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TACKLING THE LIONFISH INVASION IN THE MEDITERRANEAN. THE EU-LIFE RELIONMED PROJECT: PROGRESS AND RESULTS

Abstract

The lionfish invasion in the Western Atlantic has been characterised as one of the most ecologically harmful marine fish introductions to date; associated with habitat modifications, and severe impacts on native communities. In the Mediterranean, lionfish followed similar expansion trends and raised significant concerns among the scientific community due to its potential to cause devastating ecological and socioeconomic impacts. The coastal ecosystems of Cyprus, near the Suez Canal, are amongst the first Mediterranean waters to be affected by the lionfish invasion. Cyprus sentinel location offers therefore, an ideal site for the development of an early warning and rapid response system of marine bioinvasions. RELIONMED (Preventing a LIONfish invasion in the MEDiterranean through early response and targeted REmoval) is a four-year project, funded by the EU LIFE instrument, aiming to make Cyprus the first line of defence against the invasion of lionfish in the Mediterranean. The project has started successfully on September 2017 with a number of early (preparatory) project actions including stakeholder consultation and baseline assessment of social awareness, biological analyses of a small lionfish sample, and the development of a lionfish risk assessment following the guidelines of the Regulation 1143/2014 to include the species in the EU IAS priority list. Forthcoming project's actions strongly rely on citizen scientists' and stakeholders' participation and RELIONMED aims to develop the capacity and tools for control of lionfish, particularly in priority habitats. Preliminary results such as early maturity, high growth rates, generalist diet, and reproduction throughout the year indicate that lionfish can become a ferocious invader for the basin and RELIONMED calls for regional collaborations and coordinated management measures against lionfish invasion in the basin.

Key-words: Lionfish, Invasive species, *Pterois*, Mediterranean, Cyprus

Introduction

Non-Indigenous Species (NIS) are increasingly spreading across biogeographic barriers, shifting species' communities and assemblages (Geburzi & McCarthy, 2018). Despite a decreasing rate of NIS introductions via the Suez Canal (Zenetos, 2017), there are significant evidences that the ecosystems on continental shelves of the eastern Mediterranean are experiencing unprecedented shifts in species abundance and community composition (Arndt *et al.*, 2018; Givan *et al.*, 2018). The increasing alien species biomass is likely to obstruct any future fishery management measures and resilience to sea warming of the region, if its control is not included in an ecosystem-based management approach (Corrales *et al.*, 2018).

Evidence from throughout the eastern Mediterranean shows that a lionfish [*Pterois miles* (Bennett, 1828)] invasion is underway (Giovos *et al.*, 2018; Jimenez *et al.*, 2016; Kletou

et al., 2016). Following an unsuccessful invasion in 1991 (Golani & Sonin, 1992), the lionfish were recorded again in 2012 off Lebanon, and numbers have proliferated and spread, reaching the central Mediterranean Sea in just three years (Azzurro *et al.*, 2017; Bariche *et al.*, 2017). In the Western Atlantic, lionfish has been considered as one of the most harmful fish invasions to date, responsible for detrimental impacts on the biodiversity and ecological functions of the region (Albins & Hixon, 2013). The potential threats of lionfish in the Mediterranean were recognized in an EU horizon-scanning exercise conducted in 2014 which listed lionfish as second in a list of 95 new or emerging Invasive Alien Species (IAS) that should be prioritised for risk assessment for inclusion in the EU priority list according to the Regulation EC/2016/1141 (Roy *et al.*, 2015).

Cyprus is amongst the first Mediterranean countries to be affected by the invasion (Kletou *et al.*, 2016). Due to its sentinel location near the Suez Canal, it has a strategic role in understanding lionfish invasion dynamics, and exchanging information, data and best practices related to management programmes to the wider region. The RELIONMED project (Preventing a LIONfish invasion in the MEDiterranean through early response and targeted REmoval) is a four-year project funded by the EU LIFE instrument, which aims to make Cyprus the first line of defence against the invasion of lionfish in the Mediterranean. The project focuses on priority habitats and biodiversity hotspots such as MPAs and its main objectives are a) to develop the capacity to ensure that Cyprus can tackle the lionfish invasion, b) to assess the effectiveness of a range of lionfish invasion prevention measures such as the development and implementation of an early detection and removal system driven by motivated citizens and c) to develop tools that can be transferred and replicated in other countries of the region.

