Environmental impact assessment and black, watch and alert list classification after the ISEIA Protocol of invertebrates in Luxembourg

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Abstract. The environmental impact of 51 invasive alien invertebrate species in Luxembourg has been assessed in accordance with the Belgian ISEIA Protocol. 7 species of high ecological impact have been assigned to a black list: the arachnid *Varroa destructor* (A3); the crustacean *Pacifastacus leniusculus* (A3); the four molluscs *Potamopyrgus antipodarium* (A3), *Corbicula fluminalis* (A2), *Corbicula fluminea* (A2) and *Dreissena polymorpha* (A2); the insect *Cydalima perspectalis* (A1). 5 species of medium impact have been added to a watch list: the arachnid *Opilio canestrinii* (B3); the crustacean *Chelicorophium curvispinum* (B3); the insects *Harmonia axyridis* (B3), *Hyphantria cunea* (B1) and *Leptoglossus occidentalis* (B1). 6 species not yet present in Luxembourg have been assigned to an alert list: the crustaceans *Dikerogammarus villosus* (A0), *Orconectes immunis* (A0), *Procambarus clarkii* (A0) and *Cercopagis pengoi* (B0); the insects *Anoplophora chinensis* (B0) and *Anoplophora glabripennis* (B0). While these 18 species have been listed, the remaining 33 taxa of low ecological impact have not been included in any list.

Keywords. Risk assessment, ISEIA Protocol, biological invasions, invasive alien species, neobiota, neozoa, invertebrata, invertebrates, Luxembourg.

1. Introduction

More than 12,100 alien species have been documented by DAISIE (Delivering Alien Invasive Species Inventory for Europe), a European Union funded website providing information on biological invasions in Europe (Anonymous 2017). An estimated 10–15% are known as Invasive Alien Species (IAS), whose introduction and spread outside their natural ecological range poses a threat to biodiversity and the economy (Sundseth 2014).

The problems caused by non-native or alien species are not new. The contracting parties of the Convention on the Conservation

of European Wildlife and Natural Habitats (also known as Bern Convention) have to strictly control the introduction of non-native species since the 1980s (Anonymous 1979). Nonetheless, the dispersal of non-native species continues unimpaired.

Invasive alien species (IAS) are affecting numerous natural habitats and constitute a threat for fragile ecosystems. Biological invasions are one of the main drivers of biodiversity loss, cause high economic costs, i.e. in agriculture, forestry and fisheries, and, in some cases, constitute a serious hazard to human health. The economic, health related and management costs are estimated to amount to at least EUR 12 billion per year in Europe alone (Scalera et al. 2012). Target 5 of the EU biodiversity strategy for 2020 reads: 'By 2020, Invasive Alien Species and their pathways are identified and prioritised, priority species are controlled or eradicated, and pathways are managed to prevent the introduction and establishment of new IAS' (Anonymous 2011).

All EU Member States have problems with IAS on their territory to a greater or lesser extent. The EU Regulation 1143/2014 on Invasive Alien Species entered into force on 1 January 2015. This regulation seeks to address the problem of invasive alien species in a comprehensive manner so as to protect native biodiversity and ecosystem services, as well as to minimize and mitigate the human health or economic impacts that these species can have. The Regulation foresees four types of interventions: prevention, early detection, rapid eradication and management (Anonymous, 2014).

Furthermore, as a first implementation of the regulation, the European Commission has adopted a list of invasive alien species of Union concern. This list was drawn up together with the Member States, represented through a Scientific Forum and a Committee on Invasive Alien Species, on the basis of risk assessments and scientific evidence (Anonymous 2016).

Until recently, reliable knowledge concerning alien species in Luxembourg was quite patchy. For over a decade, studies have been intensified on the topic, and in recent years, Luxembourg-related information on IAS has been made available online at www.neobiota.lu (Ries & Pfeiffenschneider 2017).

Following the EU regulation on IAS, the Luxembourg Government has created a coordination group for invasive alien species in Luxembourg on 21st November 2016 (Mémorial 2016). This "IAS Group Luxembourg" will help to intensify studies and to supply policies about IAS in Luxembourg.

