Online ISSN: 2588-3526

Journal of Wildlife and Biodiversity

*Volume 9(3): 307-317 (2025) (*http://www.wildlife-biodiversity.com/*)*

**Research Article**

# Environmental awareness actions in the control of invasive species: the case of the European catfish (*Silurus glanis*) in the River Tagus (Portugal)

**João Gago[1,2,3], Igor Dias[1,2,5], Elisabete Linhares[4,5], Luis Pereira[1], Ana Teresa Ribeiro[1,5], Verónica Ribeiro[1], Ana Silva[4,6], João Manuel Oliveira[1,2,7]***

[1]Santarém Polytechnic University, School of Agriculture, Quinta do Galinheiro - S. Pedro, 2001-904 Santarém, Portugal

[2]Research Center in Natural Resources, Environment and Society (CERNAS), Santarém Polytechnic University, Quinta do Galinheiro - S. Pedro, 2001-904 Santarém, Portugal.

[3]MARE–Marine and Environmental Sciences Centre/ARNET–Aquatic Research Network, Faculty of Sciences, University of Lisbon, Campo Grande, 1749-016 Lisbon, Portugal.

[4]Santarém Polytechnic University, School of Education, Complexo Andaluz, Apartado 131, 2001-902 Santarém, Portugal

[5]Life Quality Research Center (CIEQV), Santarém Polytechnic University, Complexo Andaluz, Apartado 279, 2001 -904 Santarém, Portugal

[6]Research Center for Arts and Communication (CIAC), Santarém Polytechnic University, Complexo Andaluz, Apartado 279, 2001 -904 Santarém, Portugal.

[7]cE3c–Centre for Ecology, Evolution and Environmental Changes & CHANGE–Global Change and Sustainability Institute, Faculty of Sciences, University of Lisbon, Campo Grande, 1749-016 Lisbon, Portugal

*Email: joao.oliveira@esa.ipsantarem.pt

Received: 26 July 2025 / Revised: 29 September 2025 / Accepted: 12 October 2025/ Published online: 16 October 2025.

How to cite: How to cite: Gago, J., Dias, I., Linhares, E., Pereira, L., Ribeiro, A.T., Ribeiro, V., Silva, A., Oliveira, J.M. (2025). Environmental awareness actions in the control of invasive species: the case of the European catfish (*Silurus glanis*) in the River Tagus (Portugal), Journal of Wildlife and Biodiversity, 9(3), 307-317. DOI: https://doi.org/10.5281/zenodo.17370939

## Abstract

This study reports on awareness-raising initiatives along the River Tagus (Portugal) targeting the spread of the invasive European catfish (*Silurus glanis*). Activities included public awareness on alien and native species, angler surveys, and culinary demonstrations with sensory evaluations, mobilising anglers and citizens for conservation. Results showed strong support for harvesting this non-native species and high acceptance of European catfish-based dishes. These findings underscore the role of environmental education in managing invasive species in Portugal's freshwater ecosystems.

**Keywords**: Angler surveys, fish biodiversity, show-cooking

## Introduction

Freshwater ecosystems in Portugal support a rich diversity of fish, including both native and non-native species, with the latter representing over 30% of the total ichthyofauna (Collares-Pereira et al., 2021; Magalhães et al., 2023). The increasing presence of non-native invasive fish species in Portuguese inland waters, driven by factors such as recreational angling (sometimes associated with illegal introductions) and exacerbated by their natural dispersal, has raised concerns about the impacts of these species on aquatic ecosystems and native species (Ribeiro et al., 2009). Major threats include ecological imbalances caused by intense predation, resource competition, and pathogen transmission (Anastácio et al., 2019).

A clear example of these invasive species is the European catfish (*Silurus glanis*), also known as Wels catfish, a top predator whose introduction into Portugal, estimated to have occurred in 2006 (Gago et al., 2016), has caused significant impacts on freshwater ecosystems (Ferreira et al., 2019; Encina et al., 2024). It has been found in the River Tagus (Central Portugal), in some of its tributaries and reservoirs, and in the River Douro (Northern Portugal) (Collares-Pereira et al., 2021; Martelo et al., 2021). In the Portuguese legal framework, the European catfish is listed as an invasive species (Decree-Law No. 92/2019), and its release after capture is prohibited (Decree-Law No. 112/2017), to help control its spread, in line with the National Strategy for Nature Conservation and Biodiversity 2030.

