Cold thermopeaking-induced drift in nase *Chondrostoma nasus* larvae

Dérive des larves de hotus chondrostoma nasus induite par les changements de température (refroidissement) liés aux éclusées

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RÉSUMÉ

L'étude des conséquences de la production hydroélectrique sur les poissons de rivière – plus particulièrement sur leurs premiers stages de développement – est devenu un sujet de recherche majeur ces dernières années. Il est reconnu que la vitesse des écoulements à l'aval des barrages n'est pas la seule variable qui impacte les larves. Elles subissent également les changements de température associés à l'*hydropeaking* (*thermopeaking*). À l'intérieur de deux tronçons de rivière semi-naturels, nous avons évalué si, en situation d'*hydropeaking*, la température pouvait influencer la dérive des larves de hotus (*Chondrostoma nasus*). Les résultats ont démontré que la dérive des larves était plus haute si la température diminuait pendant le débit de pointe (80 L/s). Ce résultat souligne l'importance de considérer les changements de température de l'eau dans les plans de mitigation pour l'exploitation des barrages hydroélectriques.

ABSTRACT

Research on how hydropower affects early fish life stages has been rapidly advancing in the last years, focusing not only on the direct impacts of rapid flow velocity changes (hydropeaking), but also on the associated variations in water temperature (thermopeaking). Using two nature-like experimental channels, we investigated how nase *Chondrostoma nasus* larvae were influenced by a rapid drop of water temperature during hydropeaking. Results showed that under peak flow conditions (80 L/s), larvae exhibited higher drift rates during the simultaneous drop in water temperature than when temperatures remained constant. These outcomes highlight the importance of considering not only river hydrology but also water temperature in dam releases and hydropower mitigation plans.

KEYWORDS

Thermopeaking, larvae drift, nase, hydropower, experimental channel

1 INTRODUCTION

Research on how hydropower affects early fish life stages has been rapidly advancing in the last years, focusing not only on the direct impacts of rapid flow changes following dam releases (hydropeaking), but also on the associated variations in water temperature (thermopeaking). While salmonids have been the main target group in this research field, more attention is being given to cyprinids (Hayes *et al.* 2019), which represent the largest freshwater fish family (Cyprinidae) in the world. The nase *Chondrostoma nasus* (L.) is considered a representative of this fish family in most European rivers, but despite its relatively widespread distribution, its populations have been declining significantly, having thus become a target species for conservation and river restoration in Europe (Duerregger *et al.* 2018). Increasing the chances of survival of early life stages of the nase in the face of a stressor such as hydropeaking is thus of most importance to ensure successful population recruitment. To evaluate the impact of thermopeaking on nase larvae drift, we perfomed an experimental study in an outdoor mesocosm facility, with the goal of assessing if drops in temperature during hydropeaking (cold thermopeaking) could lead to a higher fish drift.

2 MATERIAL AND METHODS

This study was conducted using the two nature-like experimental channels at the outdoor HyTEC facility in Lunz am See (Lower Austria). We investigated how nase *Chondrostoma nasus* larvae were influenced by a rapid drop in water temperature during hydropeaking. To this aim, we tested two hydropeaking scenarios: one with a constant temperature and a second one where the temperature dropped rapidly during hydropeaking (cold thermopeaking). Each treatment had 9 replicates, which lasted 30 minutes each, starting with a total of 50 nase larvae being stocked in a channel at a base flow of 15 L/s, for a period of 10 minutes for acclimatation. After this adaptation phase, fish experienced a 5-minute upramping until a peak flow of 80 L/s, which was maintained for 10 minutes and followed by a downramping phase lasting 5 minutes, at approximately the same rate as upramping). In each phase (adaptation, upramping, peak flow and downramping), we counted the number of fish that drifted into each drift net, placed downstream of the channel (Figure 1). Temperature was recorded every minute to ensure a significant temperature drop between treatments. After the end of each trial, all remaining larvae were cleared from the channel. Drift rates were compared between the two different treatments (hydropeaking vs. cold thermopeaking), for each phase of the trials.

