FEAR, DEATH, & LIFE HISTORY SWITCH POINTS: PROJECT SUMMARY

Phenotypic plasticity is a common and important response of individual organisms to environmental variation, and can have strong effects on populations and communities. Most animals have complex life cycles characterized by ecologically pivotal transition points that focus selection from two sequential environments, and these switch points often are plastic. This project aims to both improve our understanding of complex life cycles and use complex life cycles to study phenotypic plasticity and its ecological role. It combines broadly applicable modeling with experimental research on one well-studied amphibian. The investigators will extend the general size-based cost/benefit modeling framework for predicting switch point phenotypes by incorporating (i) density-dependent processes and (ii) variation in initial phenotypic and density conditions, and (iii) explicitly modeling recruitment across life stages. These extensions of existing theory will elucidate the relative importance of density- and size-dependence in vital rates, as well as historical contingency, on life history switch point plasticity, and of direct mortality, historical contingency, and switch point plasticity on recruitment across a range of environmental contexts. The empirical work focuses on predation as a common and important source of mortality and selection, and hatching and metamorphosis as critical ontogenetic switch points. It examines how environmental conditions affecting growth and risk affect both (i) the ecological importance of plasticity for population processes and (ii) the cumulative effect of sequential episodes of natural selection on plasticity across life stages. The study species, the red-eyed treefrog, hatches early to escape egg predators, metamorphoses early in response to tadpole predators, and delays metamorphosis in response to predators of froglets. The investigators will manipulate larval growth conditions and the lethal and non-lethal effects of egg, larval, and post-metamorphic predators in mesocosm experiments from egg through froglet stages to empirically assess the demographic and selective consequences of alternative plastic strategies in different ecological contexts. Short-term experiments to estimate predation and growth functions for larvae and froglets of the study species under different conditions will be used to parameterize the existing "minimize mortality/growth" model as well as the new extensions of this framework, allowing mesocosm experiments to serve as quantitative tests of model predictions.

Intellectual Merit. This work advances understanding of population ecology, life history evolution, and developmental plasticity, and strengthens theoretical and empirical links among these fields. The goal is to understand how environmental conditions mediate demographic and fitness effects of plasticity across complex life cycles. Specifically, this work improves our understanding of the optimal timing of life history switch points by integrating density into the theory based on size-specific risk and growth, as well as by testing model predictions based on measured pre- and post-switch risk and growth functions. It clarifies the effect of individual adaptive plasticity on population processes by assessing its magnitude across key axes of environmental variation. It advances our knowledge of plastic development by quantifying how plastic choices early in ontogeny carry over to affect phenotypes and plastic responses in later stages, and if or how this varies across ecological contexts. The modeling and empirical work make independent contributions to understanding complex life cycles; their quantitative integration adds a third component. Furthermore, this work adds a population-level perspective to Warkentin's integrative research program on red-eyed treefrogs and will facilitate future studies across scales from community ecology to individual decisions under uncertainty and risk.

Broader Impact This grant will directly support a postdoctoral researcher, 2-3 graduate students, and 6 interns (one Latin American & one from USA annually). Students will gain cross-cultural experience as well as training in tropical field biology and evolutionary and population ecology. Additional undergraduates will participate via research-for-credit and volunteer opportunities. Results will be broadly disseminated to the public and students–the PIs' research to date has been reported in print, radio, TV and internet media in many countries, as well as in textbooks. Furthermore, the grant will enhance infrastructure for experimental aquatic research at the Smithsonian Tropical Research Institute.