

Country reports

Alien species in Bulgaria: Policy, projects, research and awareness raising

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Abstract:

Bulgaria features a remarkable biodiversity owing to its geography and climate. At the same time it is much vulnerable to the introduction of alien plant and animal species. In the current paper we make a review of the information about alien species in Bulgaria (number of introduced species, pathways of introduction, status and impact of introduced populations), as well as policy, project, research and awareness raising activities related to alien species. So far the alien species within the reviewed taxonomic groups account for 340 vascular plant species, 347 terrestrial arthropods, 31 marine invertebrates, 3 freshwater bivalves, 23 freshwater fish, 1 reptile, 14 bird and 9 mammal species. About 12% of the alien vascular plant species, 25% of the aquatic species, 35% of the terrestrial arthropods, and 50% of the bird species were recorded after 2000. The main pathways of introduction of the alien species to Bulgaria and their further spread on the territory of the country include intentional as well as unintentional introductions. About 60 vascular plants, some terrestrial arthropods, most of the marine invertebrates and freshwater species, one reptile, two bird and four mammal species were reported as invasive and potentially invasive, with strong adverse impact on biodiversity, ecosystems, human health and economy of the country. Intensive project, research and awareness raising activities since 2000 focused on alien species inventory, study of their biological and ecological traits, an identification of the pathways of introduction, assessment of their impact and invasiveness, and development of risk management strategies. The results of this review demonstrate the urgent need of further studies and the development of a national strategy and risk management plan on invasive alien species in Bulgaria.

Key words:

Alien species of fungi, plants and animals; aquatic and terrestrial environment; Bulgarian legislation; research projects; information; national monitoring and reporting.

Introduction

Bulgaria features a remarkable biodiversity owing to its geography and climate. Almost 43 150 species have been recorded so far on its territory, they include a total of 30 359 animal species, belonging to 28 types and 75 classes (incl. Protozoa) (Hubenov 2008), and about 4100 species of vascular plants (Assyov et al. 2012), 719 species of bryophytes (Ganeva, Natcheva 2005), 3063 species of algae incl. Cyanoprokaryota (Temniskova et al. 2005), and about 4900 species of fungi (Denchev et al. 2005). At the same time, the biogeographic diversity of Bulgaria (Eurosiberian and Mediterranean biogeographical regions with Anatolian-Iranian, Pontian, and other elements; water bodies affiliated to three drainage river basins – the Danube River, Black Sea, and the Aegean Sea) makes it very vulnerable to the introduction of alien plant and animal species. In this paper, we make a review of the information about alien species in Bulgaria (number of introduced species, pathways of introduction, status and impact of introduced populations), as well as about policy, project, research and awareness raising activities related to alien species in Bulgaria.

Policy background

The Bulgarian legislation with provisions on alien species is in accordance with the European legislation (Table 1). The Biological Diversity Act and related ordinances provide on the introduction of alien and re-introduction of native plant and animal species into the natural environment. A permit for the release to the environment, as well as import for the purpose of breeding and raising of alien animal and plant species, can be issued only if “it is provided that this is not detrimental to any natural habitats in the natural range or to any native species of wild flora and fauna or to any populations thereof”. The procedure requires an application with an elaborate program, favourable scientific expertise, favourable decisions of the National Biodiversity Council and written authorisation granted by:

1. the Executive Director of the Executive Agency

of Forestry – in respect of any tree, shrub and game species;

2. the Minister of Environment and Waters – in respect of all other species.

A permit for re-introduction of native animal and plant species is issued only if it will be carried out in a way which would contribute to the restoration of the species in a favourable state. The procedure further requires taking into consideration the public opinion in the region of re-introduction of the species.

The provisions of the Biological Diversity Act also refer to fish and other aquatic organisms as stated in the Law on Fisheries and Aquaculture.

The release into the environment of any animal or plant species that is alien to the region is prohibited in the national and natural parks according to the Protected Areas Act. The deliberate release of GMOs into the environment is not permitted practically anywhere in Bulgaria according to the Genetically Modified Organisms Act (Table 1).

The trade with endangered species of wild flora and fauna, including those not native to Bulgaria, is regulated by both the Biological Diversity Act and the Animal Protection Act. Provisions on the import and export, as well as trade and transit transportation in the country of plant and animal species and products can be found also in the Plant Protection Act, Forestry Act, Law on Hunting and Game Protection, Law on Fisheries and Aquaculture, and the Live Stock Breeding Act (Table 1).

The phytosanitary control of plants and plant products during import, export and transit transportation, as well as production, transportation and trade on the territory of the country is regulated by the Plant Protection Act (Table 1). It corresponds to the EU Plant Health Directive and is based on species black listing approach. Provisions on the phytosanitary control of reproductive material of tree species and artificial hybrids, which are important for forestry purposes in Bulgaria and the Community, are also included in the Forestry Act.

The veterinary control of animals and animal products during import, export and transit transportation in the country is regulated by the Veterinary

Table 1. Bulgarian legislation with provisions related to alien species.

Legislation	Supplementary Regulations	Related EU Legislation	Target Group	Target Pathway	Provisions
The Biological Diversity Act (2002), State Gazette No. 77/2002 (amend. 2005, 2006, 2007, 2008, 2009, 2010, 2011, 2012, 2013)	<p>Ordinance No. 4/ 08.07.2003 on the conditions and procedure for issue of permits for release of alien plant and animal species into the environment or re-introduction of native plant and animal species</p> <p>Ordinance No. 14/ 27.10.2005 on the conditions for issue of permits for release of alien tree, shrub and game species into the natural environment or re-introduction of native tree, shrub and game species considering the public opinion in the region of re-introduction</p> <p>Decree of Council of Ministers for foreign trade regime of R. Bulgaria No. 233/ 2001, amend. 2005</p>	<p>EU Birds Directive</p> <p>EU Habitats Directive</p> <p>Wildlife Trade Regulation (WTR)</p>	Animal, plant and fungi species incl. subspecies and varieties	Intentional release into the natural environment; Import; Trade	<p>Provides on:</p> <ul style="list-style-type: none"> - Release into the natural environment, as well as import for the purpose of breeding and raising of alien animal, plant and fungi species, incl. subspecies and varieties; - Re-introduction of native animal and plant species. <p>Regulates trade with specimens of species included in the appendixes A, B, C, and D of the WTR.</p>
Protected Areas Act, State Gazette No. 133/1998 (amend. 1999, 2000, 2002, 2005, 2006, 2007, 2008, 2009, 2011, 2012, 2013)		<p>EU Birds Directive</p> <p>EU Habitats Directive</p>	Animal and plant species	Intentional release into the environment	Stipulates that release of plant and animal species that are alien to the region is prohibited in national and natural parks.
Plant Protection Act, State Gazette No. 91/10.10.1997 (amend. 1999, 2001, 2006, 2008, 2009, 2011)	<p>Ordinance No. 1 on Phytosanitary Control (State Gazette No. 82/ 17.07.1998, amend. 1999, 2002, 2003, 2006, 2007, 2008, 2009, 2010)</p> <p>And many other specific regulations on pest control</p>	Plant Health Directive	Animals, plants and pathogens harmful for the plants or plant products	Import, export and transit transportation; Production, transportation and trade on the territory of the country	Provides for phytosanitary control of plants, plant products, soils and growing medium, packages, containers, agricultural machinery, etc., associated with plants, as well as protection of plants and plant products from harmful organisms and diseases.
Forestry Act, 09.04.2011 (amend. 2012, 2013)	<p>Ordinance No. 2/ 30.01.2012 (State Gazette No. 10/03.02.2012) for the conditions and methods for applying plant protection products in the forests in Bulgaria</p> <p>Ordinance No. 56/ 11.11.2003 for protection of forests from pests, diseases and other damages</p> <p>Ordinance No. 5/ 5.02.2004 (State Gazette No. 93/27.11.2012) on the conditions and procedure for seed production in forestry, the collection and production of forest reproductive material, grading, marketing and import</p>	Council Directive 1999/105/EC on the marketing of forest reproductive material	Forest pests (animals, plants, fungi, viruses, bacteria)	Import, export and transit transportation; Production, transportation and trade on the territory of the country	Provides for protection of forests from pests, diseases and other damages and for phytosanitary control of reproductive material of those tree species and artificial hybrids thereof which are important for forestry purposes in Bulgaria and in all of the Community.

