2010

Terrestrial predators and abiotic conditions affect hatching survival of arboreal frog eggs: Implications for aquatic food web dynamics [poster]

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Terrestrial predators and abiotic conditions affect hatching survival of arboreal frog eggs: Implications for aquatic food web dynamics

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Introduction

Organisms with complex life cycles (e.g., amphibians, aquatic insects) that use both habitats sequentially through development are important links between aquatic and terrestrial food webs. The flux of these organisms moving between habitats can have important consequences for food web dynamics in adjacent ecosystems. Anuran species with arboreal eggs are vulnerable to a suite of abiotic threats and terrestrial predators. The larval (tadpole) stage of these species are important herbivores. Therefore, the degree to which terrestrial predators or abiotic conditions reduce the input of tadpoles into the aquatic environment may carry important indirect consequences for aquatic ecosystem dynamics (e.g., tadpole herbivory).

Hypothesis 1: Terrestrial predators and abiotic conditions influence the density of their herbivorous tadpole prey.

Hypothesis 2: Changes in the density of tadpoles alters feeding rates and nutrient inputs, which affect aquatic ecosystem processes

Methods

• *Field Monitoring*.- We monitored clutch density, survivorship and sources of mortality throughout the breeding season. We monitored a subset of new clutches 2x/d through to hatching.

• *Mesocosm Experiments* .- Using parameters from field monitoring we investigated how tadpole density affects aquatic primary productivity via consumption and through potential competition with zooplankton (8 initial densities each replicated 2x).

Results

- We monitored 201 clutches and ~ 7,335 developing embryos (mean clutch size 36.17 eggs clutch $^{-1}$ (mean ±SD)).
- Overall 49% of all eggs laid survived to the tadpole stage.

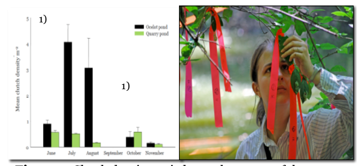


Figure 1. Clutch density varied over the course of the season and among ponds ((LM, month, $F_{1,10}$ = 5.69, P = 0.4; pond $F_{1,9}$ = 7.36, P = 0.04).

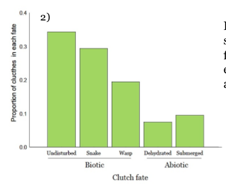


Figure 2. Major sources of mortality for clutches over the entire season and across both ponds.

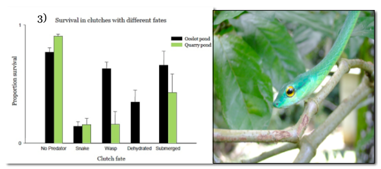
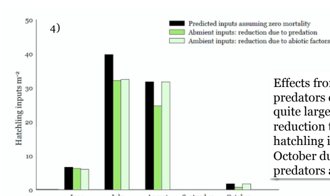


Figure 3. Different sources of mortality resulted in difference in clutch survival (GLM, fate, $F_{2,107}$ = 8.05, P = 0.0006).



Effects from predators can be quite large e.g., 79% reduction to hatchling inputs in October due to predators alone

Figure 4. Ambient hatchling inputs for Ocelot pond compared to estimated reductions due to predators and abiotic conditions.

Tadpole densities in mesocosms reflect the range of tadpole inputs under various scenarios (e.g., zero mortality, 30% snake predation Fig. 4) based on estimates from field monitoring as well as previous tadpole estimates from the Ocelot pond.

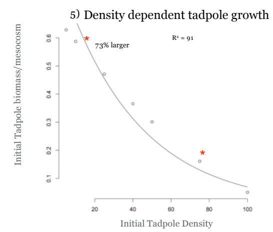


Figure 5. Density dependent tadpole growth. Initial tadpole density had a significant negative effect on final tadpole biomass

•Survival did not vary among density treatments (,p-value =0.24,R² = 0.03)

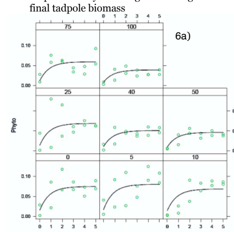
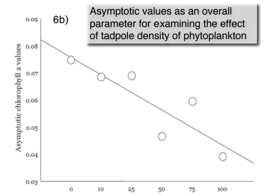
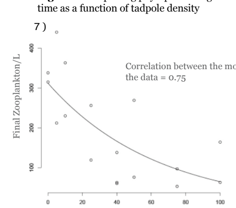


Figure 6a. Exploring phytoplankton growth over time as a function of tadpole density



Asymptotic values as an overall parameter for examining the effect of tadpole density of phytoplankton

Figure 6b. Significant negative relationship between phytoplankton and tadpole density



Correlation between the model fit and the data = 0.75

Figure 7. Initial tadpole density had a significant negative effect on final zooplankton density (Table 1).

Table 1. Model selections were based on maximum likelihood estimates. E.g., For Figure 7, the negative exponential has the lowest Δ AIC

Model	AIC	K	Δ AIC
Linear	874	1	132
Negative Exponential	742	2	0 *
Null	1388	1	646

Take Home and Future Directions

Taken together our results show that the interpretations of food web dynamics can be quite different depending on the suit of focal species. For example at low tadpole densities we might assume that the reduction in tadpole inputs due to predator and abiotic factors would have a positive effect on primary productivity (Fig. 6a). However, at these low densities, zooplankton density decreases which will have a negative effect on primary productivity. Theory predicts that our patterns could result from either population level effects (e.g., intraspecific competition) or from community effects (e.g., interspecific competition with zooplankton, Fig 7). Future analyses will begin to explore the underlying mechanisms driving these patterns.

Other questions will we continue to explore include:

•Why would resources continue to decrease even though overall consumer biomass is drastically reduced (Fig. 5)?

•Data (not shown here) also suggest that density mediated effects may help explain the trait mediated effects of tadpoles on phytoplankton (these embryos exhibit early hatching in response to predators).

Given the variation in tadpole inputs due to breeding phenology, abiotic conditions and predators highlight the dynamical effects of any underlying mechanisms predicted by classical ecology may be context dependent.

Acknowledgments

J. Kraus, M. Hughey, M. McCoy, K. Goyer, S. Summit, Beth Myer and Karen Warkentin. Funding for this project was provided by the National Science Foundation, Sigma XI and the Fulbright Foundation

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NSF SIGMA XI The Scientific Research Society Smithsonian Institution