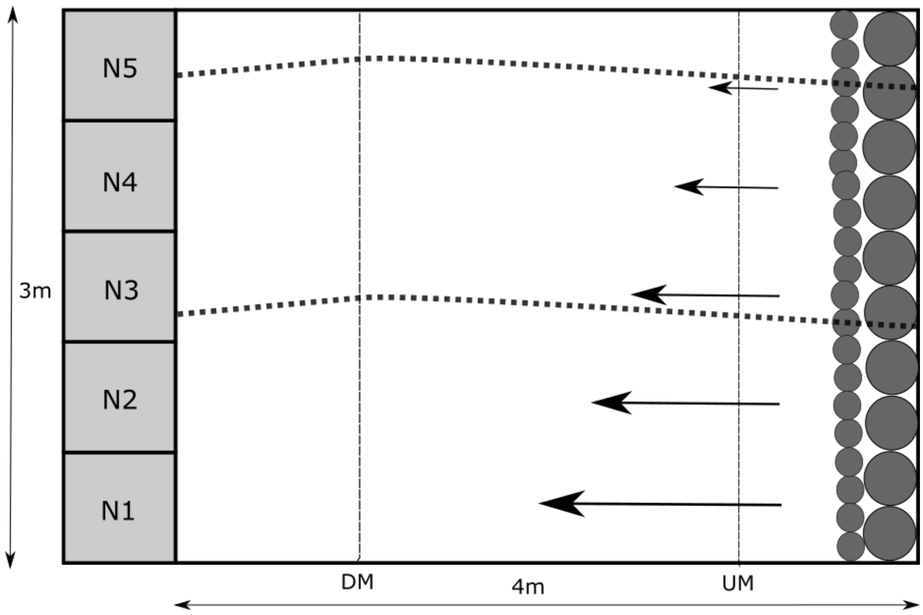

Figure 1. Scheme of the experimental area in the outdoor channels. Flow direction is indicated by the arrows and the downstream drift nets are numbered from N1 to N5, from the deepest and fastest segment to the shallowest and slowest segment). Flow velocity measurements were performed in two cross-sections (UM and DM). Dashed horizontal lines refer to the wetted width in base flow (15 L/s) and peak flow conditions (80 L/s).

3 RESULTS AND DISCUSSION

Overall, fish drift was highest in the adaptation phase, accounting for almost one third of the total drift observed in both treatments (Figure 2). Contrastingly, drift at downramping was the lowest in both hydropeaking and thermopeaking scenarios. This result was consistent with preliminary trials, which showed that at a constant low base flow of 15 L/s for 30 minutes, most of the fish that drifted did so during the adaptation period. Results also showed that under peak flow conditions (80 L/s), larvae drifted significantly more when there was an associated drop in water temperature – cold thermopeaking (Mann-Whitney test, U=17, p=0.041), highlighting the role of water temperature as one of the main environmental variables inducing drift in freshwater fishes (Zitek *et al.* 2004).

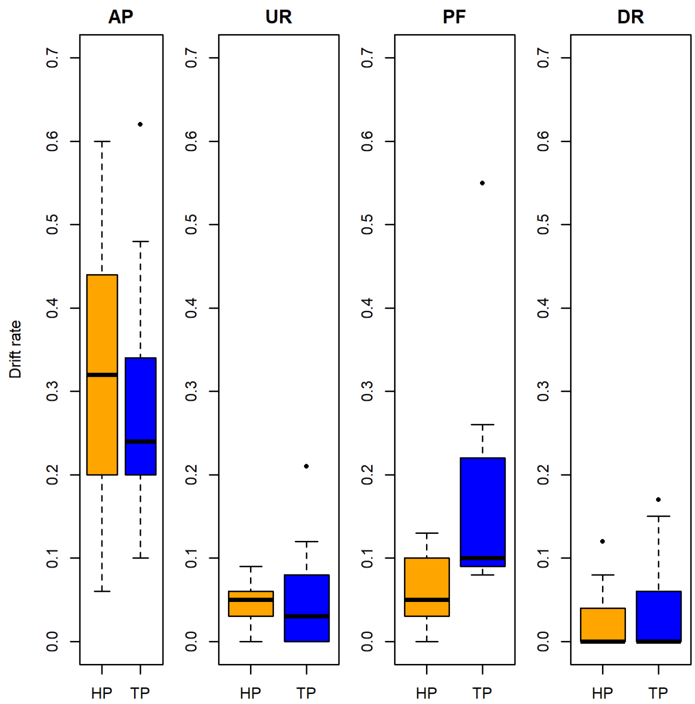

Figure 2. Drift rates in hydropeaking (HP-orange) and thermopeaking (TP-blue) treatments in each phase of the trial: adaptation (AP), upramping (UR), peak flow (PF) and downramping (DR). Bold lines and arrows refer to median values and interquartile ranges, respectively; outliers are represented by black dots.

4 CONCLUSIONS

The results of this experimental study showed an effect of water temperature on nase larvae drift, which was higher when the temperature rapidly dropped during the cold thermopeaking treatment. This highlights the importance of considering not only river hydrology, but also water temperature in turbine operations of hydropeaking operations.

5 ACKNOWLEDGEMENTS

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