Legislation	Supplementary Regulations	Related EU Legislation	Target Group	Target Pathway	Provisions
Animal Protection Act , 31.01.2008 (amend. 2009, 2011)		Commission Regulation (EC) No 1739/2005 of 21.11.2005 laying down animal health requirements for the movement of circus animals between Member States	Primates and wild cats; (Circus animals)	Import, trade, holding	Stipulates that import, trade, holding and rearing of primates and wild cats are not permitted except for zoos and rescue centers. Veterinary control for the movement of circus animals is according to the Commission Regulation (EC) No. 1739/2005.
Veterinary Medical Act , 02.05.2006 (amend. 2007, 2008, 2009, 2010, 2011, 2012, 2013)	Ordinance No. 4/ 12.03.2002 for border veterinary control (amend. 2003)	EU Animal Health Regime European Convention for the protection of animals during international transport , 13.XII.1968	Animal and bird parasites and other transmissible diseases incl. zoonoses	Import, export and transit transportation in the country	Provides for the veterinary medical control at the import, export and transit transportation in the country of animals (for breeding, raising, pets, zoos, circuses), animal products, embryos, ova, semen, cell cultures, fodder, fodder mixtures, vitamin and mineral premixes, etc.
Law on Hunting and Game Protection, State Gazette No. 78/2000 (amend. 2001, 2002, 2005, 2006, 2007, 2008, 2009, 2010, 2011, 2012, 2013)		EU Birds Directive EU Habitats Directive	Game mammals and birds	Trade and export	Regulates trade (within the country) and export of live game species and game products which is permitted only with veterinary certificate and certificate for origin. The import of game species for release into the environment or re-introduction of native species is regulated by the Biological Diversity Act.
Law on Fisheries and Aquaculture, State Gazette No 41/2001 (amend. 2005, 2006, 2008, 2009, 2010, 2011, 2012, 2013)	Ordinance No. 4/ 13.01.2006 on the procedure of first sale of fish and other aquatic organisms Ordinance No. 37/ 10.10.2008 on the use of the reservoirs which are state property for fishery	EU Habitats Directive Council Directive 90/425/EEC Council Directive 91/492/EEC Council Regulation (EC) No 2371/2002 , etc.	Fish, fish products and other aquatic organisms	Trade; Stocking	Regulates trade of fish, fish products and other aquatic organisms, including genetic material (fertilized eggs, sperm, stocking material, etc.) from fishery, aquaculture or import. Provides for standards and conditions for fish stocking in reservoirs and require preparation of stocking reports, veterinary health certificate and genetic certificate (in case of sturgeon stocking). Introduction of alien species and re-introduction of native species of fish and other aquatic organisms into the water bodies is regulated by the Biological Biodiversity Act.

Legislation	Supplementary Regulations	Related EU Legislation	Target Group	Target Pathway	Provisions
Live Stock Breeding Act, 09.09.2000 (amend. 2004, 2005, 2006, 2007, 2008, 2010, 2011, 2012, 2013)		Council Directive 94/28/EC Council Directive 91/174/EEC, etc.	Animals	Import	Regulates import from third countries of pure-bred breeding animals, their semen, ova and embryos. The veterinary control during import is carried out according to the requirements of the Veterinary Medical Act.
Genetically Modified Organisms Act, 2005 (amend. 2006, 2007, 2008, 2009, 2010, 2011, 2013)	Ordinance No. 211/04.10.2005 on contained use of GMOs Ordinance No. 212/04.10.2005 on deliberate release into the environment and placing on the market of GMOs	Council Directive 2001/18/EC	GMOs	Deliberate release into the environment; Trade; Import, export and transit transportation in the country	Stipulates that deliberate release of GMOs into the environment is not permitted in protected areas and Natura 2000 sites, incl. 30 km buffer zones, near areas with traditional agriculture and beekeeping, etc. Provides on the procedures for issue of permits for import, export and transit transportation of GMOs in the country.
Water Act, 28.01.2000 (amend. 2001, 2001, 2003, 2004, 2005, 2006, 2007, 2008, 2009, 2010, 2011, 2012, 2013)	Ordinance No. 1/11.04.2011 (amend. 2013) on water monitoring Ordinance No. H-4/14.09.2012 (State Gazette No. 22/05.03.2013) on characterization of surface waters Ordinance from 30.11.2010 on protection of the marine environment; and others	Water Framework Directive Marine Strategy Framework Directive			Alien species (origin, history of introduction, distribution and abundance) are included as criteria for the assessment of biological impact on the marine environment.

Medical Act. It is applied also to game mammals and birds during trade and export (according to the Law on Hunting and Game Protection); to fish, fish products and other aquatic organisms during trade and stocking (Law on Fisheries and Aquaculture); and to import of pure-bred breeding animals (Live Stock Breeding Act) (Table 1). The veterinary control on the movement of circus animals is according to the Commission Regulation (EC) No. 1739/2005.

In the Water Act and supplementary ordinances, the IAS are included as criteria for the assessment of biological impact on the marine environment.

The responsible institutions for the implementation of the above mentioned legal instruments are the Ministry of Environment and Water of Bulgaria and

the Ministry of Agriculture and Food and their affiliated agencies.

Review of the alien species in Bulgaria

The results of the review of alien species recorded in Bulgaria are summarised per taxonomic groups in Table 2.

About 340 alien species of **vascular plants** introduced after 1500 (neophytes) have been recorded so far in Bulgaria (Petrova, Vladimirov, unpublished data; Table 2). The families, the richest in alien taxa, are Asteraceae, Poaceae, Fabaceae, Amaranthaceae, Chenopodiaceae, and Euphorbiaceae. About 60 spe-

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Table 2. Alien species in Bulgaria.

