The benefits of artificial refuges as hideouts to pulsed flows for Iberian cyprinids

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ABSTRACT: The impacts of hydropeaking on fish communities are widely recognized, yet it is challenging to identify a causal pathway between artificial induced-flow variability and a measurable fish response. Moreover, in the context of widespread biological invasions, there is limited knowledge of how invasive species interact with native species, particularly during pulsed flows, and on the application of mitigation measures to reduce the impacts of pulsed flows associated with hydropower production, particularly for cyprinids. The objective of this work was to examine the effectiveness of artificial refuges as hideouts to alleviate the impacts of pulsed flows on the Iberian barbel (*Luciobarbus bocagei*). In addition, we evaluated whether the presence of the invasive bleak (*Alburnus alburnus*) affected the use of artificial refuges by I. barbel. The study was conducted at an indoor flume where we installed artificial refuges constructed in maritime plywood, conferring overhead cover and low-velocity areas. In the first experiment, we tested two structures differing in the angle of insertion with the flume wall (i.e. 45º and 70º). The best structure was selected to test the effect of bleak on its use by I. barbel. Fish were exposed to a base-flow (7 $L.s^{-1}$) and a peak-flow (60 $L.s^{-1}$) event. We registered the frequency and time of use of the structure by fish. In addition, the levels of glucose and lactate were quantified to investigate if the created hydraulic conditions and the presence of bleak would set off physiological adjustments. Preliminary results indicate that the 45º structure was the most effectively used and resulted in the highest permanence time, in comparison to the 70º. The presence of bleak hindered the ability of I. barbel to use the available structure, in opposition to the highest frequency of use by I. barbel without bleak, particularly during peak flows. In addition, the levels of glucose and lactate were significantly higher for I. barbel in the presence of bleak and in the peak-flow event in comparison with the base-flow event where only native species were present. Finally, the 45º refuge was upscaled and implemented downstream of two hydropower plants and equipped with underwater motion detection cameras. With this monitoring system, we expect to find fish use patterns before, during and after hydropeaking, and to identify seasonal behavioural variations. This study provides novel findings on the efficiency of insertion angles to attract fish to a refuge and on the interactions of native with invasive species in highly fluctuating flow environments, bringing additional awareness to the importance to manage artificial flow variability and biological invasions to prevent freshwater biodiversity loss.