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SHORT COMMUNICATIONS

Better a Bit of Something than a Bit of Nothing: Outcomes of Invasive Wels Catfish (*Silurus glanis*) Control in a River Reach of the Po Basin (NW Italy)

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Abstract—The introduction of non-native species is a leading driver of biodiversity loss, particularly in freshwater ecosystems, where fish communities have long been subject to human-mediated introductions and translocations. Among the most impactful invasive fishes in Europe, the Wels catfish (*Silurus glanis* L. 1758) is notable for its large size, high adaptability, and strong predatory behavior. This study presents the results of a removal campaign conducted between April 2021 and May 2023 in a confined reach of the Orba Stream (Po River basin, NW Italy), an area of high environmental quality that hosts one of the last structured populations of the South European Nase (*Protochondrostoma genei* Bonaparte 1839), a threatened endemic species. Over nine targeted removal sessions, supported by semi-quantitative sampling of the fish community, we observed a marked reduction in both abundance and biomass of Wels catfish. These trends were accompanied by signs of recovery in several native fish species. Although the complete eradication of *S. glanis* at the catchment scale is unrealistic, focused removal in ecologically sensitive areas can significantly contribute to native fish conservation.

Keywords: non-native species, invasion biology, freshwater fish, alien species control

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INTRODUCTION

The introduction of non-native species is a major driver of biodiversity loss (Clavero and García-Berthou, 2005; Hald-Mortensen, 2023). This threat is particularly severe in freshwater ecosystems, which are highly vulnerable to biological invasions (Strayer, 2010; Reid et al., 2019; Guareschi and Wood, 2022) and experience more severe impacts than terrestrial environments (Ricciardi and MacIsaac, 2011; Dudgeon, 2020). The consequences of non-native species on native biodiversity are numerous, multifaceted, and often synergistic (Erarto and Getahun, 2020). They include direct predation on native taxa (e.g. Candiotto et al., 2011; Weis, 2011), competition for habitat (e.g. Bottollier-Curtet et al., 2013) and trophic resources (e.g. Dominguez Almela et al., 2021; Saç, 2023), hybridization with native congeners (e.g. Splendiani et al., 2019), and the facilitation of emerging infectious diseases (e.g. Poulin et al., 2011) or secondary invasions (e.g. Falasco et al., 2025; Tarasova et al., 2025).

The globalisation of modern transport systems has played a key role in accelerating the rate of biological invasions (Perrings et al., 2005). However, for certain taxonomic groups and ecosystems, these processes began much earlier. Over the centuries, humans have deliberately introduced hundreds of freshwater fish species outside their native ranges, primarily for their economic value, whether for food or recreational fishing. A notable example is the common carp (*Cyprinus carpio* Linnaeus, 1758), which was intentionally introduced to the Italian Peninsula by the Romans and subsequently spread across many European countries during the Middle Ages (Balon, 1995). Unsurprisingly, the influential list of the "100 of the World's Worst Invasive Alien Species" (Lowe et al., 2000)—one of the first global efforts to rank invasive species by ecological impact—includes several freshwater fish. Among these are: brown trout (*Salmo trutta* Linnaeus, 1758), common carp (*Cyprinus carpio*), largemouth bass (*Micropterus salmoides* Lacepède, 1802), Mozambique tilapia (*Oreochromis mossambicus* Peters, 1852), Nile perch (*Lates niloticus* Linnaeus, 1758), rainbow trout (*Oncorhynchus mykiss* Walbaum, 1792), walking

catfish (*Clarias batrachus* Linnaeus, 1758), and western mosquitofish (*Gambusia affinis* Baird & Girard, 1853).

Recently, the introduction and spread of the Wels catfish (*Silurus glanis* Linnaeus, 1758) has become a growing concern in many European countries, particularly in southern Europe (Brignone et al., 2025). Native to eastern Europe and western Asia, this species has been widely introduced across western and southern European freshwater systems in recent decades, mainly to support recreational fishery, aquaculture, and, in some cases, biological control (Copp et al., 2009; Cucherousset et al., 2018). The first documented record of *S. glanis* in Italy dates back to 1957 (Manfredi, 1957). However, since the 1990s, the species has undergone rapid expansion across several river basins of the Italian peninsula, particularly within the Po River catchment (Copp et al., 2009; Mancini et al., 2022; Abbà et al., 2024).

