Herpestes auropunctatus* were introduced to the island of Mljet. Over a 20 year period, the mongoose eliminated all snakes on the island and began attacking other small reptiles, mammals and birds. The introduction of alien species in Croatia had probably started even earlier, but the biggest problems appeared in the second part of the 20th century. Known threats to Croatian biodiversity by IAS today are numerous. Their negative impacts on habitats and native species have increased due to the human activities such as trade, mobility and different economic sectors. Red books of freshwater fish, marine fish, amphibians and reptiles in Croatia have recognised the alien species as the most important or as one of the most important threats to those animal groups.

Legal and administrative background

Croatia is a contracting party of a number of international agreements, which include some provisions related to IAS, such as the Convention on Biological Diversity (CBD) and its Protocols, the Bern Convention, the Bonn Convention, etc.

At the national level, the issue of alien species is under the competence of several sectors and is governed by different regulations in the field of environmental and nature protection, agriculture, forestry, hunting, sea and freshwater fisheries, animal welfare.

The new Croatian *Nature Protection Act* (Official Gazette No. 80/2013) entered into force on 6 July 2013. It improves the national policy framework on IAS in order to minimise the risk of alien species, which enter and become established in Croatia. The new Act establishes important changes regarding alien species by regulating the criteria for import and placement on the market of the alien species, as well as their introduction into the nature, taking into consideration the risk assessment protocols in order to predict their invasiveness. All details regarding alien species management shall be laid down by the new Regulation. Alien species whose import and placement on the market will be prohibited ("Black list") and species whose import and placing on the market will be permitted without restrictions ("White list") shall be prescribed by the new Ordinance, and will be subject to the prior approval of the minister responsible for agriculture, fisheries, forestry and hunting. These lists shall be updated continuously.

The new Act is the main legislation related to the introduction of alien species into nature and their possible impact on biodiversity. According to its provisions, introduction of alien wild taxa into nature on the territory of the Republic of Croatia and in ecosystems, in which they are not native, is forbidden, but exceptionally it can be authorised by the Ministry of Environmental and Nature Protection if it is scientifically and technically founded and acceptable from the standpoint of nature protection, sustainable management and human health. The permit can be issued on the basis of the risk assessment study on introducing alien species into nature and the expert opinion of the State Institute for Nature Protection (SINP). Also, a natural or legal person who intends to breed alien wild taxa must obtain authorisation.

In the case of accidental introduction of alien taxa, or if there is a grounded suspicion that such introduction will occur, the competent authority responsible for nature protection can order measures for proceeding with the scope of destroying or preventing further reproduction of the introduced alien species.

Another important strategic document is the *Strategy and Action Plan for the Protection of Biological and Landscape Diversity of the Republic of Croatia* (NBSAP) (Official Gazette No. 143/2008), which defines the strategic objectives and action plans in relation to IAS. According to the Strategy, prevention of the introduction of IAS, resolving the issues of existing IAS, systematic monitoring of IAS distributions, and raising public awareness on IAS are recognised as critical issues. In June 2012, with the generous support of the Global Environment Facility

– GEF, Croatia started the project *National Biodiversity Planning to Support the Implementation of the CBD 2011-2020 Strategic Plan in Croatia* in order to update and revise the contemporary NBSAP. The draft outline for the new NBSAP will be prepared by 2014.

In addition, there are other sector regulations which contain provisions dealing with alien species issues and prohibit the introduction of alien species into nature, such as:

- *The Freshwater Fishery Act* (Official Gazette No. 106/2001, 7/2003, 174/2004, 10/2005);
- *The Marine Fishery Act* (Official Gazette No. 81/2013);
- *The Forestry Act* (Official Gazette No. 140/2005, 82/2006, 129/2008, 80/2010, 124/2010 and 25/2012);
- *The Hunting Act* (Official Gazette No. 140/2005 and 75/2009);
- *The Islands Act* (Official Gazette No. 34/1999, 149/1999, 32/2002 and 33/2006);
- *The Animal Protection Act* (Official Gazette No. 135/2006 and 37/2013);
- *Ordinance on Ballast Water Management and Inspection* (Official Gazette No. 128/2012) was adopted in 2012 on the basis of the Maritime Code (Official Gazette No. 181/2004, 76/2007, 146/2008 and 61/2011). The central state administration body in charge of the maritime affairs is responsible for dealing with this issue at the national level.

