

Editorial

Ecology and Conservation of Freshwater Fishes Biodiversity: We Need More Knowledge to Develop Conservation Strategies

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Freshwater fish represent one-fourth of all vertebrate species, despite freshwater occupying less than 1% of the Earth's surface [1]. They are among the most threatened vertebrates, as they are especially vulnerable to human alterations resulting from species introduction, overexploitation, fragmentation, the degradation of continental watercourses, and climate change [2]. Furthermore, freshwater fish show high levels of endemism because of the particular characteristics of their aquatic ecosystems and their evolutionary isolation; their loss could have irreparable consequences.

Knowledge regarding the conservation status and ecology of freshwater fish is less than that for terrestrial vertebrates due to biases in conservation research and management toward more charismatic species [1]. Research into the ecological subjects, environmental necessities, and pressures of freshwater fishes is considered crucial to develop effective management measures for freshwater ecosystems. Understanding these environmental features remains a key concern of freshwater fish's conservation biology.

This Special Issue of *Water* explores the relationships of environmental issues, freshwater fish biodiversity, and human impacts from different perspectives, but always focused on the conservation biology of species and ecosystems. This Special Issue comprises thirteen papers with contributions from seventy-one authors, including research studies from very diverse ecosystems, places, and countries, from the most extensive basins, such as Middle Rio Grande in New Mexico (USA) [3] or the Yangtze River Basin (China) [4], to remote areas in Andean Amazon piedmont (Peru) [5] or Lake Tana (Ethiopia) [6]. Analyzed ecosystems include basins, rivers and streams, lakes, and ponds from high mountain to estuarine places, from pristine to highly altered environments.

The articles include eleven research articles, one review and a short communication. The nature of studies included in this Special Issue is diverse, considering a variety of scientific approaches in a mixture of field topics. One of the published papers considers methodological approaches to studying freshwater fishes and their conservation status. The authors propose a methodological study and improvement on age estimation for four species of *Labeobarbus* genus using otoliths as a crucial tool for conserving these species. According to the authors, this kind of study is very relevant to Africa, particularly Ethiopia, in order to develop effective management strategies to conserve endemic species [6]. Similarly, Gebremedhin et al. review scientific methods, concepts, and processes related to stock assessment and population dynamics in Africa [7].

Three published papers present results on fish distribution, ecosystem explorations, and ecological features in unique places, using many different techniques. Perivolioti et al. [8] conduct hydroacoustic monitoring of the Lake Trichonis (Greece) fish diversity, with the aim of offering an updated assessment of this unique ecosystem and the associated endemic species, with a focus on management and conservation.

Tobes et al. [5] study the distribution of fish communities related to the environmental variables of the Alto Madre de Dios River, a poorly studied Andean–Amazon watershed



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of southern Peru. Results show a significant shift in fish diversity regarding altitude, separating headwater and middle-lowland communities. In the light of this scenario where no Andean–Amazon Basin will remain untouched, the studied basin still preserves healthy ecosystems, showing excellent environmental quality overall. This condition makes the basin a perfect candidate for serving as a reference basin for these endangered ecosystems. Schmitter-Soto et al. [9] investigate changes in a fish community during a long-term period, from 1999–2001 to 2015–2018. The results show that changes may be due to morphological changes in the channel. Still, other threats could condition these changes: illegal fishing outside the bay, and erosion in the innermost part, impacting native habitats. Li et al. analyze fish distribution, influencing factors, and habitat requirements in the East Tiaoxi River (a major tributary of the renowned Yangtze River). Results show differences in fish management and several severe threats to their conservation. Complete and continuous scientific research of fish diversity is crucial in order to develop efficient conservation and restoration plans in the Yangtze River Basin [4].

Several papers in this Special Issue explore, in more detail, applications of ecological and biological studies to improve monitoring of environmental changes and impacts on freshwater fishes. Sometimes biological studies permit us to detect reactions to environmental changes. Pastorino et al. [10] describe liver alterations observed in a bullhead population (*Cottus gobio* Linnaeus, 1758) from a mountain lake as an adaptation to extreme ecosystems and adverse conditions. Other studies highlight the interaction between ecological stress factors and biological traits and the use of sentinel species for the long-term monitoring of environmental status. This is the case with the study of Sánchez-Pérez et al. [11], where they analyze biological traits such as the growth, size structure, and somatic condition of the Southern Iberian barbel (*Luciobarbus sclateri* (Günther, 1868)) in a stressed Mediterranean river.

Some studies are focused on severely imperiled species, such as the Rio Grande Silvery Minnow (*Hybognathus amarus* (Girard, 1856)), catalogued as Endangered by the IUCN Red List of threatened species; the Spanish toothcarp (*Aphanius iberus* Valenciennes, 1846), catalogued as Endangered; or the Pyrenean Sculpin (*Cottus hispaniolensis* Bacescu-Master, 1964), included in the Spanish Catalogue of Threatened Species as Endangered [3,12,13]. Archdeacon et al. analyze the inefficiency of a specific conservation tool, the rescue of the Rio Grande Silvery Minnow during streamflow intermittency. Restoring natural flow regimes is the more effective action for species threatened by streamflow intermittency; re-establishment of the biological processes under which fishes evolved advances the conservation of this species [3].

Other species threatened by water quality have been studied in the Iberian Peninsula. Sgarzi et al. [13] examine abiotic and biotic factors that could influence the size structure and density of Spanish toothcarp in Mediterranean brackish ponds. They suggest that achieving a better pond ecological status may be necessary to conserve this endangered fish. Manubens et al. [12] describe the ex situ conservation plan for the endemic and rare Pyrenean sculpin (*Cottus hispaniolensis* Bacescu-Mester, 1964). The captive breeding process includes six consecutive phases: nesting behavior, courtship, egg fixation, parental care (incubation), hatching, and survival during juvenile development. The management plan implemented for this project has probably allowed the main impediments described in other similar programs to be largely overcome.

Conversely, some studies in this Special Issue are biological and ecological analyses of exotic invasive species, as the Pyrenean Gudgeon (*Gobio lozanoi* Doadrio & Madeira, 2004) in a Mediterranean river or the bleak (*Alburnus alburnus* (Linnaeus, 1758)) in the Iberian Peninsula. Both studies are focused on the significant role of plasticity in the success of these invasive alien species. Latorre et al. [14] assess the variability in dietary traits of the bleak in the Iberian Peninsula and compare the dietary characteristics of this species among the main Iberian rivers and a native bleak population from France. Similarly, Amat-Trigo et al. [15] evaluate other biological traits in addition to the diet. The results of both studies suggest that this wide interpopulation variability will contribute to the species'

successful establishment throughout Mediterranean Europe, posing a severe risk to native fish fauna.

All the articles included in this Special Issue point in the same direction. The current status of freshwater fish must be brought to our attention in order to design and implement effective management measures to conserve freshwater fish. While we should maintain our interest in learning and know more about the conservation status of the imperiled freshwater fish, policy and administrations should invert inefficient plans in order to revert, or at least reduce, the current crisis in biodiversity.

A change in mindset is needed to protect biodiversity in the upcoming years. Conservation plans have failed because our current knowledge is deficient and needs to be improved. We need countries to commit to protecting biodiversity and develop realistic targets that can be met while compromising with conflicting needs and interests. The articles included in this Special Issue emphasize the necessity of having more knowledge to develop conservation strategies. Future conservation targets may be advanced in part based on the knowledge provided by these papers and similar studies to ensure the long-term protection of freshwater fish and other life forms [1].

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