FiSHMED
Fishes in Mediterranean Environments

sibic
Sociedad Ibérica de Ictiología
Sociedade Ibérica de Ictiologia

FiSHPOR

Imaging freshwater fish migrations for education, awareness and science

Ricardo Morán-López

Area of Zoology, Department of Anatomy, Cellular Biology and Zoology, Science Faculty, University of Extremadura. Avda de Elvas s/n, 06071 Badajoz, Spain. https://orcid.org/0000-0002-5434-3186r. rmoran@unex.es

Uneven distribution of essential resources in space and time are at the origin of freshwater fish migrations. Hydrographic basins under Mediterranean climate also host such migrations, which mainly involve non-salmonid fish moving across river networks. These river systems feature strongly seasonal hydrological regimes and extreme events including summer droughts of variable intensity and largely unpredictable spates. Also, geomorphological features modulate water currents and create waterfalls that may pose challenge zones for fish migrations. Natural variation in these hydromorphological features drive spatial and temporal variations in river connectivity, and therefore the accessibility for fish of essential resources, such as feeding grounds, spawning habitats or summer refugia. Anthropogenic pressures add significant difficulties to such challenges, including the alteration of water quality and flow regimes, which trigger fish migrations, and river fragmentation by infrastructures (culverts, weirs, and dams), which hinder fish movements. Fish deal with natural and anthropic barriers through physiological, morphological and behavioural adaptations, which shape their ability to negotiate challenge zones and reach essential habitats. Swimming and leaping are two of the main fish behaviours while migrating, but their use and performance vary widely among species and sizes.

When migrating, freshwater fish become more easily spotted. Digital images, either photographs or video frames, are increasingly being used to study behaviours and abilities of migrating fish in field conditions. Knowing the conditions that drive fish population dynamics by maintaining connectivity or leading to fragmentation, should become a critical tool for fish conservation in river ecosystems, which are increasingly threatened globally by habitat loss and the spread of invasive species. Wildlife images are also a powerful mean to provide education and raise awareness in society (Morán-López 2014). Here, I provide a collection of four photographs depicting migrating fish species and their efforts to overcome barriers in the middle Guadiana Basin, SW Spain.

CITATION

Morán-López R (2020) Imaging freshwater fish migrations for education, awareness and science. Fishes in Mediterranean Environments 2020.004: 6p. https://doi.org/10.29094/FiSHMED.2020.004

DOI: 10.29094/FiSHMED.2020.004

Picture 1. Composite image built from three high-speed photographs, showing a leaping Iberian long-snout barbel (*Luciobarbus comizo*) that emerges from the Guadiana River under the waterfall of the Granadilla weir. The increasing temperatures and flows of the early spring impel fish to move upstream to spawning habitats. But obstacles must be negotiated, and fish exploit their swimming and leaping abilities to their maximum. Such abilities are the subject of rigorous research in more or less constrained laboratory conditions, but images taken in the field allow more realistic, *in situ* measurements. The spatial coordinates of leaping fish moving in a sequence of images can be used to calibrate a ballistic model and estimate fish trajectories, and even infer the underwater behaviour of the fish (Morán-López & Uceda, 2018) and back-calculate the forces involved in the leap (Morán-López & Uceda, 2020). Therefore, a photographic approach can contribute to the engineering of instream infrastructures to maintain, or restore, fish migrations.

DOI: 10.29094/FiSHMED.2020.004

Picture 2. Two species of *Luciobarbus* barbels perform reproductive potamodromous migrations in the middle Guadiana River: *L. microcephalus* (left) and *L. comizo* (right). While moving upstream, their swimming and leaping behaviours are visible in riffles and waterfalls, as is the case under the Granadilla weir shown in the photograph. Natural or artificial obstacles provide windows of visibility to large fish populations otherwise hidden underwater, an irresistible window of opportunity for wildlife photographers and fish scientists. Migrating barbels may number from hundreds to tens of thousands, making it difficult to estimate population sizes using conventional methods. Sampling methods based on fish photographs have been used to estimate the number of migrating *Luciobarbus* individuals (Morán-López & Uceda 2017a), providing an efficient and affordable approach for the long-term monitoring of fish populations. This approach has proven the huge impact of different hydrologic years (dry or wet) in the seasonal conditions that drive fish migrations in Mediterranean rivers. Therefore, the restoration of more natural fish migrations requires not only improvements in river connectivity, but also watershed-level management of flow regimes to mimic natural flow seasonality and disturbance incidence. Interestingly, photographs to study fish migrations can be taken by the general public, thus allowing citizen science approaches to improve watershed management and the conservation of freshwater biodiversity.