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Materials and methods

Early Preparatory Actions

A series of preparatory actions have been conducted to set a strategic plan for the implementation of the project's core actions.

Specifically, consultations with key stakeholders were organised, while public and stakeholder interviews were carried out to understand lionfish awareness. A telephone survey of 300 Cypriot permanent residents was conducted while 108 stakeholders (i.e. defined as people who make use of the marine environment as a resource or who are involved in the decision-making) were interviewed during meetings carried out across different districts of Cyprus. Additional stakeholder-focused questionnaire surveys were carried out with 20 commercial fishers, 6 dive business owners, 20 recreational fishers, 10 restaurant owners, 100 beach visitors, and 5 aquarium/pet shop owners.

A literature review was conducted to describe and assess the current distribution of lionfish, its expansion rates and the invasion pathway in the Mediterranean. High risk areas around Cyprus and the wider regions were identified and displayed on GIS risk maps. Furthermore, lionfish samplings were carried out throughout the first year of the project (September, 2017 – August, 2018), and a total of 268 lionfish (instead of 50 anticipated by the project proposal) were collected. Morphometric analysis was

conducted in all specimens, reproductive developmental stage and gonadosomatic indices were calculated for 164 lionfish, lionfish growth rates were evaluated using the otoliths of 53 individuals, stomach contents were macro- and microscopically examined from 65 specimens, and lionfish tissues from 56 individuals were genetically analysed. For the latter, the Cytochrome c oxidase subunit 1 (COI) gene and the Control Region (CR) were targeted while Bayesian inference (BI) and Maximum Likelihood (ML) methods were recruited for the phylogenetic analysis.

All of the above complemented the development of a risk assessment following the guidelines of the EU Regulation 1143/2014 and guided the strategic implementation plan of the project.

Future Core Actions

The core actions of the project are expected to start in 2019. RELIONMED has a demonstrative character with three major areas of development, namely the demonstration of surveillance and early detection system, the demonstration of a removal response system, and the lionfish market exploitation. The surveillance and early detection system will be developed in collaboration with MedMIS and will include a GIS tracking online interactive platform and a mobile phone application to alert stakeholders to the presence of lionfish. The Removal response system will be demonstrated with motivated fishers and divers who will be equipped with toolkits and will be trained on how to remove lionfish. Removal Action Teams composed of volunteer divers will utilize targeted removals in priority areas. In addition, lionfish removal derbies/championships for divers will be organised every three months for two consecutive years. The lionfish market exploitation will be demonstrated by promoting and serving lionfish as a delicacy at the restaurant business and by exploring the potential of using lionfish fins in the local jewellery and artwork market.

Ecological and socio-economic indicators will be monitored throughout the project. The results acquired from all actions will be evaluated to develop a lionfish management guide which will indicate the most cost-effective practices identified, and make recommendations of an integrative efficient management strategy for the detection and control of lionfish. Suitable dissemination and transferability activities are planned so to raise public awareness about lionfish and invasive species, and share the identified best-practices to the wider scientific and management community of Cyprus and neighbouring countries.

Results

Public and stakeholder awareness

The interviews revealed differences between public and marine stakeholders' knowledge and perceptions; with the latter being significantly more informed. There was a divergence in opinion regarding the consumption of lionfish and the purchase of products made from lionfish (e.g. jewellery). The public was more opposed to such statements than the marine stakeholders. However, there was almost unanimous support towards further research and development of a management strategy to limit the spread of lionfish. The opinions in regards to the feasibility of lionfish control were contradictory amongst stakeholders. Currently there is no market value for lionfish and lionfish caught from fishers were discarded or given to friends. Restaurant owners characterised the demand as low to non-existent, mainly due to lack of consumer awareness and little supply. Most of them believed that a chef could benefit from knowing how to prepare lionfish in the future. Most commercial fishers catch lionfish on a daily basis (many reported an average

of around five lionfish per day). Recreational fishers reported that they catch lionfish mainly using a speargun, but some reported fishing nets, fish traps, and hook and line as capture techniques.