Taxonomic group	Number of all alien species recorded	Number of alien species recorded after 2000	Pathways of introduction	Present status/ Invasiveness/ Impact
Vascular plants	ca. 340	40	<p>The main pathways are:</p> <ul style="list-style-type: none"> - introduction as commodities (e.g. for ornamental purposes, wood production, erosion control, recultivation of disturbed areas), followed by escape from the cultivation; a few species were intentionally released in nature; - introduction as contaminants in commodities; - unaided dispersal from neighbouring regions where the species are alien. 	<p>About 60 species are considered invasive or potentially invasive, of them the worst invasive terrestrial plants are: <i>Acer negundo</i>, <i>Ailanthus altissima</i>, <i>Ambrosia artemisiifolia</i>, <i>Amorpha fruticosa</i>, <i>Bidens frondosus</i>, <i>Fallopia xbohemica</i>, <i>Helianthus tuberosus</i>, <i>Opuntia humifusa</i>, <i>Paspalum paspalodes</i>, <i>Robinia pseudoacacia</i>, <i>Sicyos angulatus</i>, etc. The recorded impacts include: a competition with native plant species, changes in the composition and structure of plant communities and habitats, parasitism on local plants, competition with cultivated plants and economic losses for agriculture, threat to human health (allergies, dermatitis, etc.). Many alien species are noxious weeds, e.g. <i>Amaranthus retroflexus</i>, <i>A. hybridus</i>, <i>Cuscuta campestris</i>, <i>Erigeron annuus</i>, <i>E. bonariensis</i>, <i>E. canadensis</i>, <i>E. sumatrensis</i>, <i>Galinsoga parviflora</i>, <i>G. quadriradiata</i>, <i>Sorghum halepense</i>, and <i>Xanthium italicum</i>.</p>
Arthropods (terrestrial)	347	116	<p>The main pathway is trade - as commodity contaminants with ornamental plants; vegetables, fruits, wood, transport (vehicles, airplanes, ships).</p> <p>Other pathways are:</p> <ul style="list-style-type: none"> - as biological control agents; - spreading from neighbouring countries, where the species had been introduced. 	<p>Pests on plants and crops, some of them with potential impact on forestry, agriculture, horticulture and greenhouse industry.</p> <p>The plant pests with the highest negative impact to economy are: <i>Leptinotarsa decemlineata</i>, <i>Trialeurodes vaporariorum</i>, <i>Myzus persicae</i>, <i>Diaspidiotus perniciosus</i>, <i>Pseudaulacaspis pentagona</i>, <i>Hyphantria cunea</i>, <i>Phthorimaea operculella</i>, <i>Helicoverpa armigera</i>, <i>Grapholita molesta</i>, and <i>Frankliniella occidentalis</i>.</p> <p>The widespread species <i>Harmonia axyridis</i> and <i>Cameraria ohridella</i> pose the highest threat to biodiversity of Bulgaria.</p>
Invertebrates (marine)	31	7	As fouling organisms on ship's hulls, or as planktonic larvae in ballast water.	Some of them are highly invasive with strong ecological and economic impact – predation on and competition with native species; changes in habitats; fouling of underwater constructions and ship's hulls.
Bivalve mollusks (freshwater)	3 alien species; One translocated species	3	<p>Introduction to the Bulgarian waters through the Danube River.</p> <p>Introduction to the inland waters by passive movement upstream of the Danube tributaries or assisted by humans - mainly by transport of larvae or adult individuals with fishing equipment, boats and fish stocking material from the Danube River, fish farms nearby, and from infested reservoirs.</p>	<p>Three invasive alien mussels expanding their range of distribution upstream of the Danube tributaries and other inland water bodies (<i>A. woodiana</i>, <i>C. fluminea</i>, <i>D. r. bugensis</i>) with potential negative impact on the indigenous aquatic fauna.</p> <p>The translocated species <i>D. polymorpha</i> has strong negative ecological and economic impact in Bulgaria.</p>

Taxonomic group	Number of all alien species recorded	Number of alien species recorded after 2000	Pathways of introduction	Present status/ Invasiveness/ Impact
Fish (freshwater)	23 alien species; Several translocated species	4	<p>Introduction to Bulgaria:</p> <ul style="list-style-type: none"> - 18 species through intentional introduction for farming, stocking, biological control, recreational fishing; - 5 species through unintentional introduction -most likely by expanding their range of distribution in the Danube River (<i>L. gibbosus</i>, <i>P. glenii</i>), by stocking together with juveniles of East Asian herbivorous carp species (<i>P. parva</i>), by aquarium release (<i>Poecilia reticulata</i>) or other vectors. <p>Introduction to the inland waters mainly by fish stocking, aquaculture and as live bait.</p>	<p>Most of the species maintained by artificial reproduction and stocking in the inland waters, with decreasing populations and limited distribution.</p> <p>Five species established and widely spread in the inland waters, and one species (<i>P. glenii</i>) found so far only in the Danube River and adjacent wetlands, with potential negative impact.</p> <p>Several translocated species expanding their range outside their native range, with increasing abundance of their populations (<i>Barbatula barbatula</i>, <i>O. bureschi</i>, <i>S. abaster</i>, <i>Neogobius</i> sp., and others).</p>
Amphibians and reptiles	1		<p>The red-eared slider (<i>T. s. elegans</i>) has been introduced as pet species, followed by occasional releases by owners into natural environment throughout the country.</p> <p>Other amphibians and reptiles also introduced as pet species.</p>	<p>The red-eared slider is considered as an invasive species; it is well adapted to local conditions, competes with native species, and has a potential negative impact on the ecosystems owing to its active predation.</p> <p>At least 5 other alien species of turtles are considered of potential threat and their import, holding and trade need to be regulated.</p>
Birds	14; One translocated species	7 (?8)	<ul style="list-style-type: none"> (1) Escapees (from zoos, parks and similar collections or pets); (2) Birds from introduced European breeding populations; (3) Intentional introduction as game birds; (4) Domesticated birds. 	<p>The Rose-ringed Parakeet is considered invasive and potentially the worst among the alien bird species in Bulgaria, competing with native hole-nesting birds; in the future, a potential negative impact, such as a vector of diseases, agricultural pest and factor causing disturbance to humans, can be predicted.</p> <p>The Egyptian Goose is another potentially invasive species, so far recorded as breeding in the wild on several occasions only – in one of the Sofia city parks – involving birds freely moving from the Zoo nearby.</p> <p>A competition and interbreeding of the Chukar, translocated to non-native areas in Bulgaria, with the native Rock Partridge was reported.</p>
Mammals	9		<p>Two species escaped or released from fur farms (the coypu and American mink);</p> <p>Four species through unintentional introductions: alongside the Danube River (the raccoon dog and muskrat), or via sea ships in ancient times (the black rat and brown rat).</p> <p>At least two game species (the fallow deer and mouflon) have individuals living outside of the enclosures, but their distribution and abundance has been controlled by man.</p>	<p>The highest negative impact (threat to natural ecosystems, vector of diseases) reported for brown rat; Negative impact on natural ecosystems observed also in the coypu, the muskrat and the raccoon dog.</p>

cies (two of them aquatic) are considered invasive or potentially invasive. Of them, 17 species are included in the *List of 'Worst invasive alien species threatening biodiversity in Europe'* (Larsson et al. 2008), and 7 species are listed in the *'100 of the Most Invasive Alien Species in Europe'* (DAISIE 2009). The worst invasive species to Bulgaria are: *Acer negundo*, *Ailanthus altissima*, *Ambrosia artemisiifolia*, *Amorpha fruticosa*, *Bidens frondosus*, *Fallopia ×bohemica*, *Opuntia humifusa*, *Paspalum distichum*, and *Robinia pseudoacacia* (Petrova et al. 2012a). Most of the invasive and potentially invasive species originate from North America, followed by the Americas, Asia, South America, and the Mediterranean region. The main introduction pathway of the alien plants has been import as commodities; about 60% of these species were introduced intentionally with ornamental, forestry and erosion control purposes. The number of the newly recorded alien species has increased gradually but constantly during the last 120 years, with no indication of decrease. Since 2000, a total of 40 species have been recorded for the first time in the Bulgarian flora (Petrova et al. 2012b). A threat to human health is posed by *Ambrosia artemisiifolia* and *Iva xanthiifolia*, both of which have highly allergenic pollen. Some alien species are noxious weeds, e.g. *Amaranthus* spp., *Galinoga* spp., and *Sorghum halepensis*. Most vulnerable to the introduction of alien plant species are the disturbed and man-made habitats (urban areas, roadsides, railways, agricultural land, and riparian areas).