Several traits contribute to its invasive success: high environmental tolerance, rapid dispersal ability, high reproductive success, and remarkable trophic plasticity (Copp et al., 2009; Vejřík et al., 2017; Brignone et al., 2025). Furthermore, it is important to bear in mind that the spread of the species is also linked to continuous illegal introductions (Vejřík et al., 2019). The most significant impacts of the Wels catfish on biodiversity are related to its role as top predator. By exploiting a wide range of prey, it can lead to significant declines in the abundance and biomass of native fish populations or cause local extirpations (Copp et al., 2009; Castaldelli et al., 2013; Vejřík et al., 2017; Ferreira et al., 2019; De Santis and Volta, 2021).

Eradicating non-native species is almost always an unrealistic goal, as control measures are not consistently effective (Prior et al., 2018). The Wels catfish is particularly difficult to manage as it typically prefers large, interconnected aquatic systems (Vejřík et al., 2019). Furthermore, it is often difficult to capture using standard sampling techniques (Vejřík et al., 2019; De Santis et al., 2024) and detailed knowledge of its habitat use and behavior remains limited, although research efforts in this area are increasing (e.g. Nyqvist et al., 2022). Nevertheless, the severe ecological, social and economic impacts it causes make active management efforts essential (De Santis et al., 2024).

The aim of this study was to assess the effectiveness of a *Silurus glanis* removal campaign conducted in a limited but conservation-relevant river section in NW Italy, by monitoring the variations in Wels catfish and native fish populations over the course of the intervention.

MATERIALS AND METHODS

The study was carried out in the Orba Stream, a tributary of the Bormida River within the Po River basin (NW Italy), in a 2-km-long reach near the town of Predosa (44°46′29″ N, 8°39′50″ E, WGS84; Fig. 1).

The site was selected for its ecological relevance and environmental characteristics, particularly its high habitat quality and semi-confined structure. The reach is bounded downstream by an artificial barrier and upstream by more torrential conditions. These features limit fish movement, allowing colonization by large-bodied or low-mobility species only during flood events, when both natural and artificial barriers are temporarily bypassed. Notably, no flooding occurred during the study period, ensuring that fish movements into or out of the study area were negligible.

Nine removal campaigns were carried out between April 2021 and May 2023, across different seasons. Summer was excluded to avoid interference from dense aquatic vegetation (primarily *Potamogeton* spp. and *Myriophyllum* spp.), which hindered boat navigation and reduced the efficiency of electrofishing. Sampling campaigns were as follows: 19 April 2021, 31 May 2021, 10 December 2021, 6 January 2022, 20 April 2022, 3 June 2022, 2 December 2022, 24 January 2023, and 29 May 2023.

Sampling was carried out using an Alaska 370 S boat equipped with an electric motor to allow easy access to areas preferred by Wels catfish. Electrofishing was performed using SCUBLA ELT60 device (operating at 25–100 Hz and 300/550 V). The same transect was followed in each campaign (total length = 2000 m, mean water depth = 1.2 m, mean transect width = 6.8 m).

During each campaign, the number of *Silurus glanis* individuals captured and those observed escaping were recorded. We refer to the total of captured plus escaped individuals as "observed" Wels catfish. Captured specimens were euthanized, measured (±1.0 cm), and weighed (±1 g).

To assess changes in the broader fish community, species observed along the transect during each campaign were counted. Population trends were specifically monitored for native species of conservation concern.

Normality and homoscedasticity of the data were verified using Shapiro-Wilk and Levene's tests, respectively. Linear models (LMs) were used to test for temporal trends in the number of removed and observed Wels catfish, their biomass, length, and weight, as well as the abundance of native species. All data processing, visualization, and statistical analyses were performed in R (Posit team, 2024; R Core Team, 2023) using the following packages: car (Fox and Weisberg, 2019), dplyr (Wickham et al., 2023), ggplot2 (Wickham, 2016), ggfortify (Tang et al., 2016), and vegan (Oksanen et al., 2025).