Lionfish invasion dynamics

A total of 384 lionfish observations from Cyprus were recovered during the literature review and the RELIONMED project development or early project actions. Most lionfish were recorded within the warmer areas of eastern Cyprus; in the unexposed sites of Cape Greco MPA and Nissia, Famagusta bay and Larnaca (Fig. 1). These are areas with a predominant South - South East circulation pattern and known to favour the establishment of NIS. A total of 74 lionfish were caught in an MPA at Cape Greco area on 27th November, 2017 after four dives (composed of four divers each) in an area of around five hectares (500 m x 100 m); demonstrating the remarkable expansion that lionfish populations have experienced in recent years.

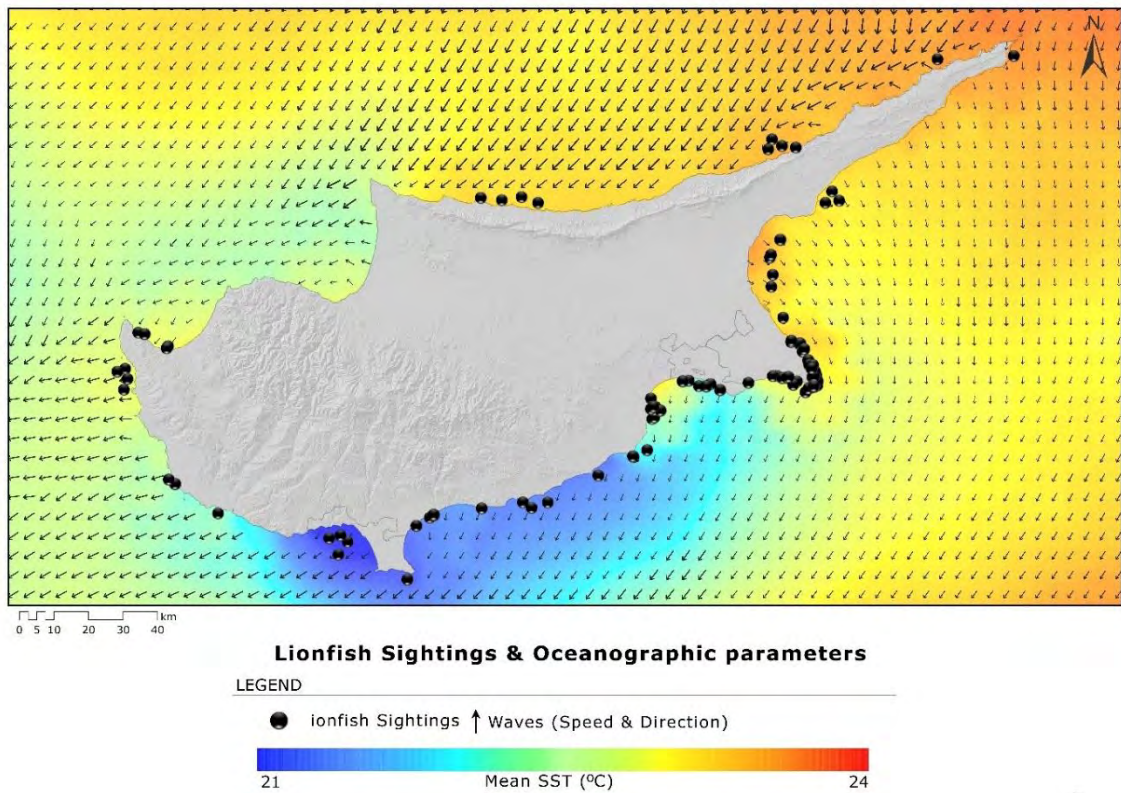


Fig. 1: Annual oceanographic conditions (SST and wave direction/speed) (Georgiou *et al.*, in prep) and lionfish sightings recovered from the grey literature

