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Short Communication

Developing innovative methods to face aquatic invasions in Europe: the Aquainvad-ED project

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Editor's note:
This study was first presented at the 19th International Conference on Aquatic Invasive Species held in Winnipeg, Canada, April 10–14, 2016 (http://www.icais.org/html/previous19.html). This conference has provided a venue for the exchange of information on various aspects of aquatic invasive species since its inception in 1990. The conference continues to provide an opportunity for dialog between academia, industry and environmental regulators.

Abstract

Aquatic Invasive Alien Species (AIAS) are increasing due to the synergistic effects of climate change and habitat destruction. AIAS can heavily impact biodiversity and human health, causing a loss of ecosystem services; therefore, their control and management have now become a priority, particularly in the light of the new EU regulation 1143/2014 on invasive alien species. The main research goal of the Innovative Training Network Marie Skłodowska-Curie Aquainvad-ED is to exploit the application of innovative tools and the power of citizen science for early detection, control and management of AIAS. Eight early stage researchers are involved in Aquainvad-ED, engaged in four main research themes: (1) development and application of novel methods for early detection of AIAS; (2) identification of vectors of introduction and pathways of dispersal; (3) impacts of freshwater and marine invaders; and (4) risk assessment and control of AIAS. In order to develop multidisciplinary approaches to address these issues, the fellows are working within an international consortium (UK, Spain, Italy) composed of scientists and conservation practitioners from three universities (Swansea University, Universidad de Oviedo, Università degli Studi di Firenze), one technological institute (AZTI), two governmental agencies (Natural Resources Wales and Cardiff Harbour Authority), one NGO (Wye & Usk Foundation) and five SMEs working in fundamental and applied aspects of AIAS (Neoalgae, Natural Applications, NEMO, Ecohydros, and Itinera C.E.R.T.A).

Key words: alien species, invasive, early detection, control, pathway

Introduction

Globally, as a result of the advancing breakdown of biogeographic barriers, the introduction of alien invasive species is greatly contributing to biodiversity decline, ecosystem homogenization, and loss of ecosystem services, heavily impacting human health and economic activities (Kettunen et al. 2009; Simberloff et al. 2013; Jeschke et al. 2014; Mazza et al. 2014; Roy et al. 2016). The problems posed by aquatic invasive alien species (AIAS) are particularly dramatic due to the synergistic effects of climate change and habitat destruction. Aquatic ecosystems, especially freshwater ones, are vulnerable to biological invasions due to the strong affinity of humans to water (e.g. alteration, exploitation, utilization) and the intrinsic dispersal ability of aquatic species compared to terrestrial ones (Gherardi et al. 2009; Strayer 2010; Havel et al. 2015; Tricarico et al. 2016).

Over the last centuries, aquatic ecosystems in Europe have been colonized by highly invasive alien species. A total of 1,369 alien species have been reported in the European seas (Katsanevakis et al. 2013), mostly introduced through the Suez Canal (with an increase since 1990s) that was recently enlarged, facilitating the arrival of new species (Zenetos et al. 2012; Galil et al. 2015). There are 756 alien species in European fresh waters (Nunes et al. 2015), introduced mainly through aquaculture, the pet/aquarium trade (an emerging important pathway since 2000s: Maceda-Veiga et al. 2013; Mazza et al. 2015) and through sport fishing (Nunes et al. 2015). In both aquatic realms, many notable invaders are present, causing substantial damage to invaded ecosystems (Katsanevakis et al. 2013; Nunes et al. 2015).

The management of AIAS has become a priority, particularly in the light of the new EU regulation 1143/2014 (EU 2014) on the prevention and management of the introduction and spread of invasive alien species (art. 25). More than half (57%) of invasive alien species included in the EU concern list are freshwater species (Implementing Regulation EU 2016/1141 of 13 July 2016). Successful management of AIAS requires several steps: early detection, identification of introduction routes and dispersal pathways, and development of efficient control measures (CBD 2002). Public awareness and stakeholder involvement are also critical for preventing new introductions and for mitigating the impact of existing ones (CBD 2002).

Several projects (e.g. DAISIE, IMPASSE, COST Action TD1209 Alien Challenge) and initiatives (e.g. Essl et al. 2015; Latombe et al. 2016; Lucy et al. 2016) have addressed and are addressing different issues concerning invasive alien species in Europe and worldwide in order to harmonize terminology and optimize actions (databases, pathways, monitoring process, fostering collaboration). In this context, the project Marie Sklodowska Curie 2014 ITN (Innovative Training Network) H2020 Aquainvad-ED (AQUAtic INVaders: Early Detection, Control and Management; 2015–2019; http://www.aquainvad-ed.com/) was developed to tackle AIAS in Europe and to harmonize with the Marine Strategy Framework Directive (2008) and the Water Framework Directive (2000). ITN projects bring together universities, research centres and companies from different European countries to train a new generation of researchers. The funding boosts scientific excellence and business innovation, and enhances researchers' career prospects through developing their skills in entrepreneurship, creativity and innovation. The main research goal of Aquainvad-ED is to exploit novel tools combined with the power of crowd data sourcing (citizen science) to develop innovative methods for early detection, control and management of AIAS.