Review of the alien species

Lists of IAS for many taxonomic groups still do not exist or they are partial. However, Boršić et al. (2008) on the basis of literature review, personal experience and field observation prepared a preliminary list of invasive alien plants in Croatia. On this list they included 64 taxa (Annex I). An updated list is available on the Flora Croatica Database web page http://hirc.botanic.hr/fcd/ .

In the Red Book of Freshwater Fish of Croatia Mrakovčić et al. (2006) also presented a list of alien freshwater fish species. On this list they included 19 species. Four new species have been recorded since 2012 and there are data for established populations of *Neogobius gymnotrachelus* (Ćaleta et al. 2011a, b; Šanda et al. 2013; *unpublished* SINP).

In the Danube River basin, the limnophilous ichthyofauna is especially threatened, while the Adriatic basin, rich in endemic fish species, is extremely threatened in this regard. The list of alien freshwater fish species can be found in Annex II. Species indigenous to the Danube River basin, intentionally or unintentionally translocated to the Adriatic basin, such as the catfish (*Silurus glanis*), pike (*Esox lucius*), carp (*Cyprinus carpio*), zander (*Sander lucioperca*), etc., are not included in the list.

Furthermore, the freshwater biodiversity is highly threatened by the invasive alien invertebrates, such as the mussels *Corbicula fluminea*, *Dreissena polymorpha, Anodonta woodiana*, the snail *Potamopyrgus antipodarum*, and the crayfish *Orconectes limosus* and *Pacifastacus leniusculus* (Gottstein et al. 2009; Lajtner and Crnčan 2011; Maguire et al. 2008).

Coupled with the global climate change, the pressure of IAS in the Adriatic is increasing. The tropical green algae *Caulerpa taxifolia* and *Caulerpa racemosa* are spreading rapidly across the Adriatic Sea coastal benthic habitats. *C. taxifolia* was initially observed at two locations in 1994 and at another one in 1996. The other invasive green algae *C. racemosa* was first found in the autumn of 2000 near Pakleni Islands. By the end of 2005, this algae was observed at 43 locations from Cavtat to the island of Vis, including one near Vrsar (Istria). The eradication of *C. racemosa* is difficult and less effective than that of *C. taxifolia* (Žuljević and Antolić 2002; Žuljević et al. 2003, 2010).

At least 35 new species became new elements of the Adriatic ichthyofauna up until 2007. These species are represented by 22 families, out of which eight families are new to the Adriatic: *Hemiramphidae*, *Leiognathidae*, *Haemulidae*, *Siganiidae*, *Ipnopidae*, *Zoarcidae*, *Monacanthidae*, and *Cylopteridae*. Since 2007 two new fish species have been recorded: *Terapon theraps* and *Fistularia commersonni* (Dulčić and Dragičević 2011).

Review of current activities on IAS in Croatia

Several projects and activities on IAS were conducted or are on-going:

a. The project "*Estimated level of bio-contamination of the Sava River basin - a step towards the common strategy for monitoring the status of invasive alien species into transboundary watercourses of Croatia and Slovenia*" started in 2012, as a result of the collaboration between the Faculty of Science of the University of Zagreb, Division of Biology and the National Institute of Biology, Ljubljana, Slovenia.

b. Through the Natura Integration Project (NIP), lists of alien species for bryophyte, fungi, algae and lichens and for all vertebrates and 15 invertebrate taxonomic groups will be compiled until 2014.

c. In 2010, the project of development and implementation of faunistic database (CRO fauna) started as part of NPIS (Nature Protection Information System), financed from the IPA 2007 – TAIB/TAF programme, led by SINP. The CRO-fauna database will be designed to store all the relevant information about the IAS, needed for the efficient early warning and rapid response system.

d. O*rder for eradication of signal crayfish (*Pacifastacus leniusculus*) from inland waters* (Official Gazette No. 39/2012) was issued on April 4, 2012 by the Ministry of Environmental and Nature Protection in order to prevent the further spread of signal crayfish and its negative impact to the Croatian biodiversity.

