RESEARCH ARTICLE (Open Access)

Invasiveness Assessment of Pumpkinseed Fish, *Lepomis Gibbosus*, in Albanian Freshwater Ecosystems by Using the Aquatic Species Invasiveness Screening Kit (AS-ISK)

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Abstract

Pumpkinseed fish is considered to be highly invasive; it has demonstrated great variability in its environmental biology in response to environmental conditions, since its first appearance in the European waters this species has established populations in at least 28 European countries. In Albania, pumpkinseed, was introduced in 1994, even though the pathways of its introduction are not very clear. Aquatic Species Invasiveness Screening Kit (AS-ISK) risk identification screening tools was used to assess the invasiveness potential of pumpkinseed fish, *Lepomis gibbosus*, in Ohrid and Prespa lakes, in order to evaluate the current or future impacts of this non-native fish species. The basic AS-ISK score of 38.3 suggests the species poses a high risk of being invasive, and this risk is expected to even higher in the future, taking in consideration the potential effects of climate change (AS-ISK Climate Change Assessment = 49.7). This study was the first application of AS-ISK in Albania, and the results suggest that it can be a useful decision-supporttool for informing legislation, policy and management of potential, existing and future, undesired translocations of non-native freshwater fish species in the country.

Keywords: Biological Invasion; Risk Analyses, Non-native Species, Ohrid lake, Prespa lakes

1. Introduction

In Europe, several decision support tools have been developed for screening aquatic organisms as a required step in the analysis of risks posed by non-native species (NNS) [6, 8, 9]. Risk screening is especially required for risk assessment areas characterized by high endemism or great biodiversity, such as the Balkan peninsulas [35, 19], especially for species like pumpkinseed fish (*Lepomis gibbosus*), which is known to be highly invasive [41, 1] in several countries. Invasiveness risk is particularly interesting to conduct for inland waters of the Balkans (Mediterranean region), where a high level of endemism has considerably contributed to increases the likelihood of native fish extinctions, due to their restricted natural ranges [31].

In the Balkans, pumkinseed fish, as a popular aquarium species, was accidentally (with a high level of uncertainty) introduced into some trans-boundary river systems in central North Macedonia and northern Greece [22, 13, 18], as well as into Lake Kastoria, Prespa (north-west Greece), River Alfios (Peloponnesus) [14] and Lake Tavropos (central Greece) [3].

According to [11], probably it was an accident even in the case of Albania, while according to [34], it was introduced in Albania in 1994. It is encountered in the

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Lake of Oher and the Lakes of Big Prespa and Small Prespa, respectively [12, 14]

The aim of the presently reported study was to assess the current and future invasiveness potential of *L. gibbosus* by using the Aquatic Species Invasiveness Screening Kit (AS-ISK) of [42] for the first time with aquatic species living in Albanian aquatic ecosystems. The outputs of the presently reported study will serve to demonstrate to environmental managers and stakeholders in Albania the potential use of AS-ISK as a decision-support tool for informing legislation, policy and management (i.e. prevention, control, containment, eradication) of potential, existing and future undesired translocations of non-native freshwater fishes in the country.

2. Material and Methods

The risk assessment (RA) area includes Ohrid and Prespa lakes parts, as parts of the Albanian territory. The Prespa and Ohrid climate is Continental/sub-Mediterranean [29], at the transition zone between Mediterranean and Continental climates, characterised by warm dry summers and rather cold humid winters. For instance Prespa average annual precipitation at lake level reaches 763 mm and lake evaporation 833 mm over the period 1951–2004, while open-pan evaporation amounts to 1041 mm [40]. Popovska and Bonacci [30] have found a statistically significant increase in temperature variability over the period 1961–1990, with an average annual precipitation decreased statistically significantly in Ohrid, but non-significantly in Prespa. This freshwater ecosystem is threatened by the dramatic fall in water level (~8 m) of Lake Big Prespa over the past three decades, which has been inconclusively related to climate change, water abstraction or earthquake-induced changes to underground karst drainage channels [27, 30]. Since 1995 water levels have remained the lowest on record, since observations started around 1917 [5]. The Lake of Big Prespa currently contributes about 25% of the total inflow into Lake Ohrid through underground karst drainage channels.