The project

In order to develop multidisciplinary approaches to address AIAS issues, Aquainvad-ED involves an international consortium of three European countries (UK, Spain, Italy), composed by scientists and professionals from three universities (Swansea University, project leader, Universidad de Oviedo, Università degli Studi di Firenze); one technological institute (AZTI); two governmental agencies (Natural Resources Wales and Cardiff Harbour Authority); one NGO (Wye & Usk Foundation) and five SMEs (Small and medium-sized enterprises) working in fundamental and applied aspects of AIAS (Neoalgae, Natural Applications, NEMO srl, Ecohydros and Itinera C.E.R.T.A scarl). Together, the Aquainvad-ED network offers a multidisciplinary approach (genetics, behaviour, ecology, citizen science, risk assessment) and the expertise of academic and non-academic partners to the assessment and management of biological invasions in aquatic habitats, through the enhancement of unique skills (e.g. technical, research and analytical competences), knowledge-sharing and capacity building.

The specific goals of the project are: i) developing, optimising and trialling innovative methods for early detection of freshwater and marine invaders; ii) identifying ecological and demographic factors determining AIAS establishment and spread; iii) recommending novel procedures for AIAS control which are applicable to natural and managed aquatic systems (e.g. rivers, estuaries, artificial reservoirs);

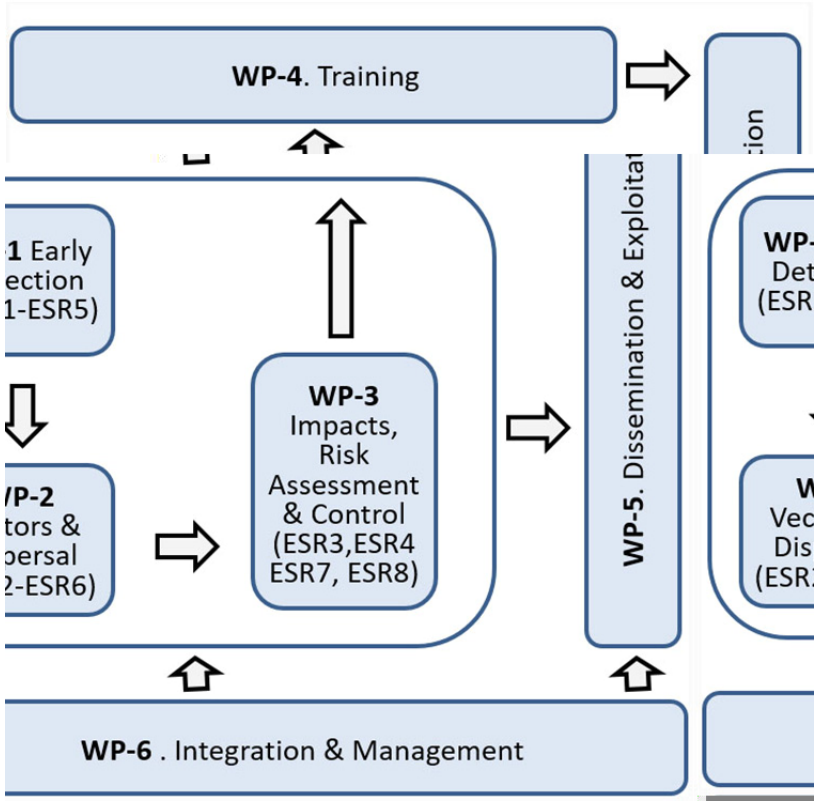

Figure 1. The six Aquainvad-ED Work Packages (WPs) along with the corresponding Early Stage Researchers (ESRs).

iv) integrating information on location, dispersion and control measures into management plans in order to prevent further AIAS introductions and dispersal in Europe, and v) raising public awareness about introduction routes and dispersal pathways, as well as about ecological and socio-economic impacts caused by AIAS.

In order to accomplish these goals, Aquainvad-ED is structured into six complementary Work Packages (WPs; Figure 1): WP1, dealing with the development and application of novel methods for early detection for AIAS; WP2, focussing on identification of introduction vectors and dispersal pathways; WP3, concerning the assessment of impacts of selected freshwater and marine invaders, as well as risk assessment and control of AIAS; WP4 on organizing training activities devoted for the recruited fellows; WP5 on dissemination and exploitation; and WP6 dedicated to the integration and management of the whole project.

The Fellows

Eight Early Stage Researchers (ESRs) are involved in Aquainvad-ED, and are dedicated to four projects linked to WP1, WP2 and WP3 (Figure 1): (1) development and application of novel methods for early detection AIAS; (2) identification of introduction vectors and dispersal pathways; (3) impacts of aquatic invaders; and (4) risk assessment and control of AIAS. Each ESR has academic and non-academic supervisors, and two planned secondments within the consortium partners in order to acquire multidisciplinary and multi-sectorial skills. WPs 4, 5 and 6 are dealing with training activities, dissemination and project management, involving the supervisors coordinated by Swansea University (WPS 4, 6) and by Wye & Usk Foundation (WP5).