Native to Central Europe and Western Asia, the European catfish is the tenth largest freshwater fish in the world. It can reach up to 2.7 m in length, 130 kg in weight (Boulêtreau & Santoul, 2016), and live for up to 70 years, with a remarkable fecundity ranging from 65,000 to 185,000 oocytes per female, depending on body size (Copp et al., 2009). Recent studies have also shown the high reproductive potential of this species in the River Tagus (Gkenas et al., 2025). The predatory impact of the European catfish is particularly evident in the lotic section of this river, where its diet is composed by native fish species of high ecological and economic importance (Ferreira et al., 2019; Moncada et al., 2021). Furthermore, its tolerance to harsh environmental conditions, such as low oxygen levels and high salinity, facilitates its spread across a variety of habitats, including estuaries and salt marshes (Copp et al., 2009).

Environmental awareness plays a key role in managing invasive non-native species by enhancing public understanding of the ecological, economic, and social impacts associated with their introduction and spread (Smith et al., 2020; Cerveira et al., 2022). This is particularly relevant in

Europe, where both the general public and decision-makers often have a limited understanding of the range of threats posed by these species (Genovesi & Shine, 2004). In this context, within the framework of the CHALLENGER SILURO project, environmental awareness initiatives specifically focused on the European catfish were carried out during angling competitions along the River Tagus. These actions comprised outreach activities addressing both native and non-native species, surveys on European catfish angling and anglers' ecological perceptions, and show-cooking demonstrations by renowned Chefs featuring dishes prepared with European catfish. These initiatives aimed to explicitly discourage the illegal practice of releasing non-native species back into the wild ('catch and release'), to raise awareness of the biodiversity of native ichthyofauna, and to promote the culinary use of the European catfish as a noble use of this emerging food resource.

## Material and methods

In 2025, awareness-raising activities were held during three angling events along the lower lotic segment of the River Tagus: Parque de Merendas, Tancos (2 March); Pinheiro Grande, Chamusca (6 April); and Ribeira de Santarém, Santarém (27 April) (Fig. 1). These actions included outreach activities on non-native species, highlighting both their ecological impacts and the role of anglers in their management; electrofishing demonstrations conducted by the project team to illustrate the diversity of native and non-native fish species in the River Tagus; questionnaires evaluating the relevance of European catfish angling and anglers' ecological perceptions of this and other invasive species; and sensory evaluations of dishes prepared with this invasive species (see video: Coito, L. (2025). *Unwanted: Silurus glanis, the Invasive Predator* (in Portuguese)).