In order to identify the potential invasiveness of *L.gibbosus*, the AS-ISK decision-support toolkit was used by us. All the assessments were conducted independently by the three authors. A direct derivative of FISK v2 (the Freshwater Fish Invasiveness Screening Kit [26], AS-ISK consists of 55 questions (Qs) on the assessed species' LHTs, invasion and environmental biology, biogeography and history of introduction [42]. Responses to these Qs provide a Basic Risk Assessment (BRA) score, which is complemented by six additional 'climate change' questions that ask the assessor to foretell the likely effects of predicted future climate on the risk screening (risks and magnitude of introduction, establishment and dispersal). Response scores to these Climate Change Assessment (CCA) Qs are added to the BRA score (BRA + CCA score). To each question, the assessor must provide a response and a justification for their response (including bibliographic references) and then rank their confidence in that response. The confidence ranking categories are: 1 = low, 2 = medium, 3 = high, 4 = very high [19]. In all cases, an overall score < 1 assigns a status of 'low risk' (hence, not likely to be invasive), whereas values ≥ 1 identify alien species as potentially invasive and posing either a 'medium risk' or a 'high risk'. Consequently the certainty factor (CF) ranges from a minimum of 0.18 (i.e. all questions with certainty score equal to 1) to a maximum of 1 (i.e. all questions with certainty score equal to 4). Furthermore, it is important to identify a 'threshold' value for the RA area concerned by way of a 'calibration' process to distinguish between species of medium and high risk of invasiveness [6, 21].

Because there has been no calibration of AS-ISK for (freshwater fish in) Albania, the choice of BRA and BRA + CCA thresholds to distinguish between medium *vs* high risk was based on the identified threshold values by [19] for 24 freshwater fish species in Balkans, the BRA threshold of 10 and BRA + CCA threshold of 12.62, for the same set of species.

3. Results and Discussion

Based on the reference threshold score of 10, the identified average BRA score (by the three assessors for *L. gibbosus*) in Albania (38.3) falls within the 'high risk' category (Fig. 1A). When the potential effects of climate change on the risk screening responses are taken into consideration, *L. gibbosus*' BRA + CCA score increases to 49.7 (hence well above the 12.62 threshold) reflecting an even higher risk of the species being invasive in Albania in the future (Fig. 1A).

