Oviposition Habitat Selectivity of Tailwater Macroinvertebrates: A Methodological Approach from the Colorado River Basin

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Introduction: Background and Hypothesis

- The response of macroinvertebrate assemblages to large-scale dam construction and management is highly variable through space and time (Figs. 1 & 2)

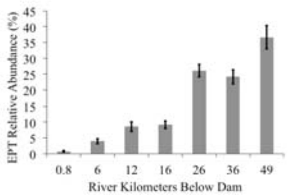

Figure 1. 20 year EPT relative abundances (±SE) at seven sites below Flaming Gorge Dam (FGD).

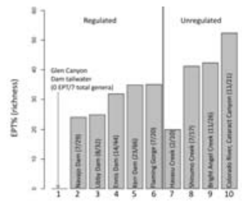

Figure 2. EPT relative richness for 6 regulated (1-6) and 4 unregulated (7-10) systems in the CO River Basin.

- Downstream recovery of invertebrate assemblages has been extensively studied in relation to thermal regimes, sediment supply, and trophic basis for secondary production, *yet no studies linking population viability of tailwater taxa to oviposition (egg-laying) constraints imposed by dam operations*

- Since invertebrates are believed to preferentially lay eggs on emergent substrates, intra- and inter-daily water level fluctuations could influence recruitment by:

1. Altering the spatial and temporal availability (i.e., quantity and quality) of optimum adult oviposition habitats (Fig. 3)

1030 am   1200 pm   1230 pm

Figure 3. Reductions in the spatial extent of wetted habitat resulting from hydropeaking on the Green River below FGD.

2. Subjecting oviposition sites to higher rates of egg desiccation and mortality if dam operations are "out-of-sync" with oviposition phenologies (Fig. 4)

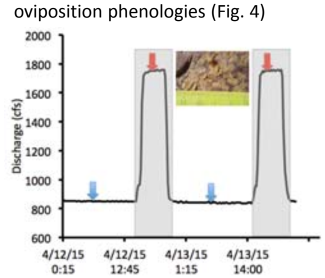

Figure 4. Green River hydrograph with flow periods that are out-of-sync with invertebrate oviposition phenologies outlined by grey boxes. Eggs laid at high flow during these periods (e.g., at dusk; red arrows) may become exposed during low flow periods (inset photograph) and are considered out-of-sync with dam operations. Eggs laid outside this period, such as at dawn (blue arrows), are in-sync with dam operations, having low risk of being exposed.

- **We hypothesize that oviposition site availability and/or egg mortality resulting from dam operations could represent significant life-cycle bottlenecks, leading to persistent extirpation and/or fitness reductions of tailwater taxa. Furthermore, fitness reductions will be most intense when dam operations are "out of sync" with daily insect phenologies (i.e., high flows during oviposition; Fig. 4).**

Project Objective and Research Questions

Project Objective:

To characterize macroinvertebrate oviposition habitat selectivity in tailwaters of the Green and Colorado Rivers and to quantify the extent to which dam operations alter the availability of oviposition habitats and subsequent recruitment success

Research Questions:

1. Are tailwater egg masses randomly distributed or are they differentially located among habitat units (e.g., riffles vs. runs), within a habitat unit (e.g., mid-channel vs. edge), or among substrate types (e.g., emergent vs. submerged)?
2. If identified, does the availability of optimal habitats differ along a spatial or temporal gradient of hydrologic alteration?

Methods: Pilot Study – Green River Habitat Selectivity

Pilot Objective:

To determine the adequacy and feasibility of a preliminary sample design to characterize oviposition habitat selectivity on the Green River below Flaming Gorge Dam

Methods:

- We used a systematic, transect-based approach (Fig. 5) at two sites to randomly survey 4 reaches, such that 50+ substrate particles were sampled for *Baetis sp*. and Chironomidae egg masses in each reach, for a total of 200+ particles at each site

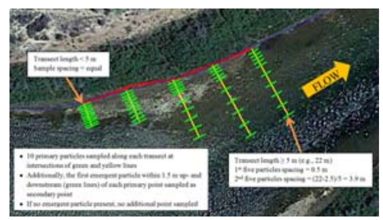

Figure 5. Example pilot study reach layout. Reaches (red line) were randomly located and consisted of 5 transects (yellow lines) spaced 5 m apart. Transect length was determined by channel midpoint or where wadeability was no longer feasible. See insets for further sampling information.

