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Egg predation at tropical reef fish spawning aggregation sites: trade-offs for fitness

Thesis submitted by
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In October 2009

For the degree of Doctor of Philosophy in Marine Biology
In the School of Marine Biology and Aquaculture
James Cook University, Townsville, Queensland, Australia

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Statement on the contribution of others

Assoc. Prof. Mark McCormick originally conceived the topic for this doctoral thesis and provided primary guidance, and financial and technical support. Intellectual support was also provided by Prof. Geoffrey Jones as co-supervisor. While undertaking this thesis I was responsible for the project design, implementation, data collection and analysis, interpretation, synthesis and formatting for publication.

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Abstract

Food resource availability has a fundamental role in shaping consumer populations. However, very few studies have investigated the role of natural fluctuations in food availability on tropical marine fish populations. Resource pulses are natural variations in food resource availability that result in a super abundant supply of a food resource and present a unique opportunity to examine the effects of natural variations in food availability on population processes. Tropical reef fish spawning aggregations provide a resource pulse for reef based planktonic egg predators, however the dynamics of egg predation at reef fish spawning aggregation sites (SASs) are largely unstudied. This thesis uses spawning aggregations as a model to study the effects of a natural variation in resource availability on reef fish population processes. The broad objectives of this study were to: (1) quantify egg predation among multiple reef fish SASs and to relate observed patterns to the reproductive behaviour of the pelagic spawners, and to (2) examine the numerical and energetic repercussions of egg predation for the egg predator community.

Reef fishes are hypothesised to spawn at SASs to minimise egg predation through: (1) using favourable locations to minimise egg predation by reef based egg predators and (2) rapidly increasing spawning intensity by synchronising spawning activity to swamp egg predators. In Chapter 2 I systematically quantified inter-specific and intra-specific differences in target egg predation among multiple SASs of resident fishes, and investigated the relationship between levels of target egg predation and spawning intensity. Levels of egg predation were significantly greater for the surgeonfish

Ctenochaetus striatus compared to other spawning species, and the levels of egg predation among species closely reflected differences in the mean volume of eggs released during a spawning aggregation event. For the spawner *C. striatus*, levels of egg predation were significantly greater at front reef SASs than at back reef SASs. In addition, front reef SASs had significantly higher densities of egg predators. At front reef SASs the damselfish *Abudefduf vaigiensis* attacked the greatest percentage of *C. striatus* spawning rushes. The relationship between spawning intensity and the rate with which rushes were attacked at front reef sites increased linearly, however there was no relationship between spawning intensity and target egg predation at back reef SASs. To test if egg predator swamping occurs at SASs it is imperative to measure rates of egg mortality rather than the number of rushes attacked. This study demonstrates that target egg predation varies greatly among spawning species, and among SASs, which result from differences in egg predator assemblages.

Theory predicts consumers will respond numerically to variations in food availability through changes in resident density and through an aggregation response. The extent to which eggs as a prey source influenced resident egg predator density and movement patterns were tested using *C. striatus* spawning aggregations. Firstly, the densities of egg predator species were compared among SASs and structurally similar non-SASs outside of spawning periods. Secondly, to determine if egg predators aggregate during spawning periods, the change in egg predator density between spawning and non-spawning periods at SASs and non-SASs were quantified. To determine the distance travelled to aggregate and feed on the pulsed resource, a movement study was conducted on tagged individuals of a key egg predator species. Densities of resident egg predators

did not differ among SASs and non-SASs and only one egg predator species, *A. vaigiensis*, showed an increase in density at SASs during a *C. striatus* spawning aggregations. The movement study conducted with *A. vaigiensis* showed that tagged individuals travelled only ten meters to feed on *C. striatus* gametes, which is within their normal home range movements. These data suggest that insufficient eggs are consumed by egg predators to influence resident densities or to warrant greater aggregation movements by *A. vaigiensis*.

Populations are predicted to respond energetically to increases in prey abundance. This study examined the effects of the consumption of *C. striatus* eggs on the allocation of energy to condition, growth and reproduction in the damselfish, *A. vaigiensis*. Fish that fed on eggs at spawning aggregation sites (SASs) had significantly greater lipid storage in liver vacuoles compared to conspecifics from non-SAS. Growth histories of male *A. vaigiensis* were significantly different among SASs and non-SASs, however there were no differences in growth histories of females among SASs and non-SASs. Female *A. vaigiensis* from SASs had significantly greater gonadosomatic indices (GSI) than females from non-SASs, while there was no difference in the GSI of males among SASs and non-SASs. No differences were found in the life history traits of the reference species, *Pomacentrus moluccensis*, which does not consume eggs at the same locations. This study demonstrates the role of natural variations in food availability on energetic processes in reef fish. Furthermore, the sex-specific energy allocation strategy highlights the complexity of the interaction between natural variations in food availability and life-history strategies. This study demonstrates that the conservation of reef fish SASs may also benefit trophically linked reef fishes.

The role of maternal nutrition is becoming increasingly recognised as an important energetic process that influences offspring phenotype and subsequent survival. In Chapter 5, I examine the role of egg consumption on the maternal effects on offspring morphology and survival in controlled laboratory conditions. Parents were fed either: (1) a control diet of plankton (*Acetes* spp.), (2) a plankton diet partially substituted with fish eggs and the same energy content as the control diet, or (3) a plankton diet supplemented with fish eggs but higher in energy content. Mothers fed diets containing fish eggs tended to produce larger offspring with greater yolk reserves, however these trends were not significantly different. Mothers fed diet 3 produced young that had significantly greater unfed survival. Collectively, these data suggest that mothers that consume eggs at reef fish SASs will produce young that have greater survival than the young produced by mothers that do not feed on eggs. Therefore, the consumption of eggs by reef based egg predators may enhance their reproductive success through both increased fecundity (Chapter 4), and enhanced offspring survival.

The results from this thesis demonstrate that natural variations in food availability have an important role in shaping reef fish numerical and energetic population processes. Egg predation is highly variable and may be a significant source of mortality for some pelagic spawning species. Eggs released by pelagic spawners are potentially an important food source for some egg predator species and are capable of influencing their movement patterns and life history traits. Therefore the conservation of reef fish SASs will not only protect spawning species, but will also protect an important trophic link that benefits the egg predator community.