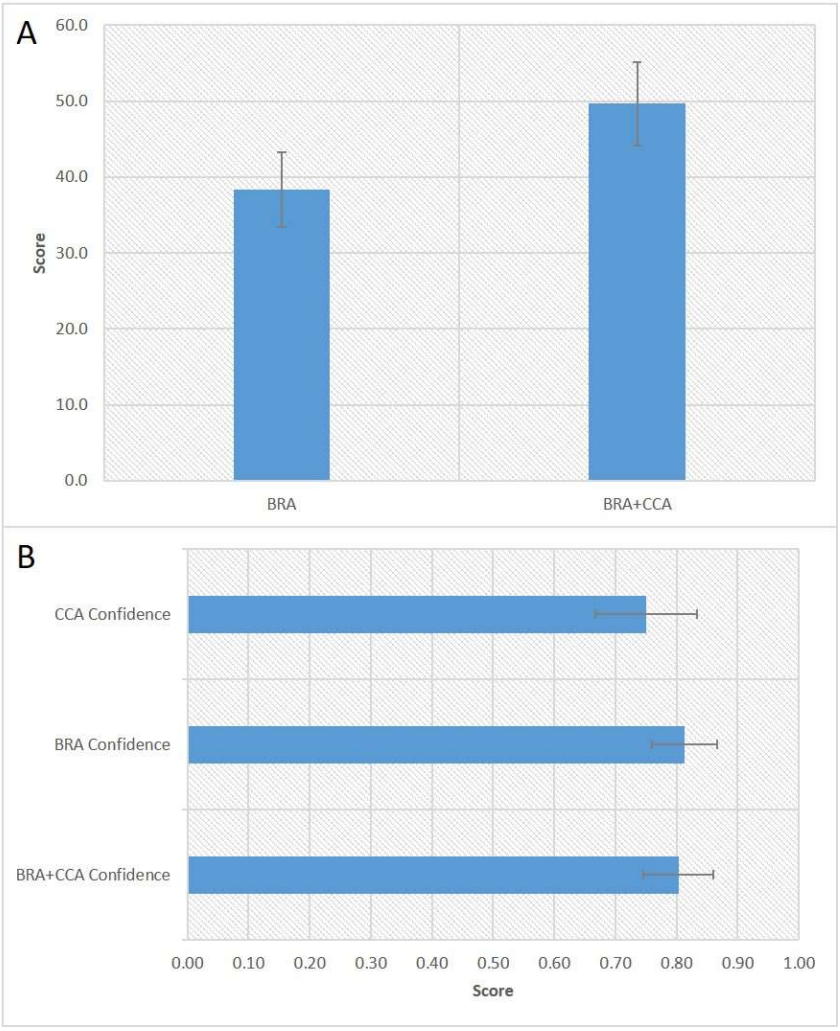

Figure 1. Graphical presentation of the identified score values from the invasiveness assessment of pumpkinseed fish by the three authors, expressed as (A) average score values of BRA and BRA+CCA and (B) confidence level of BRA, BRA+CCA and CCA.

The mean confidence levels for responses to Qs contributing to the BRA, CCA, and BRA + CCA scores for *L. gibbosus* in Albania were 0.81 (± 0.05 SE), 0.75 (± 0.08 SE) and 0.80 (± 0.06 SE), respectively, which suggests high level of confidence and furthermore a comparability among AS-ISK groups of Qs (Fig. 1B).

Factors and traits that increased *L. gibbosus'* AS-ISK score (Fig. 2A) included a history of being invasive elsewhere (12.7 ± 2.31 SE) and to lower level regarding the other historical and biogeography characteristic, represented by the high climatic match and elevated likelihood of being illegally stocked. Regarding the characteristics corresponding to the biology and ecology, the undesirable (or persistence) traits (8.3) (in case of pumpkinseed fish mainly represented by the opportunistic foraging behaviour) represented one of the most important traits together with likelihood high risks posed to native threatened or protected taxa (resource exploitation, 7.0).

Traits that reduced the overall score included reproduction and dispersal mechanisms, though it is known the existence of parental care and relatively small size at maturity of this species. The average score of tolerance attributes (3.7 ± 3.51 SE) indicate no likelihood of hybridisation with native species, though with a high uncertainty by the assessors. Generally, the high score registered for the climate change factor (11.3 ± 1.15 SE) indicate that it is likely that *L.gibbosus* will continue to disperse and establish in the RA area under current climate conditions, and more likely under predicted future climatic conditions. In the latter case, the risks of establishment and dispersal would increase the species' risk of invasiveness (Qs 50–52), and also the magnitude of future potential impacts (Qs 53–55).