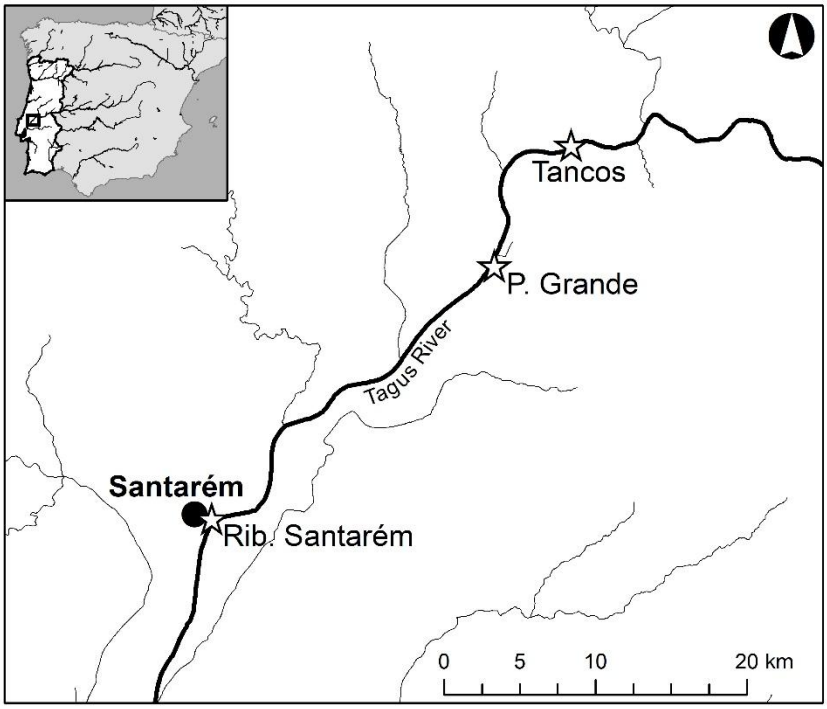


**Figure 1**. Map of the study area showing the location of the three angling events.

A structured questionnaire comprising thirteen questions on European catfish angling, anglers' ecological perceptions, and sensory evaluations of dishes was validated by a panel of experts in fish ecology and environmental education, ensuring both clarity and relevance. The initial feedback on the first version of the questionnaire was generally positive; however, the experts recommended placing greater emphasis on the role of European catfish as a potential driver of the regional economy and on its use in gastronomy as a means to promote the species' management. Accordingly, some questions were added or refined to address these aspects. Depending on the nature of each question, responses were collected using either binary options or a Likert scale ranging from 0 (nothing) to 5 (very much). All interviews were conducted face-to-face by members of the project team, with informed consent obtained from all participants. Confidentiality was assured, and responses were used exclusively for project purposes. Responses were collected anonymously, although the questionnaire included a brief identification section covering district of residence, age, and gender.

The first section began by asking respondents whether they had previously fished for European catfish—either recreationally or competitively—and about their interest in targeting this species in the future (Table 1). Subsequent questions explored their perceptions of the ecological impact of

European catfish, specifically whether they supported harvest (retention) angling of this species and considered it a viable strategy for reducing its population in the River Tagus. Finally, participants were asked whether they supported harvest angling for other invasive non-native species and regarded this practice as a potential means of conserving native fish species.

Live cooking demonstrations by renowned regional and national Chefs, followed by sensory tastings, aimed to identify the most appealing culinary techniques and promote consumption of the species among anglers and the general public. The culinary events were led by Chef Bruno Dias (1st event: catfish ceviche and catfish rice), Chef Leonel Barata (2nd event: catfish soup and braised (stew) catfish with *migas*, a traditional bread-based side dish), and Chef Rodrigo Castelo (3rd event: catfish tartare and a catfish sandwich served on *bolo do caco*, a traditional Madeiran flatbread). The target audience for the sensory evaluations included not only the anglers but also representatives from attending organizations, such as local authorities, the Institute for Nature and Forest Conservation, and the National Republican Guard's Nature and Environmental Protection Service. After tasting the European catfish-based dishes prepared by the Chefs, respondents were asked to rate each dish and indicate whether they would recommend it to others, following an explanation of the meaning of the Likert scale values. Pairwise comparisons between dishes were completed using Welch's t-tests (Field, 2018). According to this author, Welch's t-test is robust to heteroscedasticity and is recommended for comparing group means when variances are unequal. Respondents were also asked if they would be willing to cook European catfish at home, and about their perception of its gastronomic and recreational potential to promote tourism in the lower Tagus region.

## Results

In the three sport angling events, questionnaires on the relevance of European catfish angling and anglers' ecological perceptions were completed only once by 27 anglers, all male (Table 1). Most respondents were aged between 51 and 60 years, representing almost 50% of the total sample, and lived near the Tagus River basin, mainly in the Santarém district. Regarding the angler's prior experience with European catfish, one-third reported familiarity with the species and its capture methods. All respondents expressed a strong interest in targeting this species in the future. Additionally, when asked about harvesting European catfish and the effectiveness of recreational angling in controlling this non-native species, unanimous agreement was recorded. The surveys also revealed strong support for the conservation of the Tagus River's fish biodiversity, with 92.6 of respondents agreeing that recreational angling on non-native fish species can contribute to

preserving the river's native ichthyofauna. However, a lower percentage (59,3%) expressed support for the removal of other non-native fish species (Table 1).