The alien **terrestrial arthropods** recorded so far in Bulgaria account for 347 species (unpublished data, Table 2). The highest number belongs to Hemiptera (99) and Coleoptera (88), followed by Lepidoptera (34), Acari (29), Hymenoptera (23), Phthiraptera (16), Diptera (15), Araneae (9), Thysanoptera (8), Collembola (8), Orthoptera (6), Myriapoda (3), Blattodea (3), Psocoptera (3), Zygentoma (1), Siphonaptera (1), and Dermaptera (1). Most of them originate from Asia (94), followed by the Americas (84), and Africa (45). 84 of the species are cryptogenic. Only 7 species were introduced intentionally as biocontrol agents (Tomov et al. 2007, 2009; Trencheva et al. 2012; Simov et al.

2012). About 52 species are widespread crop pests in Bulgaria but only eleven of them have negative impact on economy: *Leptinotarsa decemlineata*, *Triaurodes vaporariorum*, *Myzus persicae*, *Diaspidiotus perniciosus*, *Pseudaulacaspis pentagona*, *Viteus vitifoliae*, *Hyphantria cunea*, *Phthorimaea operculella*, *Helicoverpa armigera*, *Grapholita molesta*, and *Frankliniella occidentalis*. A threat to biodiversity of Bulgaria is posed by the widespread species: *Harmonia axyridis* and *Cameraria ohridella* (Pere et al. 2010). A threat to human health is posed by the Asian tiger mosquito *Aedes albopictus* detected in Bulgaria in 2011 (Medlock et al. 2012). There is a rapid increase in the number of the newly detected alien species after 2000, when 116 species were reported as new for the fauna of Bulgaria. The trade with plant material, in particular with ornamental plants, is the main pathway for the introduction of alien arthropods in Bulgaria (Table 2).

A total of 31 alien **invertebrate marine species** were recorded in the waters along the Bulgarian Black Sea Coast (Hubenov 2014; Table 2). They belong to Crustacea (9 species), Mollusca (9), Polychaeta (6), Coelenterata (4) and Ctenophora (3). Among the first recorded invaders (late 19th century) were the barnacles *Balanus eburneus* and *Balanus improvisus*, which originate from the West coast of North America and now are widespread. In the 20th century, some highly invasive alien species were introduced, changing completely the ecosystem of the Black Sea: the polychaete worm *Ficopomatus enigmaticus* (Indian Ocean), the gastropod *Rapana venosa* (Sea of Japan), the soft-shell clam *Mya arenaria* (Atlantic Ocean), the mussel *Anadara inaequalis* (Pacific coast of the Philippines), the ctenophores *Mnemiopsis leidyi* and *Beroe ovata* (Atlantic Ocean). The main pathway of introduction of the alien invertebrate marine species is as fouling organisms on ship's hulls, or as planktonic larvae in the ballast water.

Three invasive freshwater **bivalve mollusk species** – two with Asian origin, the Asian clam *Corbicula fluminea* and the Chinese pond mussel *Anodonta woodiana*, and one with Pontic origin, quagga mussel *Dreissena rostriformis bugensis*, were recently recorded in

the Bulgarian sector of the Danube River and subsequently in the Bulgarian inland waters (Hubenov 2001, 2006; Hubenov, Trichkova 2007; Trichkova et al. 2009; Hubenov et al. 2012, 2013). Another bivalve species, the Ponto-Caspian zebra mussel *Dreissena polymorpha*, which occurred originally in the Danube River and the Black Sea Coastal lakes and rivers, has spread rapidly into the Bulgarian inland waters. Currently more than 60 water bodies (lakes, reservoirs, rivers) have been infested by *D. polymorpha* that has an adverse impact on the biodiversity and native communities, and causes serious damages and losses to various industries, such as: the power generation, irrigation industry, drinking water supply, aquaculture, fishery, and recreation (Hubenov 2002; Kalchev et al. 2013, 2014; Kenderov et al. 2014; Kozuharov et al. 2009a,b,c, 2013; Ognjanova-Rumenova et al. 2013; Trichkova et al. 2007, 2008a, 2009, 2013, unpublished data). The introduction of the bivalve species to the inland waters happened by passive movement upstream of the Danube tributaries or assisted by humans (mainly by transport of larvae or adult individuals with fishing equipment, boats and fish stocking material from the Danube River, fish farms nearby, and from infested reservoirs) (Trichkova et al. 2007, 2009; Hubenov et al. 2012, 2013).

A total of 23 alien **freshwater fish species** have been introduced intentionally or unintentionally to the Bulgarian freshwaters, including the inland rivers, lakes and reservoirs, as well as the Bulgarian sector of the Danube River (Karapetkova, Živkov 1995; Jurajda et al. 2006; Pehlivanov, Atanasov, 2007; Uzunova, Zlatanova 2007; Polačik et al. 2008a; Ivanova et al. 2013; Table 2). Some of the fish species were introduced for biological control (the Asian carps, *Gambusia holbrooki*), including zebra mussel control (*Mylopharyngodon piceus*), as well as recreational fishing and fish-farming (e.g. *Hypophthalmichthys molitrix*, *Aristichthys nobilis*, *Ctenopharyngodon idella*, *Oncorhynchus mykiss*, *Salvelinus fontinalis* and *Thymallus thymallus*). Other fish species, such as *Lepomis gibbosus*, *Pseudorasbora parva* and *Percottus glenii*, were introduced unintentionally. Many of the alien freshwater fish stocks have been maintained only by arti-

ficial reproduction or continuous import and stocking (Uzunova, Zlatanova 2007). They are characterised with decreasing number and limited distribution. Other alien fish species adapted successfully to the new environment, established and became widespread in the Bulgarian water basins (e.g., *Carassius gibelio*, Trichkova, Živkov 2007, 2010; Trichkova et al. 2008b, 2010; *Gambusia holbrooki*, Zarev 2012; *L. gibbosus*, Uzunova et al. 2008, 2012). There are reports on fish species translocated from one water basin to another within the territory of the country, followed by an increase in their non-native range and population abundance. Recent studies showed a considerable increase in abundance of the Ponto-Caspian goby species in the Bulgarian sector of the Danube River and an expansion of their range upstream of the Danube tributaries and in other inland water basins in Bulgaria (Polačik et al. 2008a,b; Vassilev et al. 2009, unpublished data). A range expansion and increased abundance in the Bulgarian sector of the Danube River was reported also for *Syngnathus abaster* (Ondračková et al. 2012). The Struma loach *Oxynoemacheilus bureschi*, which is endemic for the Aegean Sea basin (rivers Struma and Mesta) has shown a tendency for expansion of its range out of its native range in Bulgaria. The species was found in the Palakaria River, a small tributary in the upper reaches of the Iskar River, Danube River basin, in the 1980s (Dikov et al. 1988), and recently spread upstream and downstream in the same catchment (Stefanov et al. 2013). In 2011 it was recorded for the first time in the middle-lower reaches of the Iskar River of comparatively high abundance (Kenderov, Trichkova 2014). The main pathways of introduction of the translocated and alien fish species in the inland waters are most likely fish stocking, aquaculture and as live bait (Table 2).