From the 268 lionfish caught (i.e. 126 females and 82 males), the biggest specimen was a male and attained a TL of 37.1 cm, a SL of 28.4 cm and weighted 755 g. The lionfish with the highest biomass was another 850 g male, having a TL of 36.8 cm and a SL of 27.6 cm. The highest recorded mouth gap area was 32.5 cm². Lower numbers of larger lionfish during the cold seasons (i.e. winter and spring) were detected suggesting a possible ontogenetic shift to deeper waters. Lionfish can be characterised as generalist predators, as their diet constituted of a range of native pisces and crustacean prey, whereby some are of economic (e.g. *Spicara smaris* and *Sparisoma cretense*) and ecological value (e.g. *Chromis chromis* and *Thalassoma pavo*). Otolith examination

showed that lionfish grow fast and can reach 20 cm in one year of age (Fig. 2). Average age was 1.92 ± 0.66 years for females and 2.15 ± 0.80 for males with the maximum age detected being 4 years old in two individuals. Otolith and macroscopic gonad analyses suggest that lionfish may become mature in less than a year of age and that mature lionfish could be spawning year-round. High gonadosomatic indices indicate a peak in reproductive potential during summer (June – August), coinciding with seawater warming (Fig. 2). Genetic analyses demonstrated a low genetic diversity between the lionfish of the most distant and geographically distinct areas. Haplotypes resembled individuals from the Red Sea, although some showed higher genetic similarity to *P. miles* from the Indian Ocean.

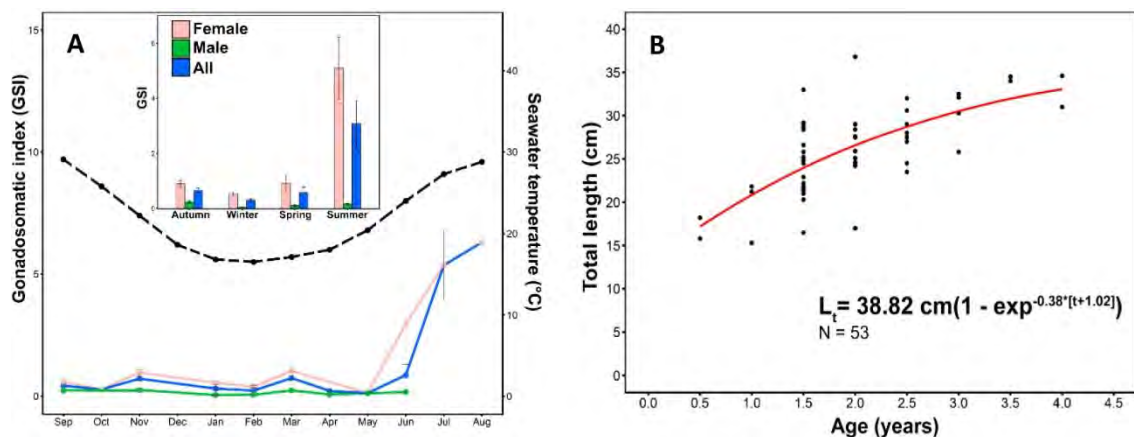


Fig. 2: (A) Mean gonadosomatic indices (GSI) \pm SE for female, male and total fish ($n=164$) collected throughout the study period, with mean water temperatures ($^{\circ}\text{C}$) at 5 m depth (dashed line; acquired from data logger at eastern coast of Cyprus). (B) Growth curve fit to length (L_t) at age (t), data derived from the examined otoliths ($n=53$).

Discussion and conclusions

The preparatory actions of the project, particularly the biological analyses, suffered from low spatial and temporal sampling size. However, the high growth rates observed, the reproductive potential exhibited, and the generalist diet, together with the rapid expansion of lionfish in the region, indicate that the species is well-established and thriving, and can potentially become a ferocious invasive species for the region. Immediate action is required from national and regional management authorities.

RELIONMED is a demonstrative project and seeks for research collaborations on a multinational or regional level to study and better understand lionfish ecology and dynamics. Enormous biological material will be collected through the demonstration activities which can become valuable in answering important biological and ecological questions.

Through the forthcoming activities, RELIONMED aims to: establish rich and deep links with the local communities, scientific communities and policy makers; strengthen regional cooperation, responsibility and surveillance on corporate and social levels and; potentially turn lionfish from a threatening and dangerous invasive species to a stimuli for environmental consciousness, material for education, information and awareness. RELIONMED has the potential to demonstrate a notable example on how communities and regions can work together to protect and improve the ecosystem.

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