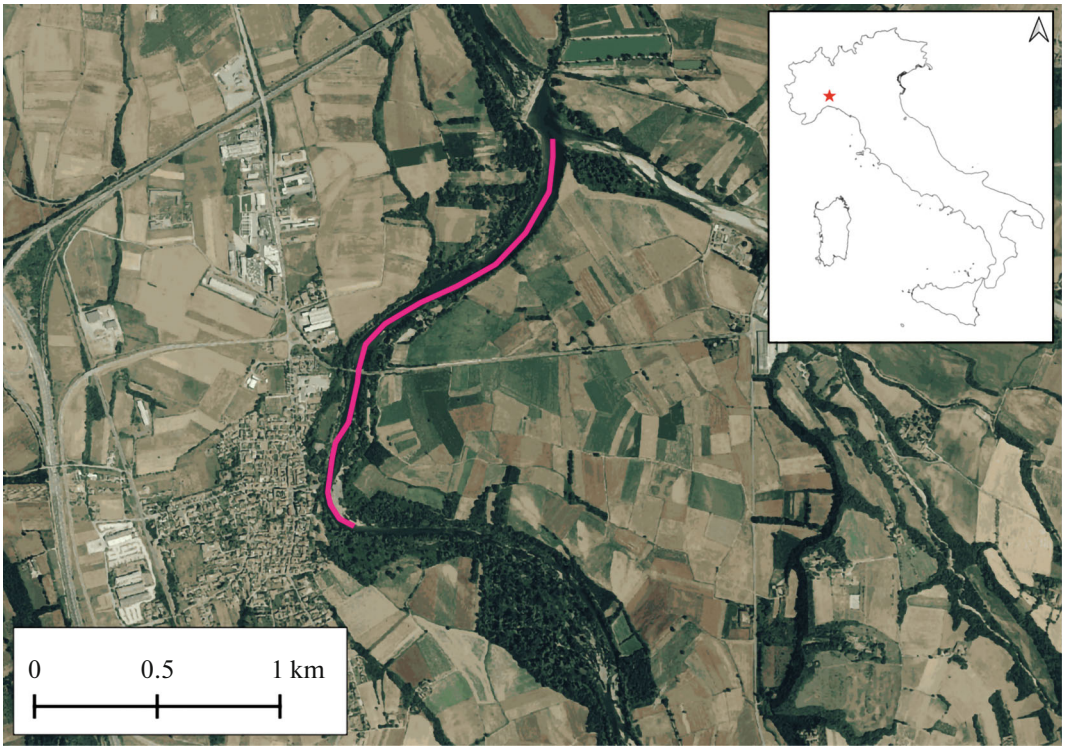


Fig. 1. Study area. The Orba stream is located in NW Italy, the study reach is shown in pink.

RESULTS

During the study period, a total of 242 Wels catfish (*Silurus glanis*) were captured, euthanized, weighed, and measured, resulting in a cumulative biomass of 1.504.63 kg. The number of removed and observed individuals varied across campaigns, with the highest number recorded during the first sampling (57 removed/86 observed) and the lowest during the final campaign (3 removed/10 observed).

A significant decreasing trend in Wels catfish abundance was detected over the course of the study (LM for removed individuals: $R^2 = 0.758$, $p < 0.001$; for observed individuals: $R^2 = 0.767$, $p < 0.001$; Fig. 2). A significant decreasing trend was observed also for the biomass of removed individuals ($R^2 = 0.823$, $p < 0.001$; Fig. 3), with a reduction from 335.58 kg in the first campaign to 11.76 kg in the last.

The mean total length and weight of removed Wels catfish were 84.42 cm (±29.98 SD) and 6.23 kg (±4.15 SD), respectively. The largest individual measured 155 cm and weighed 22.28 kg, while the smallest was 13 cm and 20 g. No significant changes in the

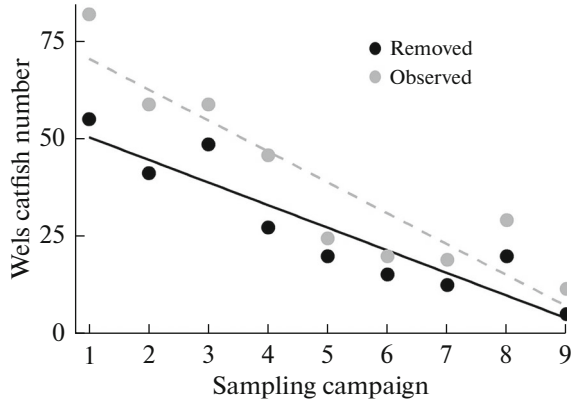


Fig. 2. Trend in the number of removed and observed (removed + escaped) Wels catfish during the study period.