**Table 1.** Results from the first section of the questionnaire, presenting percentages and absolute frequencies for Q1 (angler identification) and Q2 (angling practices, behaviours, and opinions).

| Questions (Q) | Response results % (n) |
|---|---|
| **Q1 - IDENTIFICATION** | |
| **Q1.1 Gender** | |
| Male | 100 (27) |
| **Q1.2 Age** (years) | |
| < 20 | 18.5 (5) |
| 20-30 | 18.5 (5) |
| 31-40 | 7.41 (2) |
| 41-50 | 11.1 (3) |
| 51-60 | 40.7 (11) |
| >60 | 3.70 (1) |
| **Q1.3 District of residence** | |
| Santarém | 85.2 (23) |
| Lisbon | 7.41 (2) |
| Leiria | 7.41 (2) |
| **Q2 - ANGLING** | |
| **Q2.1 Have you ever angled for European catfish before?** | |
| Yes | 33.3 (9) |
| No | 66.6 (18) |
| **Q2.2 After this angling competition, are you interested in targeting European catfish?** | |
| Yes | 100 (27) |
| No | 0 (0) |
| **Q2.3 Do you agree with the death angling for European catfish?** | |
| Yes | 100 (27) |
| No | 0 (0) |
| **Q2.4 Do you agree with the death angling for other non-native fish species?** | |
| Yes | 59.3 (16) |
| No | 40.7 (11) |
| **Q2.6 Do you think angling could help control the European catfish population in the Tagus?** | |
| Yes | 100 (27) |
| No | 0 (0) |
| **Q2.7 Do you think angling targetting non-native fish species could help for the conservation of native fish species in Tagus?** | |
| Yes | 92.6 (25) |
| No | 7.41 (2) |

Regarding the sensory evaluations, a total of 155 individual tastings of European catfish dishes were recorded across the three events (27, 24, and 33 participants in the first, second, and third tastings, respectively; note that not all participants tasted both recipes at each event) (Fig. 2). The dishes prepared by the Chefs received a high overall mean rating of 4.40, indicating strong acceptance

among participants. The highest-rated items were the stew (mean = 4.88; 91.7% acceptance) and the rice (mean = 4.81; 96.0% acceptance), both scoring significantly higher than the ceviche (mean = 3.24; 76% acceptance) and tartare (mean = 4.09; 81.6% acceptance) (all comparisons, $P < 0.05$) (Fig. 2). Participants also showed a strong willingness to recommend European catfish-based dishes to others (ratings ranging from 3.72 to 4.83), along with unanimous agreement on the species' potential to promote regional tourism. However, the willingness to cook European catfish at home was lower, with mean values of 3.70 in Tancos, 3.46 in Pinheiro Grande, and 3.36 in Ribeira de Santarém.