Risk assessments are efficient tools enabling decision makers to develop legislation, policy and management strategies, but detailed risk assessment methods for IAS are quite labour-intensive and there is a wide range of scientific approaches. For the different black and watch lists the assessment criteria are more or less extensive, occasionally including economic impacts and/or health related aspects (Genovesi & Scalera 2007, Essl et al. 2008, 2011).

One of the approaches enabling an expert group to evaluate the potential risk of the different species in a reasonable amount of time is the Invasive Species Environmental Impact Assessment (ISEIA) elaborated by the Belgian Forum on Invasive Species (BFIS) (Branquart 2009). This approach commonly known as the ISEIA Protocol has already been applied in Luxembourg to assess vascular plants (Ries et al. 2013) and vertebrates (Ries et al. 2014).

The present study presents the application of the ISEIA Protocol to classify invasive alien invertebrates in Luxembourg.

2. Methods

In 2014, the consultancy firm efor-ersa was contracted by the department of ecology of the Luxembourg National Natural History Museum (NNHM) to establish a list of invasive invertebrates present in Luxembourg and/or occurring and creating problems in at least one of the three adjacent countries. This list compiled 61 species: 11 arachnids, 6 crustaceans, 9 molluscs and 35 insects.

The following information (subject to availability) was gathered for the assessment process:

(1) General information: scientific name, family, synonyms, common name, French

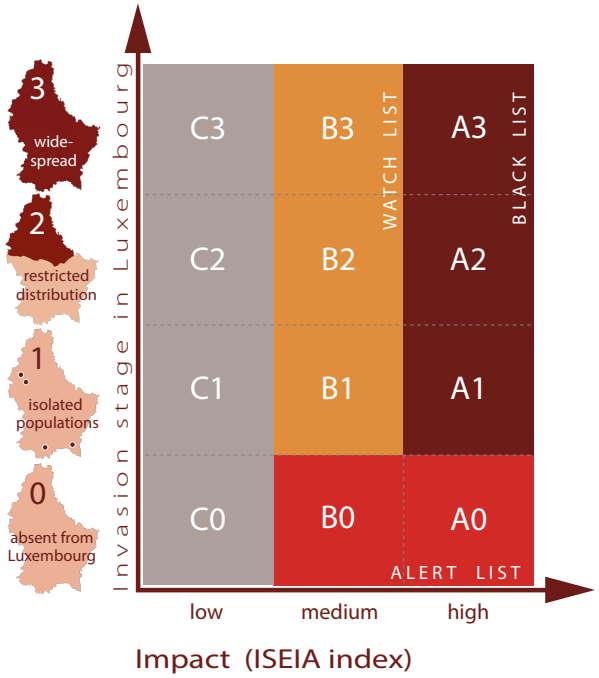

Fig. 1. List system to identify organisms of most concern in the frame of risk assessment procedures using the ISEIA Protocol (adapted after Branquart 2017).

name, German name, group, origin, habitat, history of introduction.

(2) Invasiveness: reproduction in the wild, dispersion potential, places where the species is already invasive, additional information on invasiveness.

(3) Situation in Luxembourg: first documented observation in the wild, observations in the Recorder database of the NNHM (Colling et al. 2007), invasion stage, spatial distribution, establishment potential in Luxembourg.

(4) Impacts: impacts on other species, competition, disease transmission, genetic effects, impacts on ecosystems, physical alteration, natural succession, impacts on public health, economic impacts, additional information on impacts.

(5) Data sources and references.

Two expert groups, convened on the initiative of the department of Ecology of the NNHM, were invited to evaluate the draft list in compliance with the ISEIA Protocol (Branquart 2009). The expert group dealing with insects met twice: 8 December 2014: Carlo Braunert, Manou Pfeiffenschneider, Christian Ries, Nico Schneider; 17 December 2015: Alain Frantz, Marcel Hellers, Manou Pfeiffenschneider, Christian Ries, Nico Schneider. The expert group dealing with Arachnida (arachnids), Crustacea (crustaceans), Mollusca (molluscs) and Nematoda (roundworms) met on 18 November 2015: Alexandra Arendt, Svenja Christian, Alain Dohet, Marcel Hellers, Xavier Mestdagh, Manou Pfeiffenschneider, Roland Proess, Christian Ries, Nico Schneider. One bryozoan species was assessed ad hoc with specialists Jos A. Massard and Gaby Geimer.

