Phenotypic Plasticity in Bigheaded Carp Life History Traits

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Quick Background

• Bigheaded carp (*Hypophthalmichthys* spp) invasion history well-known (started in Arkansas 1972 & 1973)

• Invasion of Great Lakes Basin considered imminent (Jerde et al. 2011)
  • Several fish already captured in Great Lakes & adjacent waters

• Substantial economic & ecological consequences of invasion & establishment very likely (Cudmore et al. 2012)

• Considerable effort expended to prevent additional introductions that could lead to establishment and wider distribution (e.g., electric barriers)
Assessing/Predicting Threats

- Prevent new introductions; halt, limit, slow dispersal
- Multiple efforts based on:
  - Life history, habitat requirements, invasion histories, & human uses (Kolar & Lodge 2002; Cudmore et al. 2012)
  - Ecological niche & habitat suitability models (Chen et al. 2007; Herborg et al. 2007; Cudmore & Mandrak 2011; Cudmore et al. 2012; Kocovsky et al. 2012)
  - Bioenergetics modeling (Cook & Hill 2010)

- Mixed results
- Constrained by knowledge of their ability to adapt to novel environments?
Key Ecological Factors (Native)

• Typically lentic & need “large” rivers to spawn
• 80-100 km undammed river/channel (Kolar et al. 2007)
  ➢ BUT, eggs known to develop in static conditions
• Rising hydrograph/water temps ≥18 °C
  ➢ Water velocity ≥0.7 m/s (Abdusamadov 1987)
  ➢ Precipitation & discharge as proxies (e.g., Kocovsky et al. 2012)
  ➢ BUT, reproductive needs may not be as restrictive in new environments (e.g., Kara Kum Canal, Turkmenistan)
• Spring/early summer spawning
  ➢ BUT, spawning may occur multiple times throughout summer (Rasmussen 2002; Papoulias et al. 2006; Schrank & Guy 2002)
Plasticity

• Sufficient anecdotal/preliminary/recently published evidence exists to suggest that bigheaded carps more plastic in novel systems
• Spawning habitats in native range different from North America (e.g., Missouri River, Deter et al. 2012)
• Bigheaded carps likely to be able to acclimate to a wide range of conditions (“adaptable,” Kocovsky et al. 2012)
• Relatively little ecological info on bigheaded carps in North American waters
• More quantitative understanding of ecology in North American waters could improve management strategies
Objectives

• Increase understanding of bigheaded carp spawning ecology in North American freshwaters

• Conduct surveys of drifting eggs in the Wabash River, IN
  ➢ Evaluate gage height, $\Delta$ gage height, water temperature as factors
  ➢ Determine the temporal extent of spawning
  ➢ Determine upstream-most extent of spawning
Study Area

Upper Wabash River

- Eagle Marsh
Drifting Egg Sampling

- **Bongo net pulls in triplicate (333 µm, 500 µm)**
  - Weekly pulls at RM310 (Summer 2011 & 2012)
  - 3-5 min pulls; velocity added in 2012
Egg Verification

- Chapman 2006; Chapman & George 2011
- DNA
  - PCR & qPCR (Jerde et al. 2011); 2011 samples
  - qPCR D-loop region of mitochondrial DNA (Coulter et al. 2013); late 2011 & 2012
Results

- **2011**
  - Eggs detected on 19 of 25 sample dates
  - Some hydrological variability early, but largely stable from mid-July – September
  - Eggs detected @ water temps from 18.5 – 29.7 °C
  - Eggs detected as late as 01-Sep
  - DNA –confirmed eggs exclusively silver carp
Results

- **2012**
  - Very little hydrological variability
  - Eggs detected @ water temps from $\approx 18$– $26 \, ^\circ C$ (to date); egg abundance increased markedly @ $25 \, ^\circ C$ despite absence of $\Delta$ gage height
  - DNA–confirmed eggs exclusively silver carp
Results

• Logistic Regression Analysis on Presence/absence
  - Presence/absence of bigheaded carp eggs at Wabash RM310 not related to change in gage height from 48-24 h prior to sampling, gage height at the time of sampling, or water temperature
Results

• Spatial Extent of Spawning (2011)
  – Conducted bongo net tows @ 5 additional sites upstream from Wabash RM310 (RM324, 340, 351, 370, & 390)
  – Limited to June due to water levels
  – Tows on 01-Jun & 02-Jun-11 yielded eggs @ 351, 370, & 390
  – Wabash River @ RM390 ≈30 m wide & drains 4,750 km²
Discussion

• Rising/changing hydrograph not essential for successful spawning
  ➢ Confirms Deter et al. (2012) & Kocovsky et al. (2012) suggestions that a rising hydrograph can be sufficient, but not required for spawning

• A wider range of rivers may be more susceptible to invasion/establishment than previously thought
Discussion

• North American bigheaded carps demonstrate protracted spawning
  - Confirms suppositions by earlier authors based on multiple size classes within YOY & variably developed eggs within ovaries of females
  - There is no question that reproductive effort is reduced over protracted period, although recruitment related to protracted events unknown
    - Analysis of quantitative measures of egg density for 2012 forthcoming
  - Also unknown are spawning habits of individuals
Discussion

- **Detection of eggs @ Wabash RM390**
  - Considerably smaller channel width & watershed area than spawning rivers in native range
  - May confirm observations by Deter et al. (2012) even though they suspected cross contamination in their samples (e.g., Lamine River (6,860 km²) and Bonne Femme Creek (464 km²) in the Missouri River basin)
  - Smaller rivers may be susceptible to invasion/establishment than originally thought
Conclusions/Implications

- Biology/ecology of bigheaded carps in native ranges do not accurately reflect the adaptability/plasticity of these species in novel systems.
- The plasticity of bigheaded carps makes them moving targets for management (plastic OR microevolution?).
- Efforts to predict invasion/establishment of these species can likely benefit from information based on existing North American populations.
- Adaptive modeling & management will likely be key for achieving goals & objectives.
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Questions?

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