Development and application of novel methods for early detection AIAS

Teja Muha (Swansea University, UK) and Anaïs Rey (AZTI, Spain) are developing molecular methods based on metabarcoding, able to detect the overall community, and qPCR, suitable for detecting specific species in freshwater [for detection of the killer shrimp *Dikerogammarus villosus* (Sowinsky, 1894), the zebra mussel *Dreissena polymorpha* (Pallas, 1771), alien macrophytes and fish] and marine environments (for detection of invaders as required by the "Ballast Water Convention"). To achieve this, laboratory and

field calibration of molecular methods are applied to a range of freshwater and marine systems in the UK, Spain and Italy. As part of a citizen science programme, a smartphone app (AquaInvaders) is being used to promote citizen science programs for the early detection of AIAS.

Identification of vectors of introduction and pathways of dispersal

Marta Rodríguez-Rey (Swansea University, UK) and Sabine Rech (Universidad de Oviedo, Spain) are working on the identification of physical and ecological constraints for the survival of AIAS. Rodríguez-Rey is mainly addressing the different role of natural vs. anthropic variables in the dispersal of non-native invasive species, as well as the social perception towards alien species. Rech is focussing on floating objects and marine litter as potential vectors of AIAS (Rech et al. 2016a). The fellows will compile an inventory of AIAS arriving to selected freshwater and marine systems in the three project countries. They will estimate optimal conditions, potential floating vectors, and high-risk activities and source and sink areas for invasion and dispersal of AIAS, before mapping the main routes of introduction and dispersal, based on floating and stranded samples of rafting biota (Rech et al. 2016b), traffic research, meta-barcoding profiles (deriving from Teja and Anaïs), fouling experiments, using eDNA and experiments under controlled conditions. In this way, it will be possible to develop recommendations and guidelines for identifying vectors of introduction and pathways of spread of key aquatic invaders.

Impacts of aquatic invaders

To quantify current ecological and socio-economic impacts and the relationships among invaders, Matteo Rolla (Swansea University, UK) and Phillip J. Haubrock (NEMO srl, Italy) are studying selected freshwater invaders [such as *D. villosus*, *D. polymorpha*, the red swamp crayfish *Procambarus clarkii* (Girard, 1852), the channel catfish *Ictalurus punctatus* (Rafinesque, 1818), the bullfrog *Lithobates catesbeianus* (Shaw, 1802); Haubrock et al. 2016a] through laboratory and field experiments (Haubrock et al. 2016b; Rolla et al. 2016). Moreover, they are assessing the ecosystem services affected by these AIAS in order to quantify the economic costs. These fellows will develop guidelines for estimating current and future AIAS impacts in aquatic environments under a range of future climate and environmental scenarios.

Risk assessment and control of AIAS

To accomplish the last step of AIAS management, Iva Johović (Università degli Studi di Firenze, Italy) and Roberta Skukan (Neoalgae, Spain) are modelling and assessing the risk of invasion for a range of freshwater (e.g. *P. clarkii*, *L. catesbeianus*) and marine invaders [the invasive seaweeds *Codium* spp., *Sargassum muticum* (Yendo) Fensholt, 1955, and *Undaria pinnatifida,* Harvey (Suringar), 1873], respectively (Haubrock et al. 2016a). They are also testing different control techniques and mitigation measures to prevent the spread of selected AIAS (Johović et al. 2016). In order to assess the risk of marine invasion, molecular species identifications and biogeography data will also be integrated in Roberta's research as a valuable tool for effective management strategies (Skukan et al. 2016a). Citizen science programs as a useful tool for early detections and prevention of algae invasions will be also implemented (i.e. Skukan et al. 2016b). Their final aim will be to develop guidelines for mitigating biological and socio-economic impacts caused by freshwater and marine invaders, as well as predictive models for the identification of vulnerable areas under current and future climate change.

Network and training activities

Aquainvad-ED partners meet annually to review progress and provide an update on project status. They also engage in specific training activities to enable ESRs to develop new skills. For example, in December 2015, they attended the Inaugural Training Event on Entrepreneurship Skills at Swansea (UK), and the Rivers Trust Spring Conference at Hay-on-Wye (UK) in May 2016, where they also participated in a training event on Citizen Science and Communication. In April 2017, they attended a training workshop in Spain on early detection methods for aquatic invaders, and in spring 2018 they will attend a training workshop on strategies and methods for AIAS management in Italy.

Conclusion

As introductions of alien species in Europe increases, new legislation requires more efficient management tools for AIAS. The Aquainvad-ED project will contribute to this task, not only through the production of science-based guidelines and deliverables, but also through the training of a new generation of multidisciplinary researchers who will be able to face biological invasions from different perspectives. The project will benefit from the outputs of the previous

cited projects and initiatives, and will surely establish a collaboration with the recently developed INVASIVESNET network (http://www.invasivesnet.org) (ET is part of COST Action Alien Challenge and INVASIVESNET).

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