Fish ladders at small hydropower plants and potential contribution to downstream passage of eggs and larvae

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Fish ladders at small hydropower plants and potential contribution to the downstream passage of eggs and larvae

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Introduction

Small hydropower plants (SHPs)
(production < 30 MW and reservoir area < 3km²)

Large hydropower plants
(production > 30 MW and reservoir area > 3km²)

• SHPs construction is increasing worldwide → advantages compared to LHPs
Introduction

• Impact of hydropower construction on fish fauna
Introduction

• Use of fishways to reconnect river segments fragmented by dams

• Fishways are often only constructed for adult fish and only consider upstream movements → failure to successfully recruit and persist
Introduction

• Important approach → downstream passage of eggs and larvae

• Effectively transport larvae and eggs to downstream reaches:

Reservoir → Water transparency
Residence time → Small reservoirs
Introduction

• Assuming the eggs and larvae reach the dam, they could pass through different ways: **turbine, spillway or fishway**
Aims

• Evaluate the potential contribution of fish ladders at small hydropower plants to the downstream passage of eggs and larvae

(a) identify if fishes with migratory reproductive behaviour are reproducing in the SHPs cascade influenced area
(b) evaluate if eggs and larvae can successfully drift downstream reaching the dams and which abiotic factors influence this drift
(c) evaluate if downstream passage of eggs and larvae occurs through fish ladders and under which environmental conditions this passage occurs
Material and methods – Study area

- Sapucaí-Mirim River (Southeastern Brazil)
  - One of the main tributaries of Rio Grande River
  - More than 100 fish species, including migratory
  - Three SHPs in cascade, with weir-and-orifice type fish ladders
Material and methods - Samples

Fortnightly between November 2016 and February 2017 at night
Material and methods - Samples

Derived Conical-cylindrical plankton net

Limnological variables with water probe (DO, ORP, TDS, pH, K, Temperature, Turbidity)
Material and methods

Data Analysis

• Selected only the families of larvae that have reproductive migratory behaviour and external fertilization
• The density of eggs and larvae were standardized as individuals/10 m$^3$ of filtered water
• Palmeiras and Retiro SHPs were analyzed separately
• Two factors:
  Section (Lotic; Transition and Lentic zones)
  Sample period [November (1); November (2); December (1); December (2); January (1); January (2); February (1) and February (2)]
Results

• Sampled 658 larvae of the selected families and 815 eggs

• Families with migratory behavior and external fertilization:
  • Anostomidae
  • Characidae
  • Heptapteridae
  • Pimelodidae
  • Prochilodontidae
Results – Retiro Eggs

• Differences for the factor **section period** and the **interaction** between both factors
• December 2, higher density in lotic than transition and lentic; higher in transition than lotic
• Temperature (27%), ORP (23%) and Turbidity (23%)
Results – Retiro Larvae

- Differences for the factor **section period** and the **interaction** between both factors
- January (2), higher in transition than lotic and lentic; higher lentic than lotic; February (1) lower in lotic than transition and lentic
- TDS (51%), turbidity (47%) and cumulated rain 5 days before the sample (25%)
Results – Palmeiras Eggs

- Differences for the factor section, period and the interaction between both factors
- December 1 and January 2, higher density in transition than to lentic and lotic
- Turbidity (42%), precipitation in the day of the sample (30%) and precipitation one day before the sample (26%)

![Graph showing density of eggs and precipitation over time]

![Map of the area with labels for Lentic, Transition, and Lotic regions]
Results – Palmeiras Larvae

- Differences for the factor **period** and the interaction between both factors
- **December (1)**, lower density in lentic than lotic and transition; **January (2)**, higher in lentic than lotic and transition; higher in transition than lotic
- **Turbidity (45%)**, precipitation one day before the sample (40%) and precipitation in the day of the sample (25%)
Results

• Presence of eggs and larvae within fish ladder only in few events
• Eggs - No environmental variables can predict the density of eggs within fish ladder
• Larvae - density of larvae in the reservoir predicted the density of larvae within fish ladder

• Percentage of larvae present in reservoir which pass through fish ladder:
  Palmeiras SHP 14.6% in January 1
  Retiro SHP 65.0% in December 2 and 15.8% in January 1
Discussion

• There is spawning of families with migratory reproductive behaviour in the influence area of the cascade of SHPs in Sapucai-Mirim River

*Pimelodus maculatus*  
*Prochilodus lineatus*  
*Megaleporinus obtusidens*
Discussion

• The offspring can successfully drift downstream and reach the dam
Discussion

- Once in the dam, the larvae can pass through the fish ladder but only when there is a high abundance of larvae in the reservoir.
Conclusion

• The fish ladders of SHPs in Sapucaí-Mirim River have a small contribution to the downstream passage of eggs and larvae of the migratory species.

• Migratory species can complete their life cycle, but high rates of recruitment could be achieved with a proper design of fishways, incorporating the downstream passage of egg and larvae of fish.
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THANK YOU!

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