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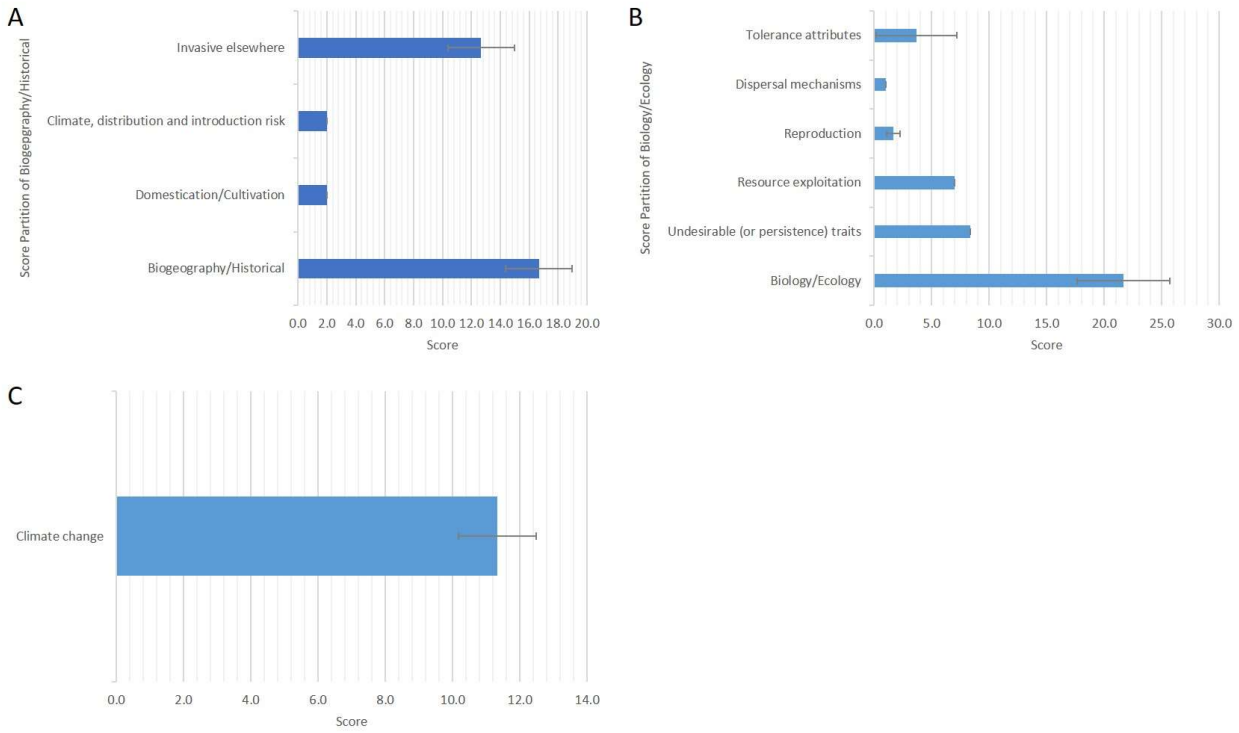

Figure 2. Graphical presentation of Score Partition of (A) Biogeography/History related factors, (B) Biology/Ecology contributors and (C) Climate change on the invasiveness level of pumpkinseed fish in the Albanian ecosystems.

In Fig. 3 are shown the sectors affected by the pumpkinseed fish invasiveness in the Prespa and Ohrid ecosystems. The species (24 ± 4 SE) populating the ecosystem due to the population nuisance traits will be mostly affected by the presence of *L. gibbosus*, while the commercial sectors (like the fisheries or tourism) will be less affected by the potential invasiveness of pumpkinseed fish (18 ± 2.31 SE). Generally, the environment will suffer less than the previously mentioned sectors by the presence of this species (12 ± 1.53 SE).

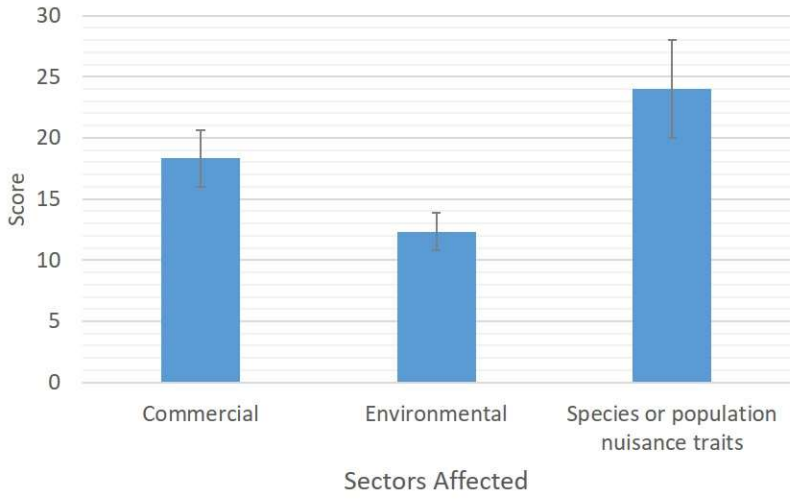

Figure 3. Graphical presentation of the impact toward different sectors close to the Prespa and Ohrid Lakes by the presence of pumpkinseed fish.