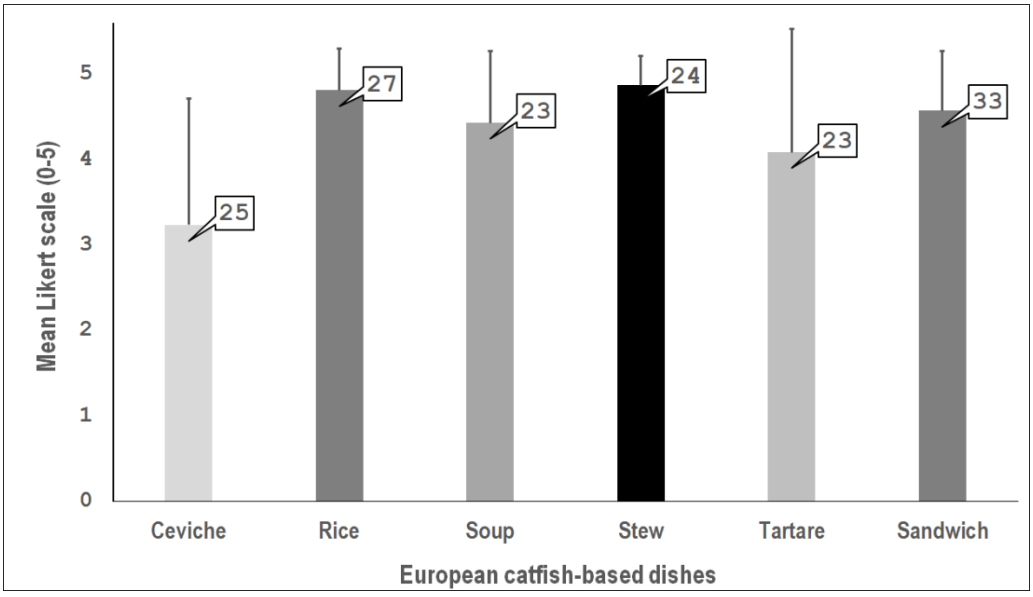


**Figure 2**. Mean ratings (± standard deviation) from a Likert scale (0-5: 0 = not at all to 5 = very much) regarding the tasting of European catfish-based dishes (Question: "Did you like the dish you tasted?"). Numbers inside the boxes indicate the number of respondents. Total number of respondents (n=35).

## Discussion

Awareness-raising activities were a central component of the CHALLENGER SILURO project, playing a key role in highlighting the ecological impacts of European catfish and promoting adherence to the ban on 'catch and release', in accordance with Portuguese freshwater angling regulations. Previous studies have emphasised the importance of environmental awareness in preventing the introduction and spread of invasive species (Smith et al., 2010; Golebie & van Riper, 2022). Despite the limited number of responses collected during the angling events, the surveys revealed unanimous support for harvesting European catfish, with all or the majority of respondents agreeing that the removal of this species may contribute to biodiversity

conservation—a noteworthy outcome, considering the potential lack of awareness regarding the species' ecological impacts (Ribeiro et al., 2022). Nevertheless, future studies should expand the geographical scope beyond the River Tagus to include other rivers where European catfish are present. They should also increase the number of survey participants to obtain a more comprehensive understanding of anglers' opinions and behaviours regarding this species.

Recently, Gago et al. (2025), through a combination of online and face-to-face surveys conducted with Portuguese anglers, estimated a 'catch and release' rate for European catfish at around 50%. However, in the present study, participants were aware that releasing this species back into the water is not allowed, suggesting a pre-existing level of compliance and engagement in its removal. Nonetheless, a significant proportion of respondents expressed reluctance to kill other exotic species—such as largemouth bass (*Micropterus salmoides*) and pikeperch (*Sander lucioperca*)—even when required by law, due to their higher perceived recreational value. In fact, anglers believe that intensive fishing on these species could lead to a significant decline in stocks, which in turn would affect their recreational activity. Moreover, the longer invasion history of these higher trophy-value species may also explain the generally higher catch-and-release rates. This finding underscores the persistence of cultural barriers and the need for ongoing educational efforts to ensure compliance with current fishing legislation (Anastácio et al., 2019).

One limitation of this preliminary exploratory research, which should be addressed in future studies, is the absence of a control group of anglers or members of the public outside angling competitions to enable comparisons of attitudes and behaviours. Nevertheless, the main objective of our study was to specifically target current and potential future European catfish anglers and to raise their awareness of the species' ecological impact and relevant angling regulations. Longitudinal studies, in turn, could provide valuable additional evidence of the long-term effectiveness of awareness initiatives on angler behavior.

The consumption of non-native species has emerged as one of the most widely promoted strategies for their control (Lai, 2013; Cerveira et al., 2022). Our live cooking demonstrations were met with strong enthusiasm, underscoring the success of the events in engaging the audience. Sensory evaluation results revealed a clear preference for more traditional recipes, such as the stew and rice dishes, likely reflecting cultural familiarity and established culinary preferences. In contrast, participants' intention to prepare European catfish at home was notably lower, suggesting limited familiarity with its preparation. Integrating European catfish into traditional cuisine and developing

innovative marketing strategies, such as preserved or frozen fillet formats, could support the gradual adoption of its consumption, while also increasing the species' visibility and public acceptance. Nevertheless, a precautionary approach should be adopted, since consuming invasive species as a control strategy must be carefully planned to protect native biodiversity and avoid new ecological introductions as well as cultural assimilation (Nuñez et al., 2012). In the specific context of this study, the main goal of promoting human consumption of the European catfish was to provide a meaningful use for the fish, addressing ethical concerns regarding animal suffering and mortality, which are increasingly emphasized in catch-and-release practices.