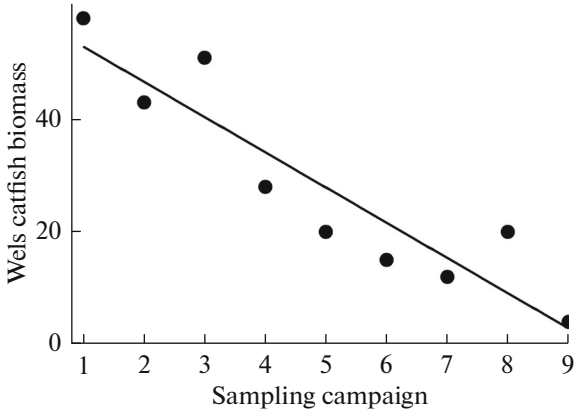


Fig. 3. Trend in the biomass (kg) of removed Wels catfish during the study period.

Table 1. Native and non-native species that make up the fish community of the study reach

Native species	Non-native species
Alborella—*Alburnus arborella* (Bonaparte, 1841)	European barbel—*Barbus barbus* (L., 1758)
Triotto—*Leucos aula* (Bonaparte, 1841)	Gudgeon—*Gobio gobio* (L., 1758)
Italian chub—*Squalius squalus* (Bonaparte, 1837)	Pumpkinseed sunfish—*Lepomis gibbosus* (L., 1758)
Italian barbel—*Barbus plebejus* (Bonaparte, 1839)	Stone moroko—*Pseudorasbora parva* (Temminck & Schlegel, 1846)
South European Nase—*Protochondrostoma genei* (Bonaparte, 1839)	European bitterling—*Rhodeus amarus* (Bloch, 1782)
Italian spined loach—*Cobitis bilineata* (Canestrini, 1865)	Common carp—*Cyprinus carpio* (L., 1758)
Padanian goby—*Padogobius bonelli* (Bonaparte, 1846)	*Carassius* sp.
	Northern pike—*Esox lucius* (L., 1758)
	Danubian loach—*Cobitis* cf. *elongatoides* (Băcescu & Mayer, 1969)
	Black bullhead—*Ameiurus melas* (Rafinesque, 1820)
	Wels catfish—*Silurus glanis* (L., 1758)

mean length or weight of removed individuals were observed over time (Length: $R^2 = -0.004$, $p > 0.05$; Weight: $R^2 = -0.002$, $p > 0.05$).

In terms of fish community composition, a total of 17 species were recorded during the study (Table 1), of which 10 were non-native.

Over the study period, all native species exhibited a positive trend in abundance (Fig. 4), although only *Protochondrostoma genei* showed a statistically significant increase (LM: $R^2 = 0.564$, $p < 0.05$). Other native species showed non-significant increasing trends: *Barbus plebejus* ($R^2 = 0.011$, $p > 0.05$), *Squalius squalus* ($R^2 = 0.402$, $p > 0.05$), *Leucos aula* ($R^2 = 0.086$, $p > 0.05$), and *Alburnus arborella* ($R^2 = 0.001$, $p > 0.05$).

DISCUSSION

The introduction and subsequent proliferation of non-native freshwater fishes in riverine ecosystems poses a serious threat to native biodiversity (Strayer, 2010; Reid et al., 2019). The management of *Silurus glanis*, given its role as an apex predator, its large body size, and its trophic plasticity, represents a pressing challenge in the conservation of freshwater in numerous southern European countries (Copp et al., 2009; Vejřík et al., 2017; De Santis et al., 2024).

