There and Back Again: Spatial and Temporal Variation in the Recruitment Dynamics of an Amphidromous Fish

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Chapter 1

Preface

One planet, one experiment

- E.O. Wilson

1.1 Abstract

A primary goal of ecology is to identify the factors underlying recruitment variability, and how they may shape population dynamics. Recruitment is driven by the input of new individuals into a population. However, these individuals often show high diversity in phenotypic traits and life histories, and the consequences of this variation are poorly understood. Phenotypic variation is widespread among the early life stages of fish, and this variation may be influenced by events occurring across multiple life stages. While many studies have investigated phenotypic variation and its effect on population dynamics, comparatively few studies use an integrated approach that evaluates patterns and processes across multiple life history stages. Here I focus on a native amphidromous fish, *Galaxias maculatus*, and I explore patterns and consequences of phenotypic variation during larval stages, migratory stages, and post-settlement stages of this fish.

I explore variability in phenotypes and early life history traits of G. maculatus through both space and time. I use metrics derived from body size and otolith-based demographic reconstructions to quantify potentially important early life history traits. I found that cohorts of juvenile fish sampled later in the year were comprised of individuals that were older, smaller, and grew more slowly relative to fish sampled earlier in the year. I also found that two sampled sites (the Hutt River and the Wainuiomata River) showed different temporal trends, despite their close geographical proximity.

I then investigated whether phenotype was related to mortality. I used otolith-based traits to characterise larval 'quality' for individual fish. I then calculated the average larval quality for discrete cohorts of fish, and used catch-curve analysis to estimate mortality rates for these cohorts. I investigated the overall relationship between quality and mortality, and compared the trend between two sites. My results indicate that phenotype and mortality were not significantly correlated. However, this inference may be limited by low statistical power; the non-significant trends suggest that the relationship might be negative (i.e., larvae of higher quality tend to have lower rates of mortality). This trend is typical of systems where population expansion is limited by food rather than predators.

I then investigated whether phenotypic traits in the juvenile cohorts were correlated with traits in adult cohorts. I resampled the focal populations ~6 months after sampling the juvenile stages (i.e., targeting fish from sampled cohorts that had survived to adulthood), and I used data from otoliths to reconstruct life history traits (hatch dates and growth histories). I compared adult life history traits to the traits of discrete juvenile cohorts.

My results suggest that fish that survived to adulthood had comparatively slower growth rates (reconstructed for a period of larval/juvenile growth) relative to the sampled juvenile cohorts (where growth rate was estimated for the same period in their life history). I also found that the distributions of hatch dates varied between sites. Fish that survived to adulthood at one site hatched later in the breeding season, while adult stages from the other site had hatch dates that were distributed across the entire breeding season. Both hatch date and growth rate are likely linked to fitness, and their interaction may have influenced patterns of survival to adulthood. These results provide evidence for carry-over effects of larval phenotype on juvenile success.

Collectively my thesis emphasises the importance of phenotype and life history variability in studies of recruitment. It also highlights the importance of spatial scale, and how biological patterns may differ between geographically close systems. Some of the general inferences from my study may extend to other migratory Galaxiid species, and perhaps more generally, to many species with extensive larval dispersal. Finally, my work highlights potentially important interactions between phenotypes, life histories, and mortality, which can ultimately shape recruitment, and the dynamics of populations.

1.2 Acknowledgements

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Chapter 2

Literature

Here is a review of existing methods.

Chapter 3

Methods

We describe our methods in this chapter.

Chapter 4

Applications

Some *significant* applications are demonstrated in this chapter.

4.1 Example one

4.2 Example two

Chapter 5

Final Words

We have finished a nice book.