In the RA freshwater ecosystems, a strong climate related impact on the limnology and physical parameters including the Lake Prespa [2], is predicted to be followed by a significant decrease in productivity, enhanced mixing, strong decomposition and soil erosion. For instance, future climate changes could lead to an accelerated water-level fall and a reduction in lake volume, then there will be substantial negative consequences for regional water resources and global biodiversity. The lake Prespa currently contributes ~25% of the total inflow into Lake Ohrid through underground karst drainage channels, while it has been observed that falling lake levels will decrease this underground discharge [27] and the Lake Ohrid outflow to the Drini River will decrease consequently. Furthermore, a reduction in lake volume will consequently bring out to an increase in pollutant concentrations and accelerate the on-going eutrophication of the Prespa Lakes [27]. Another deteriorating factor is represented by the introduced species, like *L. gibbosus*, which has been shown to be highly invasive in other European countries. For the first time in Albania, this species invasiveness potential was assessed by identifying *L. gibbosus* BRA and BRA+CCA (Fig. 1). Relative to *L. gibbosus* BRA and BRA+CCA scores published for other RA areas, except the case of Thrace and Anatolia (Turkey, [39]), those for Albania were consistently higher than for Poland [20], Lake Marmara (Turkey, [38]), River Neretva catchment (Bosnia and Herzegovina, and Croatia [19]).

Differently to Albanian freshwater ecosystems (Fig. 2), the analysed factors and traits that increased *L. gibbosus*' AS-ISK score in the study of [20] (Poland) included a historyof being invasive elsewhere, high climatic match, parental care, relatively small size at maturity, opportunistic foraging behaviour, and elevated likelihood of being illegally stocked. Traits thatreduced the overall score included no likelihood of hybridisation with native species and low risksposed to native threatened or protected taxa.

Twenty-eight taxa of fish have been identified from Prespa and Ohrid lakes [37], mostly represented by members of Cyprinidae and Salmonidae members, where there are endemic species like *Squalius prespensis* in Prespa and *Salmo letnica* together with *Salmo ohridanus* in Ohrid Lake. Most of the fish catches in Prespa lakes are represented by carp, while in Ohrid Lake the main interest is toward the two endemic species (authors observatons). As shown in the graphic of Fig. 3, the presence of *L. gibbosus* could deteriorate the abundance of the endemic fish species subject of fishing activities, with a considerable impact not only to this commercial activity, but also to tourism related activities – strictly linked to the presence of the endemic species. Other vertebrate and invertebrate species population could also suffer by the presence of the pumpkinseed fish populations, because pumpkinseed fish is omnivorous [10, 7] and demonstrates trophic and/or resource polymorphism. For example, individuals in the pelagic zone appear to be specialized for foraging on zooplankton, while those that live in shallow littoral habitat feed primarily on macro-invertebrates [32, 28]. With age, pumpkinseed fish becomes increasingly predatory, and its diet may consist of small fishes and amphibians [33, 23]. Pumpkinseed fish has also been known to consume fish eggs and aquatic plant debris [17, 10].

However, despite the BRA and BRA + CCA scores, which classify *L. gibbosus* as likely to pose a high risk of invasiveness, the species' known adverse impacts are not yet fully understood for the RA area, here represented mainly by south-eastern Albania. For instance, studies in southern England of the species' microhabitat and trophic interactions with native fishes found limited or no evidence for adverse impacts [36, 24], whereas impacts have been recorded in managed ponds in the Netherlands [41] and in natural streams of the Iberian Peninsula [1].

4. Conclusions

Each county provides particular evidences regarding relative impacts of pumpkinseed fish to the aquatic ecosystem. As such, further research is needed in Albania to assess the potential impact of *L. gibbosus* on this country's native species and ecosystems. This could be considered as the first step followed later by surveys and similar initiatives. Several similar studies would be needed not only for creating an invasive alien species strategy (including a plan of action), but also with interest at international level (as part of comparisons with other neighbour countries outputs).

5. Acknowledgements

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