*e. Order for eradication of wild boar (*Sus scrofa*) from the Adriatic islands* (Official Gazette No. 49/2012) was issued on April 27, 2012 by the Ministry of Environmental and Nature Protection in order to prevent further spread of wild boar and its negative impact to the Croatian biodiversity.

f. Related to the promotion of nature conservation and raising awareness among the interested public, the Ministry of Environmental and Nature Protection has established a new web portal for nature protection www.zastita-prirode.hr to provide the public with an easy access to information on nature protection issues in Croatia.

g. As part of an educational and awareness raising campaign, the State Institute for Nature Protection has established the new website on IAS www.invazivnevrste.hr This website should become a part of the Croatian early warning and rapid response system on IAS and provide lots of information about IAS in the Republic of Croatia.

h. The State Institute for Nature Protection is working on the development of an application for smartphones to simplify reporting and sending photos to the web page www.invazivnevrste.hr .

i. In 2013 SINP will work on the development and testing of the risk assessment system. Assessment for minimum 10 species will be done and the preparation of white and black lists will start.

j. In 2012, through cooperation of SINP with the GEO magazine, every month an article on invasive alien species was prepared and published in the GEO magazine. Furthermore, issues on IAS were presented by SINP to the interested public on the annual festival of aquarists and terrarium owners AkTer organised in October in Zagreb.

Case studies/ Best practices

a. In February 2012, one specimen of the signal crayfish (*Pacifastacus leniusculus*) was recorded in the Korana River, after which a rapid response was initiated. Activities were coordinated by SINP and involved the Ministry of Environmental and Nature Protection, Faculty of Science of the University of Zagreb, Public Institution for Governing Protected

Natural Assets in the Karlovac County "Natura Viva" and volunteers from local NGO's Sedra, RK Žabac and KPA Karlovac. Different measures were conducted:

- Education and public awareness
- Field research and preparation of an eradication plan
- Eradication action with 150 crayfish traps, done by 20 local volunteers.

The main goal is to stop and control future dispersion of the signal crayfish upstream and downstream. The eradication activities have started after preliminary research was done and an area of occurrence was defined. The project will continue in the coming years.

b. The NGO Biom conducted a research project in collaboration with the Public Institution Nature Park Lastovo. The project's goal was to conduct experimental eradication of the black rat (*Rattus rattus*) on three small islands, as well as to determine the influence of these measures on the nesting success of two bird species - the Cory's Shearwater (*Calonectris diomedea diomedea*) and the Yelkouan Shearwater (*Puffinus yelkouan*). The preliminary results showed nesting success and positive trends on two out of the three islands.

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Invasive species in Croatia: http://www.invazivnevrste.hr

Nature Protection Web Portal of the Croatian Ministry of Environmental and Nature Protection: www.zastita-prirode.hr

Institute of Oceanography and Fisheries: http://jadran.izor.hr/kaulerpa/

Annex I - Preliminary list of invasive alien plants in Croatia (Boršić et al. 2008)

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

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

Annex II - List of alien freshwater fish species in Croatia

Taxon	Family
Ameiurus melas (Rafinesque, 1820)	Ictaluridae (Ameiuridae)
Ameiurus nebulosus (Lesueur, 1819)	Ictaluridae (Ameiuridae)
Carassius auratus (Linnaeus, 1758)	Cyprinidae
Carassius gibelio (Bloch, 1782)	Cyprinidae
Coregonus lavaretus (Linnaeus, 1758)	Coregonidae
Coregonus peled (Gmelin, 1788)	Coregonidae
Ctenopharyngodon idella (Valenciennes, 1844)	Cyprinidae
Gambusia holbrooki Girard, 1859	Poecillidae
Hypophthalmichthys molitrix (Valenciennes, 1844)	Cyprinidae
Hypophthalmichthys nobilis (Richardson, 1845)	Cyprinidae
Lepomis gibbosus (Linnaeus, 1758)	Centrarchidae
Micropterus salmoides (La Cepede, 1802)	Centrarchidae
Neogobius fluviatilis (Pallas, 1814)	Gobiidae
Neogobius gymnotrachelus (Kessler, 1857)	Gobiidae
Neogobius kessleri (Gunther, 1861)	Gobiidae
Neogobius melanostomus (Pallas, 1814)	Gobiidae
Oncorhynchus mykiss (Walbaum, 1792)	Salmonidae
Oreochromis niloticus (Linnaeus, 1758)	Cichlidae
Perccottus glenii Dybowski, 1877	Odontobutidae
Piaractus brachypomus (Cuvier, 1818)	Characidae
Pseudorasbora parva (Temminck & Schlegel, 1842)	Cyprinidae
Salvelinus alpinus (Linnaeus, 1758)	Salmonidae
Salvelinus fontinalis (Mitchill, 1814)	Salmonidae