DOI: 10.29094/FiSHMED.2020.004

Picture 3. A *Carassius* fish, arguably *C. gibelio*, leaps at the entrance of a fish pass retrofitted to the Granadilla weir. The populations of *Carassius* fish in the Guadiana basin downstream the Granadilla weir are greatly increasing in the recent years (own unpublished observation), possibly due to the irruption of *C. gibelio*. This introduction had passed unnoticed by fish specialists for a long time, due to the high morphological similarity between *C. gibelio* and *C. auratus* (Ribeiro et al., 2015). The middle Guadiana River harbours abundant populations of several invasive fish species that migrate upstream, and concentrate under the obstacles which surpass their swimming and leaping abilities. As a consequence, efforts aimed at restoring connectivity for native species may also favour the spread of invasive fish. On the contrary, intended fragmentation may favour reproductive migration failure and possibly prevent further dispersal of invasive exotics. Balancing costs and benefits, the selective fragmentation approach (Rahel & McLaughlin 2018) exploits specific variations in fish maximum swimming and leaping abilities to restore native fish migrations while controlling the populations of invasive species. Fish photographs can be used to measure such differences (Morán-López & Uceda 2017b), and determine the characteristics of a waterfall or velocity barrier that will block invasive fish while allowing its negotiation for most native populations. *Carassius* fish have clearly inferior leaping capabilities than the native *Luciobarbus* barbels, providing an opportunity to develop absolute design criteria for semi-permeable obstacles.

DOI: 10.29094/FiSHMED.2020.004

Picture 4. Allis shad (*Alosa alosa*) is a long-distance anadromous migrating species that must negotiate several challenge zones to reach optimum spawning habitats. When moving through large rivers, only the dorsal and caudal fins of shads can be seen breaking the surface in shallow rapids, especially in turbid waters typical of the middle Guadiana River. Images of migrating Allis shad can be obtained in very rare occasions (Morán-López 2014). Shads do not leap, and they repeatedly try to negotiate obstacles by swimming, as shown in the photograph, taken in the Moscoso mill weir, a part of La Pesquera weir. Here, hundreds of shads unsuccessfully try to negotiate the barrier, under which fish concentrate when migrating upstream. Along with those of other migrating fish, shad images taken while trying to overcome natural or artificial challenge zones can be used to study and monitor its large populations (unpublished data; Morán-López & Uceda 2017a). The middle Guadiana River harbours an interesting land-locked Allis shad population, whose life history has excluded a marine phase in most hydrologic years because of the Pulo do Lobo natural obstacle (Nachón et al. 2019). Since 2002 this population is completely isolated from the sea, due to the construction of the Alqueva dam, in Portugal. Although potamodromous shad migrations still occur in the middle Guadiana River (unpublished data), other inland populations of this species are now extinct. Fish photographs can thus be an important tool for the long-term monitoring and conservation of these singular shad populations.

DOI: 10.29094/FiSHMED.2020.004

RELATED REFERENCES

Morán-López, R. (2014). Iberia bajo el agua dulce. Fotografía de peces y otros organismos de agua dulce en su hábitat [Iberia underwater. Photography of fish and other freshwater organisms underwater] In spanish. https://wadianas.wixsite.com/hiberipisces

Morán-López, R., & Uceda, O. (2017a). Image techniques in turbid rivers: A ten-year assessment of cyprinid stocks composition and size. Fisheries Research 195, 186-193

Morán-López, R., & Uceda, O. (2017b). Relative leaping abilities of native versus invasive cyprinids as criteria for selective barrier design. Biol. Invasions 19, 1243-1253

Morán-López, R., & Uceda, O. (2018). Obstacle negotiation attempts by leaping cyprinids indicate bank-side spawning migration routes. Fisheries Research 197, 84-87.

Morán-López, R., & Uceda, O. (2020). Biomechanics of fish swimming and leaping under waterfalls: a realistic field, image-based biophysical model with bioengineering implications. Bioinspiration & Biomimetics (in press)

Nachón, D. J., Vieira, R., Cobo, F. (2019). Sábalo – *Alosa alosa*. En: Enciclopedia Virtual de los Vertebrados Españoles. López, P., Martín, J., Cobo, F. (Eds.). Museo Nacional de Ciencias Naturales, Madrid. http://www.vertebradosibericos.org/

Rahel, F.J., & McLaughlin, R.L. (2018). Selective fragmentation and the management of fish movement across anthropogenic barriers. *Ecological Applications* 28 :2066-2081.

Ribeiro, F., et al. (2015). Prussian carp *Carassius gibelio*: a silent invader arriving to the Iberian Peninsula. Aquatic Ecology 49, 99-104.