Only a few alien species of **amphibians and reptiles** have been found so far in Bulgaria. The red-eared slider (*Trachemys scripta elegans*) is the most common alien species at the market and it is also widespread in the wild. As a popular pet this species has been commonly released nearby big cities, but it was also found at distant locations from settlements (Stojanov et al. 2011). A number of other aquatic turtle species were

imported and have become popular pets in Bulgaria in recent years: the yellow-bellied slider (*T. s. scripta*), the false map turtle (*Graptemys pseudogeographica*), the common snapping turtle (*Chelydra serpentina*), the Chinese softshell turtle (*Pelodiscus sinensis*), the Florida softshell turtle (*Apalone ferox*), and others. All of them have already been found in the wild in other European countries. These species should be considered as a potential threat to Bulgaria as well. The alien turtles may have an adverse impact on the native turtle species, the European pond turtle (*Emys orbicularis*), by competing it, and on the ecosystems in general, by being active predators. The introduction of alien green frog species in Europe is another potential threat to Bulgaria. Among these species, the American bullfrog (*Lithobates catesbeianus*), deserves more attention as it has already become widespread in Western and Southwestern Europe, and there have already been inquiries about opening of commercial farms for this species in semi-natural enclosures in the country. A poorly studied group is that of the European green frogs (genus *Pelophylax*). Many species have already spread actively or passively across the European continent. This group is problematic because a specific set of methods is required for the proper species identification. There is also a large number of amphibian and reptile species that are commonly bred in captivity. The regulation of their import, holding and trade on the territory of the country is crucial.

A total of 14 alien **bird species** have been recorded in Bulgaria to date (Nankinov 2006), the tropics and the temperate zone being equally involved as their regions of origin. Four of them originate from the Americas – the Canada Goose (*Branta canadensis*), Muscovy Duck (*Cairina moschata*), Wood Duck (*Aix sponsa*), and the Wild Turkey (*Meleagris gallopavo*). Three species originate from Africa – the Egyptian Goose (*Alopochen aegyptiacus*), Helmeted Guineafowl (*Numida meleagris*), and the African Collared Dove (*Streptopelia roseogrisea*), while another two, both from Africa and Asia – the Laughing Dove (*Streptopelia senegalensis*) and the Rose-ringed Parakeet (*Psittacula krameri*). Two species are native to Australia – the Black Swan (*Cygnus atratus*) and the

Budgerigar (*Melopsittacus undulates*), two to East Asia – the Mandarin Duck (*Aix galericulata*) and the Japanese Quail (*Coturnix japonica*), and one to southwestern Europe – the Red-legged Partridge (*Alectoris rufa*). The main pathways of introduction of the alien bird species to Bulgaria include: (1) escapees from zoos, parks and similar collections or pets, and/or (2) birds from introduced European breeding populations – the Black Swan, Canada Goose, Egyptian Goose, Wood Duck, Mandarin Duck, African Collared Dove, Laughing Dove, Budgerigar, and the Rose-ringed Parakeet; (3) intentional introduction as game birds – the Japanese Quail and the Red-legged Partridge; (4) domesticated birds – the Muscovy Duck, Wild Turkey, and the Helmeted Guineafowl. Most of the intentional introduction attempts of alien species (as in the case of the Japanese Quail and the Red-legged Partridge) performed by the Union of Hunters and Fishermen in Bulgaria failed because of the lack of profound scientific studies prior to the releases. Such studies should become an essential part of any initiated introduction program. At least two of the alien bird species can be considered invasive, with potential negative impact in the future (Table 2). The Rose-ringed Parakeet is considered an invasive species and potentially the worst among the alien bird species in Bulgaria. It competes with the native hole-nesting birds, and in the future, a potential negative impact such as transfer of diseases, damages to agriculture and disturbance to humans can be predicted. Since its first record in Bulgaria in 1996 (Nankinov, Popov 1997), numerous records throughout the country have been collected, most of them coming from the Black Sea Coast and predominantly during autumn and winter time. An unsuccessful breeding attempt was observed in 2006 along the Northern Black Sea Coast (Nankinov 2006). The Egyptian Goose is another potentially invasive species in Bulgaria, so far recorded as breeding in the wild on several occasions only – in one of the Sofia city parks – involving birds freely moving from the Zoo nearby. The species is very adaptive and its numbers can increase exponentially when suitable conditions are available (Gyimesi, Lensink, 2010). A competition and interbreeding of the

Chukar (*Alectoris chukar*) with the Rock Partridge (*A. graeca*), both of them native to Bulgaria, was reported, as a result of the Chukar translocation into non-native areas; similar results were reported elsewhere as well (Barilani et al. 2007).

Nine alien **mammal species** have been reported in Bulgaria so far. There are records that individuals of the American mink (*Mustela vison*) escaped from some fur farms. However, for the present the distribution of the free-living individuals of the American mink is fairly restricted and there are no data about a negative impact from that species in Bulgaria. There are also reports that specimens of the coypu (*Myocastor coypus*) were intentionally released in certain swamps in South Bulgaria (Peshev et al. 2004). Two species (the raccoon dog, *Nyctereutes procyonoides*, and the muskrat, *Ondatra zibethicus*) entered the Bulgarian territory alongside the Danube River (Popov 1993). An enlargement of the range in one of them, the muskrat, is currently observed as some individuals have already been found in South Bulgaria (Milchev 2007), though there is not a direct link between the Danube River catchment area and the Aegean Sea basin. Two rat species (the black rat, *Rattus rattus*, and the brown rat, *Rattus norvegicus*) were introduced to Bulgaria in ancient times most likely via the sea ships. Among the alien mammal species, the brown rat had the highest negative impact on the natural ecosystems and humans. A negative impact on natural ecosystems was observed also in the coypu, the muskrat and the raccoon dog. There are some non-native game species introduced for the purposes of hunting tourism in Bulgaria (e.g. the European bison, *Bison bonasus*, and the Alpine ibex, *Capra ibex*) (Spiridonov, Spassov 1993). However, these species are kept in game reserves, living in large enclosures. There are data for only two game species (the fallow deer, *Dama dama*, and the mouflon, *Ovis musimon*), individuals of which have been found outside of the enclosures, but the distribution and abundance of these species are controlled directly by man. The breeding of exotic mammals as pets is becoming widespread in Bulgaria. Some of those animals have been released accidentally in nature as in the case of the American gray

squirrel (*Sciurus carolinensis*) (Grozdanov et al. 2004). For the time being, the mentioned release remain an isolated event, but may turn into a real issue with regard to some native species such as the Red squirrel *Sciurus vulgaris* (Grozdanov et al. 2004).

