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Effects of hydropeaking and shelter configurations on the behaviour of cyprinids in an experimental flume

Maria João Costa[1], Isabel Boavida[1], Steven J Cooke[2], Teresa Ferreira[3], António Pinheiro[1]

[1]CERIS, Instituto Superior Técnico, Universidade de Lisboa, Av. Rovisco Pais, 1049-001 Lisboa, Portugal
[2]FECPL, Ottawa-Carleton Institute for Biology, Carleton University, 1125 Colonel By Drive, Ottawa, Ontario, Canada K1S 5B6
[3]CEF, Instituto Superior de Agronomia, Universidade de Lisboa, Tapada da Ajuda, 1349-017 Lisboa, Portugal
Corresponding author: costa.mj@gmail.com

Abstract

Despite the growing awareness of the hydropeaking impacts on freshwater fish, few studies report habitat mitigation measures and evaluate fish behaviour according to those. The aim of this work is to assess the movement behaviour of cyprinids exposed to peak flows in an experimental flume and propose habitat mitigation measures. It presents a novel approach in the peak flows tested and by combining techniques that quantify movement behaviour, namely accelerometry and organism level responses.

Keywords: Hydropeaking, cyprinids, accelerometry, fish locomotion, fish physiology

Introduction

Hydropower production results in marked daily peaks of discharge downstream the hydropower plant.
This phenomenon, termed as hydropeaking, produces major impacts on the riverine ecosystem (Ribi *et al.* 2014; Scruton *et al.* 2008) with subsequent negative effects on freshwater biota. The impacts of artificial flow regimes in downstream fish communities are well documented but the effects of pulsedpeak flows on the movement behaviour of fish remains unclear (Young *et al.* 2011). Potential negative impacts of pulsed flows include downstream displacement (Bruno *et al.* 2010; Young *et al.* 2011), stranding (Nagrodski *et al.* 2012; Tuhtan *et al.* 2012), search for velocity refuges (Taylor and Cooke 2012), alteration of migration patterns (Taylor and Cooke 2014) and decreased growth (Korman and Campana 2009; Scruton *et al.* 2005). These pulsed peak flows are unpredictable and extreme; whether or not fish move laterally or longitudinally to find velocity refuges and return to the initial habitat after the peak flow remains unknown (Halleraker *et al.* 2003).
There is a considerable amount of research describing the effects of hydropeaking in fish, but very few evaluate fish movement behaviour under cycles of rapid peak flows over time (Puffer *et al.* 2014; Taylor and Cooke 2014). Furthermore, only a handful of studies propose mitigation measures based on hydrodynamic models (Boavida *et al.* 2015; Person *et al.* 2014) and very few evaluate fish responses

according to structural mitigation measures (Ribi *et al.* 2014). Additionally, most of the research on the impacts of hydropeaking focuses on salmonids and other species of commercial interest.

Cyprinids have lower swimming ability and consequently they are subjected to higher energetic costs making them more vulnerable to the severe flow changes. The knowledge on movement behaviour in cyprinids and habitat preferences is scarce, particularly when both are combined with hydrological parameters (but see Ribi *et al.* 2014; Vilizzi and Copp 2005). Additionally, cyprinids are an important component of fish assemblages and with the increase of human energy demands, these assemblages might be compromised.

The main objective of this work is to assess the effects of rapid flow fluctuations on the movement behaviour of two Iberian cyprinids and how it affects their habitat choice. To accomplish it, different shelter configurations will be installed in an experimental flume and fish will be exposed to different cycles of rapid peak flows. Fish movements will be described under the pulsed peak flow cycles over time and analysed using movement tracking and physiological tools.

Methodology

Hydraulic test trial

Ongoing experiments are being conducted in an indoor artificial flume located at the hydraulic laboratory of Instituto Superior Técnico, University of Lisbon. The flume (8m length x 0.7m width x 0.8m height) has a steel frame and glass viewing panels on both sides. Flows are controlled by an upstream plane gate and a downstream flap gate allowing rapid variations in flow.

