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Seasonal use of fish passes in a modified Mediterranean river: first insights of the LIFE+ Segura-Riverlink

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The LIFE+ Segura-Riverlink is a project which aims to validate management measures for the development of a Green Infrastructure (GI) approach in the context of Mediterranean river basins characterized by high human impacts. The project aims to recover the longitudinal connectivity in a sector of 54 km long in the Segura River, implementing fish passes over several artificial barriers to improve and restore fish movements and it will also support other best practices of riverine restoration. Since September 2015, five fish passes have been implemented (Oliva-Paterna *et al.*, 2016), two of them nature-like fishway types (bypass types B1 and B2) and the others technical fishway types (vertical-slot fishway: T1 and submerged notch and orifice: T2 and T3).

A monitoring programme evaluates the performance of these actions with the aim of validating the GI approach to river basin management. Two main fish-based assessments have been developed to reach the aims of the monitoring: one focused on the use of fish passes by different fish species (1), and a specified mark-recapture program of sentinel species (2). During two migration periods (2016 and 2017) we will evaluate the effectiveness of each fish-

way through regular samplings. Here we briefly describe the monitoring methods and preliminary results from the 2016 migration period.

From February to July 2016 fishways and its downstream stretches (100 m length) were sampled by wadeable electrofishing biweekly and once a month respectively. Four species have been selected as sentinel or target species: *Luciobarbus sclateri* Günther, 1868 (Southern Iberian barbel) the only native to the study area, *Alburnus alburnus* (Linnaeus, 1758) (Bleak), *Pseudochondrostoma polylepis* (Steindachner, 1865) (Iberian straight-mouth nase) and *Gobio lozanoi* Doadrio & Madeira, 2004 (Pyrenean gudgeon).

Total captures were quantified and all individuals were measured (to the nearest cm) and weighted (to the nearest g). Target fish specimens longer than 8 cm (fork length, FL) were marked with Visible Implant Elastomer (VIE-tag), with different colour code for captures inside the fish pass and in the downstream locations. Since September 2015 a total of 735 specimens have been marked, 53.3% inside the fish passes and 46.7% outside in their next downstream stretches. Moreover, T-Bar Anchor tags with individual codes were used in a specified mark-recapture program (only in *L. sclateri* longer than 25 cm FL), with a total of 695 individuals of *L. sclateri* marked since November 2014. More than half of these tagged individuals (375) were marked at nature-like fishway B2 and in its downstream fluvial sector (about 3 km long) looking for specific information about movements and home-range.

Since January to July 2016, a total of 2973 individuals of 8 fish species were collected inside fishways (Figure 1A). Target species which normally show seasonal movements accounted for 98% of the total abundance: *A. alburnus* (47.2%), *G. lozanoi* (31.3%), *L. sclateri* (11.1%) and *P. polylepis* (8.5%). *Lepomis gibbosus* (1.4%) and *Cyprinus carpio* (0.5%) had much lower abundances, and *Exos lucius* and *Sander lucioperca* were detected only sporadically (one specimen in a fish pass). This spectrum of fishes represented the 72.7% of the fish species richness that occur in the fluvial sectors outside the passes (Oliva-Paterna *et al.*, 2014). Most captures were detected in the vertical-slot fishway T1 (56% of individuals), followed by the nature-like fishway B1 (18% of individuals) (Figure 1A and 1B).

The rate of recaptures inside the passes was 17.6%, and 5.9% for 2nd recaptures, being in both cases, and for all species, larger in nature-like fishways. *G. lozanoi* was the dominant species in recaptures (50.9%), and *L. sclateri* the second one (19.9%). Only 6.3% of recaptures inside the passes were from specimens marked downstream.

According to the specified mark-recapture program, we obtained a high level of recaptures of *L. sclateri*, 43.8%, and we detected higher values of the use of fishways by the species in summer (Figure 1B). Moreover, 58.7% of the total recaptured individuals occurred just at the same sampling point where they had been marked, and 79.0% in the same stretch (250 m long) regardless of down or upstream. So, this specific mark-recapture study showed low movement and high site fidelity of *L. sclateri*, a sentinel species of the project which could be related to years of confinement and absence of river connectivity in the past. When movements of populations of potamodromous species are hampered by instream barriers, they can change their life strategy to become resident populations on condition that spawning grounds are present between barriers, a hypothesis that has advanced by other authors (Branco *et al.*, 2012).