Engaging the angling community and the general public as active partners in biodiversity conservation is crucial for controlling and preventing the spread of invasive non-native species. In fact, their involvement supports the implementation of long-term conservation strategies, aligned with the National Strategy for Nature Conservation and Biodiversity 2030, while reinforcing the central role of environmental education in invasive species management. Finally, we argue that strategies promoting sport-recreational angling of invasive species, without 'catch and release', can represent a mutually beneficial approach that effectively balances environmental conservation with sustainable tourism development.

## Conclusion

This study highlights the value of combining environmental awareness initiatives with participatory approaches, in promoting the control of invasive species. The strong support for European catfish harvest angling, combined with public acceptance of its gastronomic use, offers a promising outlook on societal involvement, particularly among anglers, in efforts to curb the growth and spread of this invasive species. Moreover, turning an invasive species into a resource capable of contributing to regional tourism—both as a leisure activity and a food product—presents a potential win-win scenario. However, this approach must always be carefully contextualized within a broader strategy aimed at protecting native biodiversity and ecosystem integrity. Despite these positive outcomes, the study also identified persistent cultural barriers to public engagement, including anglers' reluctance to harvest other non-native species with high recreational value, and the lower acceptance of less traditional catfish recipes. These findings underscore the need for continued education and the development of diversified strategies to foster long-term behavioural change.

## Acknowledgments

The authors thank the 'Pica e Puxa' Angling Club for their support in organizing the angling competitions, as well as João Reis, Luís Coito, Luís Cunha, and Miguel Macário for their institutional and logistical assistance. This study was funded by the Environmental Fund (Notice No. 11545/2023) of the Ministry of Environment and Climate Action (MAAC), under the CHALLENGER SILURO project. This project also supported the fellowship of L. Pereira. J.G., I.D., and J.M.O. acknowledge funding from the Portuguese Foundation for Science and Technology (FCT) through the Research Centre for Natural Resources, Environment and Society — CERNAS (UIDB/00681).

## References

Anastácio, P. M., Ribeiro, F., Capinha, C., Banha, F., Gama, M., Filipe, A. F., Rebelo, R., & Sousa, R. (2019). Non-native freshwater fauna in Portugal: A review. *Science of the Total Environment*, *650*, 1923–1934. https://doi.org/10.1016/j.scitotenv.2018.09.251

Boulêtreau, S., & Santoul, F. (2016). The end of the mythical giant catfish. *Ecosphere, 7*(11), e01606. https://doi.org/10.1002/ecs2.1606

Cerveira, I., Baptista, V., Teodósio, M. A., & Morais, P. (2022). What's for dinner? Assessing the value of an edible invasive species and outreach actions to promote its consumption. *Biological Invasions*, *24*(3), 815–829. https://doi.org/10.1007/s10530-021-02685-3

Coito, L. (2025, July 22). *Unwanted: Silurus glanis, the Invasive Predator*. https://www.youtube.com/watch?v=s6K80ze0t9Q

Collares-Pereira, M. J., Alves, M. J., Ribeiro, F., Domingos, I., Almeida, P. R., da Costa, L., Gante, H., Filipe, A. F., Aboim, M. A., Rodrigues, P. M., & Magalhães, M. F. (2021). *Guia dos peixes de água doce e migradores de Portugal continental*. Edições Afrontamento.

Copp, G. H., Britton, J. R., Cucherousset, J., García-Berthou, E., Kirk, R., Peeler, E., & Stakėnas, S. (2009). Voracious invader or benign feline? A review of the environmental biology of European catfish *Silurus glanis* in its native and introduced ranges. *Fish and Fisheries*, *10*(3), 252–282. https://doi.org/10.1111/j.1467-2979.2008.00321.x

Encina, L., Rodríguez-Ruiz, A., Orduna, C., Cid, J. R., de Meo, I., & Granado-Lorencio, C. (2024). Impact of invasive European catfish (*Silurus glanis*) on the fish community of Torrejón reservoir (Central Spain) during a 11-year monitoring study. *Biological Invasions, 26*(3), 745–756. https://doi.org/10.1007/s10530-023-03204-2

Ferreira, M., Gago, J., & Ribeiro, F. (2019). Diet of European catfish in a newly invaded region. *Fishes*, *4*(4), 58. https://doi.org/10.3390/fishes4040058

Field, A. (2018). *Discovering statistics using IBM SPSS statistics* (5th ed.). Sage.