Our results show that periodic removal efforts in a relatively short and ecologically confined river section can effectively reduce Wels catfish abundance and support native fish population recovery. Notably, the South European nase (*P. genei*), a species in sharp

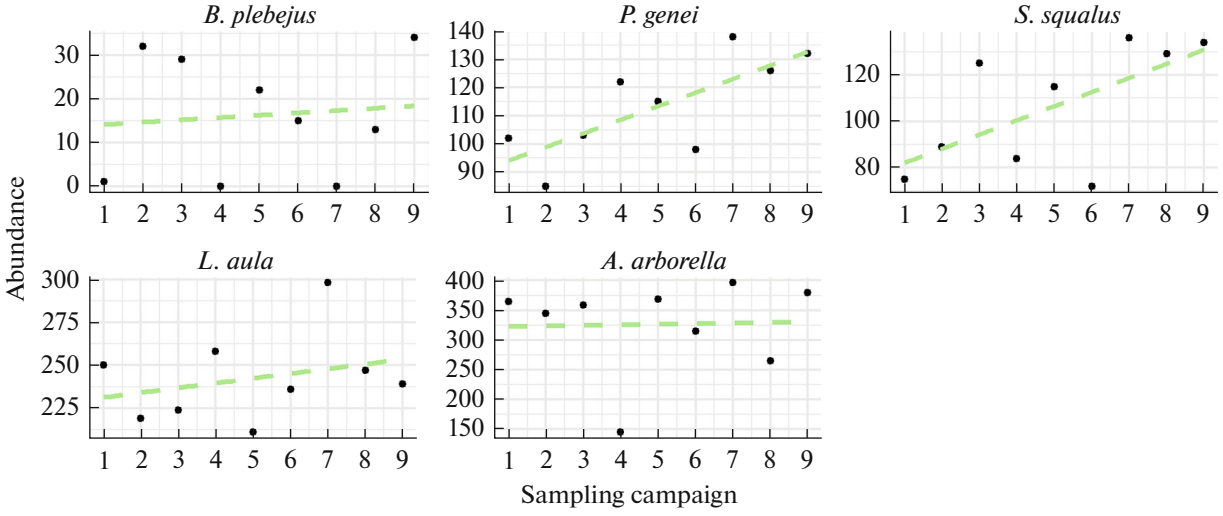


Fig. 4. Population trends of the species counted during the study period.

decline across its range (Abbà et al., 2024), showed a marked population increase. While we were unable to assess long-term outcomes, these short-term results are promising.

Although removal efforts rarely restore ecosystems to pre-invasion conditions, certain environmental features may enhance their effectiveness. Less disturbed systems and more isolated management units appear to facilitate ecological recovery following control measures (Prior et al., 2018). In our study, the high conservation value of the Orba stream section, along with its partial hydrological isolation both upstream and downstream, likely contributed to the success of the interventions. These characteristics make the site a manageable conservation unit and a potential refuge for endangered native species.

Therefore, despite the spatial and temporal limitations of this intervention, our findings are of considerable relevance: although complete eradication or even broad containment of Wels catfish from the Italian river network is currently unfeasible, a site-specific, targeted control strategy can yield meaningful ecological benefits. Such approaches can promote the recovery and resilience of native fish communities and may serve as a valuable model for conservation management in other ecologically sensitive or protected freshwater systems.

These results highlight the importance of adaptive, localized management strategies as viable tools for mitigating the impacts of invasive species and enhancing biodiversity conservation in freshwater ecosystems.

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AUTHOR CONTRIBUTION

All authors contributed to the study conception and design. Material preparation and data collection were carried out by Alessandro Candiotto, Stefano Fenoglio, and Tiziano Bo. Data analysis was performed by Margherita Abbà and Anna Marino. The first draft of the manuscript was written by Stefano Fenoglio and Margherita Abbà, and all authors provided comments and revisions on previous versions of the manuscript. All authors read and approved the final version of the manuscript.

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ETHICS APPROVAL AND CONSENT TO PARTICIPATE

The removal of the Wels catfish (*Silurus glanis*), an invasive alien species included in the Union List under Regulation (EU) No. 1143/2014, was carried out in compliance with this Regulation and with the Italian Legislative Decree No. 230 of 15 December 2017, which implements the rules on the prevention and management of invasive alien species, and upon specific authorization issued by the Province of Alessandria (Prot. Gen. N. 20220003619, Date January 25, 2022 2022).

CONFLICT OF INTEREST

The authors of this work declare that they have no conflicts of interest.

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