Most of the species present in the studied fluvial sector (Torralva *et al.*, 2005, Oliva-Paterna *et al.*, 2014) used the different types of technical and nature-like fishways, being dominants the migratory fishes characterized by reproductive seasonal movements. The knowledge of species behavior, biological traits and ecological needs will influence the final parameters in the design of new fishways structures. Experience is showing that the correct hydraulic operation of the fishways will condition their effectiveness. Therefore, regardless of the type of fish passes built, the development of successful solutions has occurred when engineers and biologists worked together systematically to design and evaluate passage structures. In this context, final results of the present study will contribute to this goal.

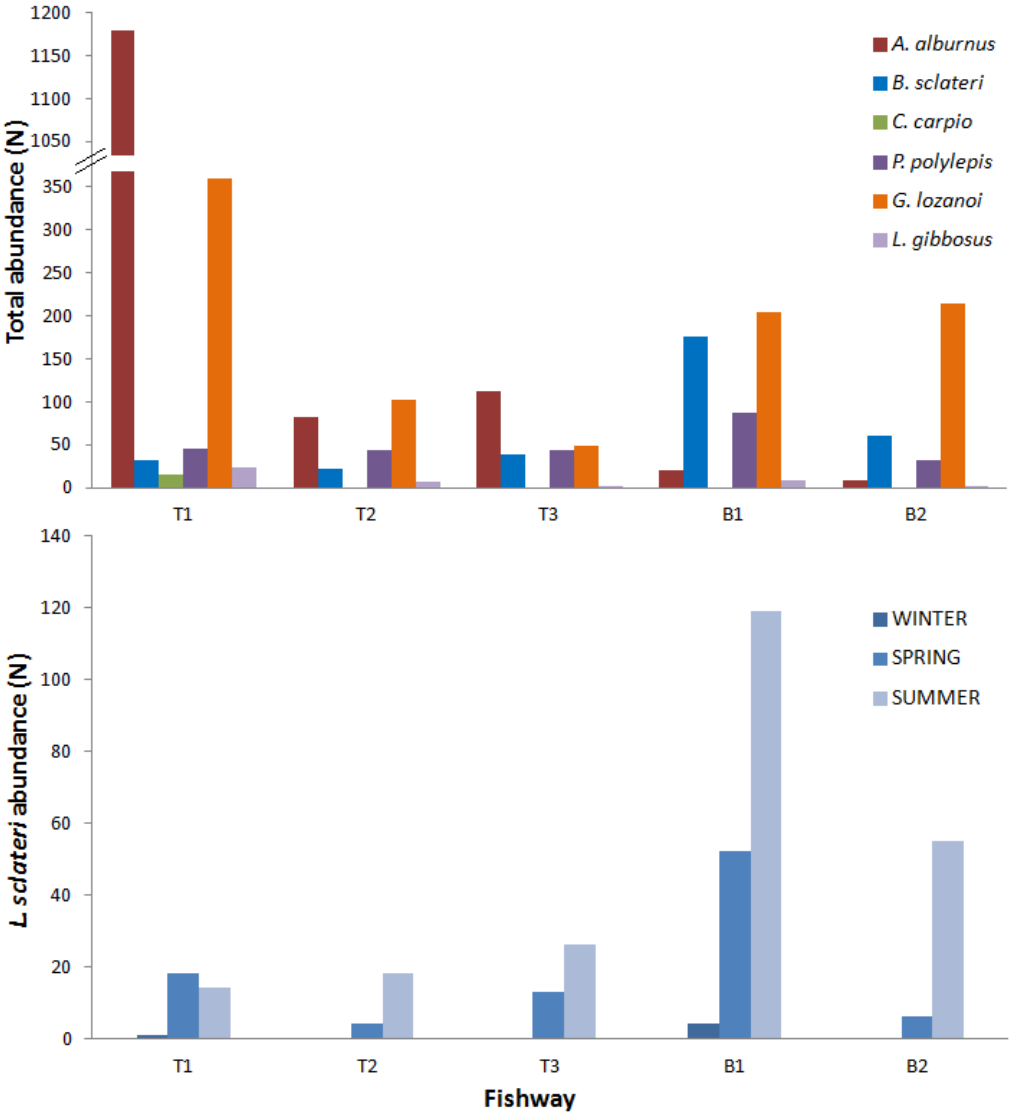

FIGURE 1. (A) Total abundance for each species captured inside fishways; residual captures of *Esox lucius* and *Sander lucioperca* are not shown. (B) *Luciobarbus sclateri* seasonal captures inside fishways. (Ts are technical fishways; Bs are nature-like baypass fishways).

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