Gago, J., Anastácio, P., Gkenas, C., Banha, F., & Ribeiro, F. (2016). Spatial distribution patterns of the non-native European catfish, *Silurus glanis*, from multiple online sources – a case study for the River Tagus (Iberian Peninsula). *Fisheries Management and Ecology, 23*(6), 503–509. https://doi.org/10.1111/fme.12189

Gago, J., Rivaes, R., Ribeiro, D., Dias, D., Castagné, P., Santoul, F., & Ribeiro, F. (2025). Anglers perceptions about European catfish *Silurus glanis* in a newly invaded region. *Diversity, 17*(4), 252.

https://doi.org/10.3390/d17040252

Genovesi, P., & Shine, C. (2004). *European strategy on invasive alien species: Convention on the Conservation of European Wildlife and Habitats (Bern Convention)* (Nature and environment No. 137). Council of Europe Publishing.

Gkenas, C., Sequeira, V., Ribeiro, D., Gago, J., Dias, D., Verma, C. R., Kumkar, P., & Ribeiro, F. (2025). Reproductive traits of the European catfish, *Silurus glanis*, during the early stages of invasion. *Journal of Vertebrate Biology*, *74*, 24122. https://doi.org/10.25225/jvb.24122

Golebie, E. J., & van Riper, C. J. (2022). Enhancing Aquatic Invasive Species Outreach Through Values-framed Messages. *Environmental Communication*, *17*(1), 67–86. https://doi.org/10.1080/17524032.2022.2156574

Lai, B. (2013). How (and why) to eat invasive species. *Scientific American*, *309*(3), 40–43. http://www.jstor.org/stable/26017983

Magalhães, M. F., Amaral, S. D., Sousa, M., Alexandre, C. M., Almeida, P. R., Alves, M. J., Cortes, R., Farrobo, A., Filipe, A. F., Franco, A., Jesus, J., Oliveira, J. M., Pereira, J., Pires, D., Reis, M., Ribeiro, F., Robalo, J. I., Sá, F., Santos, C. S., Teixeira, A., & Domingos, I. (2023). *Livro Vermelho dos Peixes Dulciaquícolas e Diádromos de Portugal Continental*. FCiências.ID & ICNF, I.P.

Martelo, J., da Costa, L. M., Ribeiro, D., Gago, J., Magalhães, M. F., Gante, H. F., Alves, M. J., Cheoo, G., Gkenas, C., Banha, F., Gama, M., Anastácio, P. M., Tiago, P. M., & Ribeiro, F. (2021) Evaluating the range expansion of recreational non-native fishes in Portuguese freshwaters using scientific and citizen science data. *BioInvasions Records 10*(2), 378–389. https://doi.org/10.3391/bir.2021.10.2.16

Moncada, M., Nogueira, S., Ribeiro, D., Gago, J., Rodrigues, M., Alves, M. J., Magalhães, M. F., Curto, M., & Ribeiro, F. (2025). Hidden in the gut: Metabarcoding reveals overlooked predation by the invasive European catfish (*Silurus glanis*). *Journal of Fish Biology*, *2025*, 1-15. https://doi.org/10.1111/jfb.70152

Nuñez, M. A., Kuebbing, S., Dimarco, R. D., & Simberloff, D. (2012). Invasive species: To eat or not to eat, that is the question. *Conservation Letters, 5*(5), 334–341. https://doi.org/10.1111/j.1755-263X.2012.00250.x

Ribeiro, F., Collares-Pereira, M. J., & Moyle, P. B. (2009). Non-native fish in the fresh waters of Portugal, Azores and Madeira Islands: A growing threat to aquatic biodiversity. *Fisheries Management and Ecology*, *16*(4), 255–264. https://doi.org/10.1111/j.1365-2400.2009.00659.x

Smith, E. R. C., Bennion, H., Sayer, C. D., Aldridge, D. C., & Owen, M. (2020). Recreational angling as a pathway for invasive non-native species spread: awareness of biosecurity and the risk of long distance movement into Great Britain. *Biological Invasions*, *22*(3), 1135–1159. https://doi.org/10.1007/s10530-019-02169-5