Review of the project, research and awareness raising activities related to alien species in Bulgaria

An inventory of alien and invasive alien species in the Bulgarian flora and fauna was initiated by the Ministry of Environment and Water of Bulgaria in 2004. The Ministry funded two projects, which were implemented by the Institute of Zoology and the Institute of Botany of the Bulgarian Academy of Sciences (BAS):

- Assessment of the alien species in the Bulgarian flora and mycota and measures to control their impact on the native ecosystems and species (2004-2006): Project leader: Assoc. Prof. Dr Ana Petrova
- Assessment of alien species in the Bulgarian fauna and measures to control their impact on the native ecosystems and species (2004-2006): Project leader: Prof. Dr Mladen Živkov.

Within these projects lists of alien and invasive alien species of plants, fungi, invertebrate and vertebrate animals were developed. Available information about distribution, biology, ecology and impact of these species was collected. Measures for prevention and reduction of the negative impact on native ecosystems were recommended. To raise the public awareness, a leaflet “*Invasive alien plants and fungi in Bulgaria – To mitigate their impact*” and a poster “*Invasive alien plants and fungi – To stop their invasion in Bulgaria*” were published and disseminated in 2006 with the financial support of the Ministry of Environment and Water.

Following and based on these initial inventories, several other research projects, focusing on alien species of different taxonomic groups, were implemented. Two projects funded by the National Science Fund at the Ministry of Education, Youth and Science, and

implemented by the Institute of Botany (currently Institute of Biodiversity and Ecosystem Research), BAS, were related to **invasive alien species of plants**:

- Investigation and control of the populations of the allergenic species of *Ambrosia* (Asteraceae) in Bulgaria; Project MU-B 1514/2005 (2005-2008); Project leader: Vladimir Vladimirov
- Biology, ecology and control of the invasive alien species in the Bulgarian flora; Project DO 02-194/2008 (2008-2012); Project leader: Assoc. Prof. Dr Ana Petrova.

Data on the distribution, ecology and biology of the invasive alien species in the Bulgarian flora were collected. The impact of the most harmful invasive plants on the native species and ecosystems, as well as on the human health was assessed. A review of the current worldwide practices for mitigation and control of the invasive alien species of plants, as well as testing of appropriate measures in Bulgaria were made. The results were summarised and published in more than 20 scientific papers and in a book entitled: *Invasive alien species of vascular plants in Bulgaria* (Petrova et al. 2013). The book presents information about 60 invasive and potentially invasive alien vascular plants recorded in Bulgaria, with a brief description of the morphological, biological and ecological characteristics, origin and distribution, as well as major measures for control. All taxa are illustrated with original colour photographs. The book is intended to focus the attention of the governmental authorities concerned with nature conservation on the growing threat of the invasive alien species of plants to the natural habitats, species and communities. The book is also of interest to scientists, university lecturers, students, teachers, and the general public.

Several research projects implemented by Bulgarian entomologists were related to the **alien terrestrial arthropods**:

Bioecology of horse-chestnut leafminer *Cameraria ohridella* Deschka & Dimic, 1986 (Lepidoptera: Gracillariidae); Project B-901/1999 (1999-2004); Funded by the National Science Fund; Project leader: Prof. Dr Rumen Tomov

- Sustainable control of the horse chestnut leafminer, *Cameraria ohridella* (Lepidoptera, Gracillariidae), a new invasive pest of *Aesculus hippocastanum* in Europe (CONTRO-CAM); Project QLK5-CT-2000-01684 (2000-2004), www.cameraria.de; Funded by the EC FP5. Participant from Bulgaria: Prof. Dr Rumen Tomov
- Species composition of the flea beetles (Coleoptera, Chrysomelidae) pests on Solanaceae plants in the mountain and semimountain areas in Bulgaria; Project 112/07.04.2005 (2005); Funded by the University of Forestry; Project leader: Prof. Dr Rumen Tomov
- Assessing large-scale environmental risk with tested methods (ALARM); Project 506675 (2005-2008) (www.alarmproject.net); Funded by the EC FP6; Participant from Bulgaria: Prof. Dr Rumen Tomov
- Population genetics of a highly invasive insect pest (2007-2008); Funded by the SEE-ERA.NET Programme; Participant from Bulgaria: Prof. Dr Rumen Tomov
- Non-indigenous insects and their threat to biodiversity and economy in the Balkans (2006-2008); Funded by the Swiss government within the SCOPES programme; implemented together with CABI Switzerland (www.cabi.org), Bulgaria, FYR Macedonia, Albania; Project leader for Bulgaria: Prof. Dr Rumen Tomov
- Invasive scale insects of ornamental plants in Bulgaria and China (2008-2010); Bilateral project Bulgaria-China, funded by the National Science Fund; Project leader: Dr Katica Trencheva
- Alien terrestrial arthropods and their impact on biodiversity in Bulgaria (ATARTIB); Project DO 02-191/2008 (2008-2012); Funded by the National Science Fund; Project leader: Prof. Dr Rumen Tomov
- Supporting fruit fly pest prevention and management in the Balkans and the Eastern Mediterranean; Project RER5018 (2011-2015);

Funded by the International Atomic Energy Agency, Participant from Bulgaria: Prof. Dr Rumen Tomov

With the implementation of these projects a complete inventory of alien arthropod species in Bulgaria was made. Data about their distribution, biology, ecology and impact were collected. Based on some case studies, the role of natural enemies in the invasion success of alien arthropods was assessed. The role of alien arthropods as vectors of diseases in some mammal and bird species was studied. Some of the results were summarised and published in the book: *Non-indigenous insects and their treat to biodiversity in Albania, Bulgaria and Republic of Macedonia* (Tomov et al. 2009). The book contains a list of alien insects and presents fact-sheets for 29 species. The book is published in Bulgarian, Albanian, Macedonian, and English and aims at raising awareness among scientists, decision-makers in agriculture and forestry sectors, NGOs, etc. In the framework of the project ATARTIB, a website was developed (www.atartib.bg), where an updated information about the alien arthropods in Bulgaria, including species lists, fact sheets, information about projects, publications and other relevant information can be found. As an awareness-raising campaign, the University of Forestry in collaboration with the Ministry of Agriculture and Forestry, and the Balkan Plant Protection Society organised an international conference on “*Alien arthropods in South East Europe – Crossroad of three continents*”, 19-21 September, 2007, Sofia, Bulgaria. About 40 contributions of participants from 21 countries were presented, some of them published in full text in the Conference Proceedings.

Research on biological control was carried out within the project “*Impact of entomopathogenic fungus Entomophaga maimaiga on gypsy moth Lymantria dispar (Linnaeus) population and entomofauna biodiversity in oak ecosystems in Bulgaria (2008-2012)*” coordinated by the Institute of Forestry, BAS. The fungus *E. maimaiga* was introduced to Bulgaria and a post-release monitoring was implemented. The project focused on the evaluation of the significance of *E. maimaiga* as a regulating factor of *L. dispar* in the for-

ests and the impact on sympatric species in the natural ecosystems (Georgiev et al. 2012, 2013, www.entomophaga.com)

Several research projects implemented by the Institute of Zoology (currently IBER-BAS) deal with the **aquatic invasive alien species**. In collaboration with the Institute of Vertebrate Biology, Academy of Sciences of the Czech Republic (ASCR), the Institute implemented several projects related to the invasive Ponto-Caspian gobiid species, e.g.:

- Parasitism and invasive species: effect of parasite infection on the biology of *Neogobius kessleri* in its native and introduced range (2005-2006); Funded by the ASCR; Project leader: Dr Markéta Ondračková
- Biology and ecology of invasive gobiid species (Gobiidae, Pisces) in the Lower and Middle Danube River (2005-2008); Funded by the National Science Fund; Project leader: Prof. Dr Mladen Živkov.