During the next trial period, PVC flashboards will be installed in the false bottom of the flume to simulate deflectors that mimic fish shelters in the river.

Potential cycles of peak flows are already in test to evaluate the flume efficiency to control the flow in the simulation of sub-daily hydropeaking conditions. These flow changes will vary in magnitude, frequency and duration to test whether or not the amount of water and the rapid changes over time shape fish movement behaviour. Different cycles of rapid flow changes will be simulated as follows: step up and down ramping rates, single up and down ramping with different degrees of abruptness, repetition of cycles of peak flows versus base flows with alternating frequencies.

Water parameters, namely temperature, pH and dissolved oxygen will be maintained constant and controlled in a sub-daily basis using multiparametric probes. Velocity fields will be measured with an Acoustic Dopler Velocimeter (ADV).

Biological survey setup

Iberian barbel (*Luciobarbus bocagei*) and Iberian chub (*Squalius pyrenaicus*) were the selected fish species representing different velocities and feeding habitat preferences namely benthic and water column guilds, respectively.

Fish sampling will take place at River Alviela where no hydropeaking conditions occur. Fish will be sampled using low-voltage electrofishing and transported in constantly aerated large containers to the laboratory. Sample size will vary, depending on electrofishing efficiency and tank volume. Fish will be sorted according to species and transferred to 900 L acclimation covered tanks with ambient temperature and natural photoperiod for 3 days. Water will be permanently aerated, filtered and monitored using a multiparametric probe. Before each trial, fish will be acclimated in the experimental flume for 20 minutes under base-flow regimes. Fish will only be fed during the acclimation period. After the trial period and before returning them to the wild, biometric data will be recorded including the removal of scales for age determination.

Flume experiments will occur during autumn and spring season for two years. Adaptive management will be performed assuring that the proposed mitigation measure will be optimized according to successful usage rate by fish.

Fish movement behaviour

Movement behaviour will be classified according to each swimming activity as: resting, holding station, drifting, bursting and swimming. Species specific individual behaviour will be addressed. Each trial will be conducted with five fish with three replicates. To quantify the movement behaviour and energy expenditure of the fish a combination of two techniques will be used: biologging (accelerometers) and visual observation (video recordings). The retrieved data from the accelerometers will be used to quantify finer scale behavioural states associated with locomotor activity. The synchronization of acceleration data and each specific locomotor activity will be assisted by two video cameras that will be installed in the flume. Resultant frame sequences will be accurately addressed to each cycle of swimming activity.

Data retrieved from the video recordings will be analysed according to number of attempts, approach direction and time spent in each mitigation measure and to each swimming activity.

All these metrics will be further related with the hydraulic environment using ADV and the simulation results from Flow3D hydraulic models.

As unpredictable peak flow events will likely trigger burst swimming activity in fish, increase of lactate blood levels will also be measured. Tightly connected to locomotion, blood lactate will likely present an organism level response to rapid and pulsed peak flows. Additionally, external stimuli that cause exhaustive exercise produce other organism level responses, such as the increase of blood glucose. Therefore, blood glucose and lactate will be used as stress indicators. Blood samples will be taken via caudal puncture within a period no longer than 3 min of capture. Blood lactate and glucose values will be measured using portable meters that have been confirmed to provide valid results (Brown *et al.* 2008).

Expected contributions

With this study we will assess the effects of pulsed peak flows on the movement behaviour of two Iberian cyprinids using a combination of tools that quantify fish movement behaviour. We expect that the results from this study will contribute to the design of more adequate habitat mitigation measures and provide a valuable insight on the importance of organism level responses for the environmental flow science particularly in hydropeaking rivers. Our pilot studies suggest that the selected cyprinid species search for velocity shelters when they are available. Thus, we hope that the results from the future trials will identify specific flow thresholds that can be suitable for these species. Finally we expect that the results will enable us to propose habitat mitigations measures that ameliorate the effects of hydropeaking in fish movement behaviour.

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