In total, 51 invertebrate taxa were assessed: 8 arachnids, 1 bryozoan, 10 crustaceans, 5 molluscs and 27 insects.

The environmental impact of non-native species was assessed in a standard, objective and transparent way using a simplified protocol consisting of four sections, i.e. the potential for spreading and colonising natural habitats as well as the adverse impacts on native species and ecosystems:

(1) dispersion potential / invasiveness: potential of an organism to spread in the environment by natural means and/or by human assistance;

(2) colonisation of high conservation value habitats: potential of a species to colonise habitats with high conservation value (irre-

spective of its dispersal capacities), based on habitat preference information from native and invaded areas;

(3) adverse impacts on native species: potential of a species to cause species replacements through different mechanisms;

(4) alteration of ecosystem function: potential of a species to alter ecosystem processes and structures in ways that significantly decrease native species' ability to survive and reproduce.

Scores for each section were based on the organism's history of impact in neighbouring areas together with its ecological profile according to the following scale: low risk (1), medium risk (2), high risk (3). When data was insufficient, the following alternative scale was used: unlikely (1), likely (2), deficient data (0).

The sum of the 4 scores allows assigning the species to one of the following categories:

4–8 = C (no list attribution)

9–10 = B (watch list)

11–12 = A (black list)

Potential watch or black list species not occurring in Luxembourg were assigned to the alert list.

The combination of these scores and the actual spatial distribution of each species produced the ISEIA index as can be seen in Fig. 1. The assessment was made by strictly applying the ISEIA protocol and did not take into consideration economic impacts or health related aspects.

3. Results

The results of the assessment of the 51 non-native taxa are compiled in Table 1. While 33 taxa were considered of low ecological impact and were consequently not included in any list (C), seven species were regarded as being of high ecological impact and were assigned to the black list. The watch list includes five species of medium impact. Finally, six species that are not yet present in Luxembourg, but already cause major problems in neighbouring areas - at least locally - were assigned to the alert list.

Arachnida

Eight arachnids were evaluated in accordance with the ISEIA protocol. The widespread bee parasite *Varroa destructor* (A3) (Meisch 1986) was assigned to the black list. The widespread *Opilio canestrinii* (B3) (Muster & Meyer 2014) was added to the watch list. The remaining six species were not added to any list (C1, C2, C3).

Bryozoa

The magnificent bryozoan *Pectinatella magnifica* (C1), that recently appeared in the artificial lake of Esch/Sûre (Massard et al. 2013), was not added to any list.

Crustacea

Ten crustaceans were evaluated. The widespread *Pacifastacus leniusculus* (A3) (Duhr & Massard 1995; Administration de la gestion de l'eau 2010) was assigned to the black list and *Chelicorophium curvispinum* (B3) (Duhr & Massard 1995) to the watch list. Four species that are not yet present in Luxembourg were added to the alert list: *Dikerogammarus villosus* (A0), *Orconectes immunis* (A0), *Procambarus clarkii* (A0) and *Cercopagis pengoi* (B0). The remaining four species were not added to any list (C0, C1, C2).

Mollusca

Out of five molluscs that were assessed, four were added to the black list: the widespread *Potamopyrgus antipodarium* (A3), as well as *Corbicula fluminalis* (A2), *Corbicula fluminea* (A2) (Duhr & Massard 1995) and *Dreissena polymorpha* (A2) (Duhr & Massard 1995), all three species with a more restricted distribution. One remaining species was not added to any list (C0).

Insecta

27 insects were evaluated. Only one insect made it into the black list: *Cydalima perspectalis* (A1) (Hellers & Christian 2016), while three species were added to the watch list: *Harmonia axyridis* (B3) (Schneider & Loomans 2006, Guinet 2009), *Hyphantria cunea* (B1) and *Leptoglossus occidentalis* (B1) (Schneider 2010, Schneider & Christian 2013). The two longhorn beetles *Anoplophora chinensis* (B0) and *Anoplophora glabripennis* (B0) were added to the alert list. The remaining 21 species were not added to any list (C0, C1, C2, C3).