- Substrate and egg mass characteristics were collected at each particle (Table 1)

Table 1. Variables measured to characterize habitat availability and utilization by ovipositing adults in Green River pilot study.

1. Habitat-unit (e.g., pool vs. riffle) from which a particle was selected *
2. Location of substrate within habitat-units
    - Distance from wetted bank*
    - Particle depth: surface to top of particle*
    - Water depth: surface to riverbed upstream
3. Characteristics of substrate
    - Substrate type (e.g., emergent rock, submerged wood)*
    - Size*
    - Height of emergent substrate above water level*
    - Percent organic cover
    - Percent inorganic cover
    - Percent embeddedness
    - Emergent substrate area*
    - Velocity*
    - Splash: water surface roughness
4. Characteristics of egg masses on substrate
    - Number of egg masses per species (*Baetis* sp. or Chironomidae)*
    - Location of >50% egg masses (rocks: upperside, underside, or lateral side)*
    - Orientation of egg masses (up- or downstream half of substrate)*

* Indicates variables to be quantified as part of future stratified habitat surveys (panel 3)

Results: Pilot Study

- In total, 462 particles sampled for eggs across both sites (Table 2)

Table 2. Particle and egg detection rates for substrate types sampled during pilot study on Green River.

Substrate		# Sampled	% of Total Sampled	# with Eggs	% with Eggs
Emergent	Rocks	44	9.5	10	23
	Veg	25	5.4	3	12
	Wood	7	1.5	0	0
	Dry	4	0.9	0	0
Submerged	Rocks	239	51.7	3	1
	Veg	47	10.2	0	0
	Wood	12	2.6	3	25
	Sand/fines	84	18.2	0	0
Total		462	100	19	4.1

- Species data analyzed jointly using RandomForest package in R
- Three predictors explained 28% of the variability in egg abundances: particle depth, velocity, and distance from wetted edge (Figs. 6 & 7)

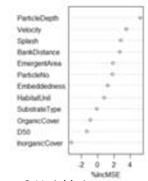

Figure 6. Variable importance plot for all considered predictors. X-axis is % increase in mean square error.

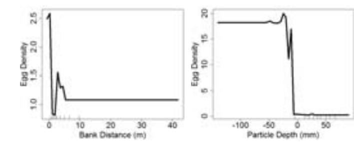

Figure 7. Egg density as a function of bank distance (left) and particle depth (right). Y-axis is a rescaled measure of egg density.

Discussion: Pilot Study

- Low egg detection rate (4.1%) using random sampling
- Preferred oviposition habitats (emergent rocks/vegetation, submerged wood) collectively sampled <20% of time
- Tailwater taxa prefer emergent substrates located in moderate velocities near the shore
- *Need to revise sampling design to increase sample sizes in patchily distributed, preferred oviposition habitats*

Next Steps: Implementation of Stratified Habitat Surveys

- Three sites to be sampled: 1, 12, and 26 kilometers below FGD
- Each site represented by a 1.5 km river segment
- Within each segment, 3 fast-water and 3 slow-water reaches will be randomly selected for sampling
- Each reach divided into "mid-channel" and "edge" habitats
- Within each habitat, 15 particles will be sampled from each of the following substrate categories:
    - Submerged rocks and wood, emergent rocks, and vegetation
- At each particle, record substrate and egg mass characteristics (Table 1)
- Visually estimate aerial extent of different habitat and substrate categories (Fig. 8) for scaling habitat availability and egg densities to reach- and segment-scales

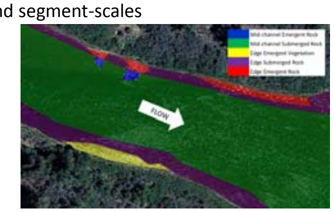

Figure 8. A hypothetical fast-water reach of the Green River stratified by habitat and substrate categories.