The comparative studies carried out contributed to the knowledge of current distribution, abundance, morphometric characteristics, biological and ecological traits, including parasites, of the four fish species of the genus *Neogobius* (Gobiidae) - *N. fluviatilis*, *N. gymnotrachelus*, *N. kessleri*, and *N. melanostomus*, which had expanded upstream from their native distribution (the Lower Danube River) and invaded the middle and upper sections of the Danube River. The results were summarised in a number of joint publications: Ondračková et al. (2006); Polačík et al. (2008a,b, 2009, 2012).

Another alien fish species, the gibel carp, *Carassius gibelio*, which is widespread in Bulgaria, was studied within the project:

- Genetic, biochemical, morphological and biological characteristics of invasive *Carassius gibelio* populations in Bulgarian water basins; Project B-1536/05 (2005-2009); funded by the National Science Fund, MEYS; Project leader: Teodora Trichkova

Comparative studies on morphology, genetic and biochemical characteristics as well as biology (length, age, sexual structure, maturity, growth rate, condi-

tion, fecundity) of the gibel carp populations in rivers and reservoirs from the Danube River, Black Sea and Aegean Sea basins in Bulgaria were carried out. Project results were published by Trichkova, Živkov (2007, 2010); Trichkova et al. (2008b, 2010); Živkov, Trichkova (2008); Živkov et al. (2008); Ivanova et al. (2013).

The studies on fish species invasions in the Bulgarian waters will be further developed in the frame of the joint project:

- Ecosystem consequences of biodiversity change due to fish species invasions (2014-2016); Funded by the BAS and ASCR; Project leaders: Teodora Trichkova and Dr Pavel Jurajda.

Much research efforts focused on the invasive mussels in Bulgaria, in particular on the two dreissenid species, zebra mussel *Dreissena polymorpha* and quagga mussel *Dreissena rostriformis bugensis*. The following projects were implemented by the Institute of Zoology BAS in collaboration with the U.S. Army Corps of Engineers, USA, University of Innsbruck, Austria, Hydrobiological Institute Ohrid, FYR Macedonia, and “Grigore Antipa” National Museum of Natural History, Romania:

- Assessment of zebra mussel (*Dreissena polymorpha*) infestation risk using GIS for water basins in the North-West Bulgaria (2006-2007); Funded by the U.S. Army Engineer Research and Development Center’s International Research Office; Project leader: Prof. Dr Mladen Živkov
- *Dreissena* spp. native range and recent invasions – current knowledge, potential approaches and further actions (2008-2009); Funded by the Austrian Federal Ministry of Science and Research; Project leader: Teodora Trichkova
- Assessment and management of *Dreissena* spp. invasions in the Bulgarian water bodies; Project DO 02-283/2008 (2008-2012); Funded by the National Science Fund; Project leader: Prof. Dr Ivan Pandourski.

The current distribution of zebra and quagga mussels in Bulgaria and its relation to environmental factors, such as altitude, water body morphometric characteristics, substrate type, and water chemistry was stud-

ied (Hubenov 2005; Hubenov, Trichkova 2007; Trichkova et al. 2007, 2008, 2009; Kozuharov et al. 2009a,b). The invasive *Dreissena* populations were characterised in terms of shell morphometry, quantitative and molecular-genetic parameters (Trichkova et al. 2007, 2008; Kozuharov et al. 2009a,b). The pathways and vectors of introduction of the mussels to the inland waters of Bulgaria were identified (Trichkova et al. 2007, 2009). Risk assessment of zebra mussel infestation in water bodies in North-West Bulgaria was made using GIS method (Trichkova et al. 2007). The impact of *Dreissena* invasions on the aquatic ecosystems – water physicochemical parameters, bacterio-, phyto- and zooplankton, epilithic diatoms, benthic macroinvertebrates and fish was evaluated (Kalchev et al. 2013, 2014; Kenderov et al. 2014; Kozuharov et al. 2009c, 2013; Ognjanova-Rumenova et al. 2013; Trichkova et al. 2013, unpublished data). Based on a specific method developed by the researchers, the impact of *Dreissena* on water engineering facilities was assessed. Risk management guidelines were developed using risk based multi-criteria decision analysis method. Aiming to raise the awareness among interested institutions, water managers, fishermen and the general public, a brochure: *Guidelines for monitoring and control of invasive mussels of genus Dreissena in Bulgaria* was published. It provides information about 11 management actions for prevention and control of invasive mussels of the genus *Dreissena* in open waters and 10 management actions for infrastructure facilities (of water power plants, thermoelectric power plants, water intake structures). A website was developed (www.dreissena.info), and it presents extensive information about *Dreissena* mussels, projects, working team, activities, publications. The website contains an online GIS database intended for early warning of *Dreissena* invasions in Bulgaria. The interactive map provides hydrographic data, data on reservoir management and use, data on *Dreissena* distribution and infestations, population density, year of first record, etc. The information is in Bulgarian and English, and the online GIS application is easily accessible and user-friendly (Trichkova et al. 2011). A series of meetings were convened with training and awareness raising purposes, for example:

1. ***Zebra mussel (*Dreissena polymorpha*) management short course***, 27-30 June 2005, Sofia, Bulgaria. The training course was organised by the Ministry of Environment and Water of Bulgaria, Institute of Zoology BAS, U.S. Army Engineer Research and Development Center and the Maritsa East 2 TPP. The course instructors were from Bulgaria and USA and the lectures focused on biology and ecology of zebra mussels, their mechanisms for introduction and spread, their impact on the environment and human activities, designing and implementing monitoring programs, as well as basic control methods and management strategies. Sampling techniques and methods for assessing the risk were presented. The participants had the opportunity to visit local sites where infestations had occurred. The course was attended by 60 participants from Bulgaria, Romania and USA, including experts from Universities and research institutes, governmental institutions, industry, environmental NGOs and students.

2. International workshop ***Dreissena species native range and recent invasions – current knowledge, potential approaches and further actions***, 9-12 October 2008, Sofia, Bulgaria. The workshop was organised by the Institute of Zoology BAS, funded by the Austrian Federal Ministry of Science and Research, and attended by participants from Austria, Bulgaria, FYR Macedonia and Romania. The research results were presented at an open session attended by scientists, students, representatives of governmental institutions and NGOs.

3. International workshop on the ***Assessment and management of *Dreissena* spp. invasions in the Bulgarian water bodies with training on risk based multi-criteria decision analysis***, 26-30 July 2010 in Sofia, Bulgaria. The event was organised by the IBER-BAS and the US Army Corps of Engineers (USACE), with the participation of experts from Austria, Bulgaria, FYR Macedonia and Romania. The USACE organised a training of the participants on how to implement a structured and risk-based decision making process in order to identify the best alternative to manage invasive mussels in the Bulgarian water bodies.

Bulgaria initiated and currently implements two ESENIAS projects. The first one is:

- Potential threats to environmental and eco-

nomics sustainability in the Danube and Black Sea region: the Danube River as invasive alien species corridor (2012-2016); Funded within the frames of the International Association of Danube Research (IAD) and ESENIAS: Project leader: Teodora Trichkova.