4. Discussion

The mollusc *Arion vulgaris* was removed from the assessment as it's status is currently controversal. Although this species has often been discussed since the 1970s as an invasive species with a negative environmental impact in Central Europe, recent studies suggested that this species is not alien but represents a native Central European species that became much more abundant through major changes in agriculture (Pfenninger et al. 2014).

18 (35%) assessed invertebrate taxa are listed in one of the three list types black list, watch list and alert list, compared to 10 (40%) listed vertebrate taxa (Ries et al. 2014) and 27 (49%) listed vascular plant taxa (Ries et al. 2013).

The results show that, at present, seven invertebrate species are to be considered a threat to biodiversity in Luxembourg. However, current knowledge is often patchy, especially in relation to the class of invertebrates, where Luxembourg often has only one or very few experts for specific taxonomic groups.

Furthermore, regular updates on a broader data basis are necessary because changes in the impact of an invasive species can occur quite rapidly. It is therefore essential to continuously update such lists (Kowarik 2010: 398). This underlines the need for inventories of known and new alien species. While such inventories have been conducted for vascular plants and for fish (monitoring in accordance with the Water framework directive), only few equivalent studies exist for other alien animal species in Luxembourg, e. g. a recent survey on the invasive birds *Branta canadensis* and *Alopochen aegyptiacus* (Bastian 2016).

Only accurate and up-to-date data will enable the competent authorities to prioritize, elaborate and implement management plans for specific IAS, which has become a duty in the framework of EU Regulation 1143/2014 on Invasive Alien Species (Anonymous 2014).

Six of the assessed species are on the list of the "One Hundred of the World's Worst Invasive Alien Species" as defined by the Global Invasive Species Database (Lowe 2004, Luque et al. 2014): the black-listed mollusc *Dreissena polymorpha* (A2); the insect *Anoplophora glabripennis* (B0) and the crustacean *Cercopagis pengoi* (B0), both on the watch list; and the crustacean *Eriocheir sinensis* (C0), the insects *Aedes albopictus* (C0) and *Linepithema humile* (C0) not listed in Luxembourg. These species have been recognised as a major threat to biodiversity as well as to agriculture and other human interests on a global scale. Therefore, the monitoring of the population of species present in the country and the horizon scanning for taxa not yet present, as it has been done on European level (Roy et al. 2015), is essential.

After the completion of the first risk assessments in Luxembourg, based on the ISEIA Protocol and encompassing vascular plants (Ries et al. 2013), vertebrates (Ries et al. 2014) and, in the present study, invertebrates, further taxonomic groups like fungi still remain to be assessed in subsequent exercises.

However, especially since the EU Regulation 1143/2014 on Invasive Alien Species has entered into force, risk assessments will have to be upgraded using a new protocol incorporating all stages of invasion and different types of impacts. Among the few risk assessment protocols available at present (cf. Roy et al. 2014: 100 ff.), the Harmonia⁺ protocol, a scheme which has recently been developed in Belgium for the first-line risk assessment of potentially invasive alien species (D'hondt et al. 2014), might be an interesting choice for Luxembourg.

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Table 1. Risk assessment of 52 non-native invertebrates for Luxembourg. Column "Evaluation": 1st score = dispersion potential or invasiveness; 2nd score = colonization of high conservation value habitats; 3rd score = adverse impact on native species; 4th score = alteration of ecosystem functions. ISEIA index: A = high impact; B = medium impact; C = low impact; 0 = absent from Luxembourg; 1 = isolated populations; 2 = restricted distribution; 3 = widespread.

Species	Family	Evaluation	Spatial distribution	ISEIA index
ARACHNIDA				
Argiope bruennichi	Araneidae	2+2+2+2=8	widespread	C3
Brigittea civica	Dictynidae	2+1+2+1=6	widespread	C3
Cheiracanthium punctorium	Miturgidae	2+2+2+1=7	restricted	C2
Dermacentor marginatus	Ixodidae	2+1+2+1=6	isolated	C1
Dicranopalpus ramosus	Phalangiidae	2+2+2+1=7	restricted	C2
Leiobunum sp.	Sclerosomatidae	2+2+2+1=7	restricted	C2
Opilio canestrinii	Phalangiidae	3+2+3+1=9	widespread	B3
Varroa destructor	Varroidae	3+3+3+3=12	widespread	A3
BRYOZOA				
Pectinatella magnifica	Pectinatellidae	3+2+1+1=7	isolated	C1
CRUSTACEA				
Astacus leptodactylus	Astacidae	1+1+1+1=4	isolated	C1
Cercopagis pengoi	Cercopagidae	2+2+3+3=10	absent	B0
Chelicorophium curvispinum	Corophiidae	3+1+3+2=9	widespread	B3
Dikerogammarus villosus	Gammaridae	3+2+3+3=11	absent	A0
Eriocheir sinensis	Varunidae	2+1+2+2=7	absent	C0
Gammarus tigrinus	Gammaridae	3+1+3+1=8	restricted	C2
Orconectes immunis	Cambaridae	3+3+3+2=11	absent	A0
Orconectes limosus	Cambaridae	1+2+3+1=7	restricted	C2
Pacifastacus leniusculus	Astacidae	3+3+3+2=11	widespread	A3
Procambarus clarkii	Astacidae	3+3+3+3=12	absent	A0
MOLLUSCA				
Corbicula fluminalis	Corbiculidae	3+3+3+3=12	restricted	A2
Corbicula fluminea	Corbiculidae	3+3+3+3=12	restricted	A2
Dreissena polymorpha	Dreissenidae	3+3+3+3=12	restricted	A2
Potamopyrgus antipodarium	Hydrobiidae	3+2+3+3=11	widespread	A3
Sinanodonta woodiana	Unionidae	2+1+2+1=6	absent	C0
INSECTA				
Aedes albopictus	Culicidae	2+3+1+1=7	absent	C0
Anoplophora chinensis	Cerambycidae	3+3+2+1=9	absent	B0
Anoplophora glabripennis	Cerambycidae	3+3+2+1=9	absent	B0
Cameraria ohridella	Gracillariidae	3+1+1+1=6	widespread	C3
Corythucha ciliata	Tingidae	3+1+1+1=6	widespread	C3
Cydalima perspectalis	Crambidae	3+3+3+3=12	isolated	A1
Drosophila suzukii	Drosophilidae	3+2+1+1=7	isolated	C1
Graphocephala fennahi	Cicadellidae	2+1+1+1=5	isolated	C1
Harmonia axyridis	Coccinellidae	3+2+3+2=10	widespread	B3
Hulecoeteomyia japonica	Culicidae	2+1+1+1=5	absent	C0
Hyphantria cunea	Arctiidae	3+3+1+2=9	isolated	B1
Lasius neglectus	Formicidae	3+1+1+1=6	absent	C0
Leptinotarsa decemlineata	Chrysomelidae	3+1+1+1=6	widespread	C3
Leptoglossus occidentalis	Coreidae	3+3+2+1=9	isolated	B1
Linepithema humile	Formicidae	3+1+2+2=8	absent	C0

Meconema meridionale	Tettigoniidae	2+1+1+1=5	restricted	C2
Obolodiplosis robiniae	Cecidomyiidae	3+1+1+1=6	widespread	C3
Phyllonorycter leucographella	Gracillariidae	3+1+1+1=6	widespread	C3
Phyllonorycter medicaginella	Gracillariidae	3+1+1+1=6	isolated	C1
Phyllonorycter platani	Gracillariidae	3+1+1+1=6	widespread	C3
Phyllonorycter robiniella	Gracillariidae	3+1+1+1=6	widespread	C3
Pulvinaria regalis	Coccidae	3+1+2+1=7	widespread	C3
Sceliphron curvatum	Sphecidae	3+1+1+1=6	isolated	C1
Stephanitis rhododendri	Tingidae	3+1+1+1=6	absent	C0
Stephanitis takeyai	Tingidae	3+1+1+1=6	absent	C0
Stictocephala bisonia	Membracidae	2+1+1+1=5	restricted	C2
Vespa velutina nigrithorax	Vespidae	3+1+1+1=6	absent	C0

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