The main goal of this project is to analyse the role of the invasive alien species (qualitative and quantitative parameters, impact, measures) for the sustainable development in the Danube and the Black Sea region. To implement this goal, a regular monitoring in the Bulgarian section of the Danube River has been carried out so far, lists of alien and invasive species, as well as pathways of their introduction, will be developed, data about biology, ecology and impact will be collected. The study will be extended to cover other sectors of the Danube River and the results will be used in the development of risk management plans.

The main goal of the second project is to study/identify the impact posed by the climate change and invasive alien species to biodiversity and ecosystem services in Lake Ohrid and its watershed and to formulate measures for the prevention and mitigation of impact:

- Climate change and invasive alien species – growing threats to biodiversity and ecosystem functionality in ancient Lake Ohrid and its watershed (2012-2014); Funded by the Royal Norwegian Embassy – Skopje/ Belgrade; collaboration between FYR Macedonia, Bulgaria, Albania; Project Leader: Prof. Dr Sasho Trajanovski, Hydrobiological Institute Ohrid
- Bulgaria is also a member of three currently implemented COST projects related to alien species:
- FPS COST Action FP1002 - Pathway Evaluation and pest Risk Management In Transport (PERMIT) (2010-2014)
- FA COST Action TD1209 - European Information System for Alien Species (ALIEN Challenge) (2013-2017)
- ESSEM COST Action ES1304 - European network on invasive parakeets: Understanding invasion dynamics and risks to agriculture and society (ParrotNet) (2013-2017).

The project and awareness raising activities in Bul-

garia covered not only scientific issues but also policy related to alien species.

The Ministry of Environment and Water in Bulgaria in collaboration with the Convention on the Conservation of European Wildlife and Natural Habitats organised a *National workshop on Invasive Alien Species in Bulgaria*, 20-21 October 2008, Sofia, Bulgaria. The workshop was attended by experts from the Bern Convention's Group of Experts on IAS, experts from the Ministry of Environment and Water, Bulgarian Academy of Sciences, Universities and NGOs. Presentations and discussions included broad range of issues, which covered research activities and legislation on IAS in Bulgaria, IAS key definitions, threats and actions in Europe, The Bern Convention European Strategy on IAS and the progress towards an EU framework on IAS.

An *Information workshop on the European Strategy on Invasive Alien Species* was organised on 24 March 2011, in Sofia, Bulgaria, by the University of Forestry and IBER-BAS. The aim of this workshop was to inform the interested governmental and non-governmental institutions about the progress of the Working Groups on Invasive Alien Species of the European Commission for the development of the EU Strategy on Invasive Alien Species.

Despite the numerous projects and research activities on alien species, a large part of which we reviewed in the current report, there is still no national list and national strategy in Bulgaria on invasive alien species.

A list of invasive and potentially invasive alien species was prepared as a component of the indicator "*Invasive alien species in Bulgaria*" in the **National Report on the State and Protection of the Environment** (2012, <http://eea.government.bg/bg/soer/2010/soer-bg-2010.pdf>), elaborated in accordance with the Environment Protection Act (Article 22, Paragraph 1), by the Executive Environment Agency, Ministry of Environment and Water of Bulgaria. This indicator was developed based on the SEBI indicator 10 "*Invasive alien species in Europe*". It has two components: an increase in the number of alien species that can potentially become invasive for a certain period of time (since 1900) and a list of the worst invasive alien species in Bulgaria. The assessment of trends in the number of

alien species is made by main ecosystems (terrestrial, freshwater, marine) and taxonomic groups (vertebrates, invertebrates, vascular plants, mosses, algae and fungi). The list of the worst invasive alien species is based on two criteria: 1) species that have a serious detrimental impact on biodiversity, and 2) species that further can have negative impact on human health and economy. According to this indicator, the cumulative number of alien species in Bulgaria has increased steadily since 1900. A total of 50 species of ferns and seed plants, 30 species of animals and 20 species of fungi are listed as invasive and potentially invasive alien species in Bulgaria.

Some of the invasive and potentially invasive alien species can be monitored in the future in the frame of the **National Biodiversity Monitoring System** (NBMS). This is a comprehensive mechanism for long-term study and summary of biodiversity changes in Bulgaria. This is possible through concerted and long-term monitoring of the biodiversity components, accompanied by collection, processing, storage and data transmission, on the one hand, and through system of assessment and analysis of impact on the biodiversity, its status as well as the measures taken to prevent its loss, on the other hand. The NBMS is an essential tool for decision making at national level, its **main objective** is to provide information that is necessary for an effective national environmental policy. An **Information System (BioMon)** to the NBMS has been developed in accordance with the Biological Biodiversity Act (Article 115, Paragraph 1, Points 10 and 11). This information system will provide updated information on the distribution, number and population status of fungi, plant and animal species, as well as on their habitats in Bulgaria. The information system will contribute to the collecting and mapping of information from published sources, thus making possible the evaluation and comparison of current data with data from previous studies and periods. The next step in the development of the information system will be the development of a module for data collection and risk assessment of the invasive alien species in Bulgaria. It will serve as a tool for assessment of the risks posed by the alien species to native species, habitats and ecosystems in Bulgaria.

Conclusions

This review shows that the alien species recorded in Bulgaria so far within the reviewed taxonomic groups account for 340 vascular plants (only neophytes), 347 terrestrial arthropods, 31 marine invertebrates, 3 freshwater bivalves, 23 freshwater fish, 1 reptile, 14 birds and 9 mammal species. About 12% of the alien vascular plant species, 25% of the aquatic species, 35% of the terrestrial arthropods, and 50% of the bird species were recorded after 2000.

The main pathways of introduction of the alien species to Bulgaria include intentional as well as unintentional introductions. The intentional introductions were related mostly to plants (for ornamental, erosion control and reforestation purposes), and well as to few terrestrial arthropods (as biological control agents), fish (for farming, stocking, biological control, recreational fishing), and amphibian, reptile, bird and mammal species (as pets, ornamental and game species). The unintentional introductions were related mainly to vascular plants and terrestrial arthropods (as commodity contaminants, range expansion), and to many aquatic species (as fouling organisms, by ballast water, as contaminants, range expansion through the Danube River). The alien species introductions and spread on the territory of Bulgaria were mostly assisted by humans, e.g., by transfer of larvae and adults of aquatic organisms by fish stocking, aquaculture, fishing and recreation equipment, and as live bait; intentional release to nature of amphibian, reptile and bird species used as pets; escape of bird and mammal species from zoos, parks and fur farms.

About 60 vascular plants, some terrestrial arthropods, most of the marine invertebrates and freshwater species, one reptile, two bird and four mammal species were reported as invasive and potentially invasive, with strong negative impact on biodiversity, ecosystems, human health and economy of Bulgaria.

Since 2000 many projects have been implemented by Bulgarian scientists, with the research efforts focusing on the alien species inventory, study of their biological and ecological traits, an identification of the pathways of introduction, assessment of their impact

and invasiveness, and development of risk management strategies. A series of awareness raising campaigns were organised. However, in view of the fast growing threats to the biodiversity and economy by the invasive alien species, further studies and management activities will be crucial in the future. In this respect, a national strategy and risk management plans on invasive alien species are urgently needed in Bulgaria.

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