

IH311 Q10 relationships of fishes inhabiting intertidal nursery areas, Indonesia

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Early life history of fishes is a fascinating subject of study. Most fishes pursue a strategy whereby the juvenile members of the population occupy so-called nursery areas that are spatially segregated from adult habitats. This strategy has many advantages; primary among them being the reduction of intraspecific resource competition and cannibalism. Regardless of the specific microhabitat used, fish nurseries also exhibit similar physical properties. They are typically shallow, intertidal regions that cannot be easily accessed by large predators. Nurseries are also structurally complex, providing ample hiding places for juvenile fishes. Finally, nurseries are extremely productive areas, supporting both high levels of primary photosynthetic activity as well as multiple trophic levels. The abundance of bacteria protists and small animals provide a ready food source for juvenile fish that generally experience rapid growth rates as a result.

Ironically, the same characteristics that make nurseries attractive to juvenile fishes also present the greatest challenges to survival. Indeed, intertidal nurseries are some of the harshest environments on Earth. Owing to their shallow nature and high level of biotic activity, nursery areas are prone to rapid shifts in temperature and oxygen levels. Temperature change can be especially problematic in that the shifts are often rapid, unpredictable and of unusually high magnitude. For example, we have measured temperature increases in mangle nurseries at Hoga Island of up to 15°C over the course of 2-3 hours.

Recently there have been concerns raised that changes in global climate are likely to have an especially profound effect on nursery zones. To date however, a large gap exists in our understanding of how juvenile fish will be affected by changing thermal conditions. Many good models have been developed to understand how open ocean temperatures may change in the face of climate warming; however, but it is unclear how these changes may affect important fish nurseries. Unlike more voluminous open ocean habitats, shallow nurseries will experience more extreme spikes in temperature as well as a 1 to 2°C increase in average temperature. Considering that most ectotherms double their metabolic rate with every 10°C increase in ambient conditions, it seems likely that changing nursery temperatures will disrupt normal growth rates and timing of fish recruitment to nearby reefs. The threat of global climate change therefore, has placed a new urgency on understanding the physiological consequences of temperature change on fish metabolism and growth.

The purpose of this project is to evaluate metabolic temperature sensitivity of selected juvenile reef fishes from nursery areas around Hoga Island. Briefly, juvenile reef fish will be captured using light traps placed out overnight in key nursery zones (e.g., seagrass beds, patch reefs or mangle habitats). Fish will be transported to the Hoga Marine Research Center and held at ambient conditions (typically a cycling temperature regimen of 25 to 28°C) similar to those experienced in the field. After a two-week holding period upper and lower thermal tolerance (measured using Critical Thermal Methodology, see Beitinger et al., 2000 in the reading list) will be determined for a subset of 10 fish. These values will be used to establish the high and low acute temperatures used in the metabolic trials.

Flow-through respirometry techniques (see Cech 1990 on the reading list) will be used to estimate metabolic rates for 15 fish of each selected species. Fish will be placed, one each, into a temperature-controlled 250 ml respirometer flask the night before the trial and allowed to become accustomed to the respirometer. Clean seawater from a headbox will flow through the flask at a rate of approximately 50 ml/min (depending on fish mass). Oxygen content of seawater entering and leaving the flask will be measured using either an oxygen meter, or by Winkler titration. Metabolic rate is determined by multiplying the respirometer flow rate by the difference in oxygen content between the respirometer inflow and outflow streams. Three metabolic rates will be determined: 1) at the average holding temperature, 2) following and acute increase 5°C above holding temperature, and 3) following an acute decrease 5°C below the holding temperature. High and low acute temperature levels will be adjusted accordingly for fish with thermal tolerance scopes (high temperature tolerance – low temperature tolerance) of less than 10°C.

Metabolic sensitivity to temperature increase is determined as the temperature quotient or Q_{10} . The Q_{10} is an index that represents the relative increase in metabolic rate over a 10°C change in temperature, such that a Q_{10} of 2 is equal to a doubling of metabolic rate, a value of 3 indicates a tripling of rate, and so on (see Taylor et al., 2005 and Eme and Bennett, 2009 on the reading list). The temperature quotient is a good indicator of how a given fish species will respond to increasing nursery temperatures. Values below 2 are indicative of hyperthermic specialization, suggesting that these fishes will likely experience few adverse metabolic effects related to increased ambient temperatures. Fishes with Q_{10} values at or above 2 however, may be at risk as temperatures increase, in extreme cases perhaps to the point that they are extirpated from the reef. By better understanding the thermal physiology of nursery fishes it becomes possible to more accurately predict future changes in reef fish diversity and density, and perhaps implement more effective management strategies to protect reef and nursery areas.

Students participating in this research project will need the following:

1. sturdy pair of dive booties
2. wetsuit
3. waterproof field notebook and pencils
4. polarized sunglasses

All other necessary equipment and training will be provided by the field supervisor.

Reading List

Beitinger, T.L., Bennett, W.A., McCauley, R.W., 2000. Temperature tolerances of North American freshwater fishes exposed to dynamic changes in temperature. *Environmental Biology of Fishes* 58, 237–275.

Cech, J. J., 1990. Respirometry. In 'Methods for Fish Biology'. (Eds C. B. Schreck and P. B. Moyle.) pp. 335–356. American Fisheries Society: Bethesda, MD.

Eme J. and Bennett W. A., 2009. Acute temperature quotient responses of fishes reflect their divergent thermal habitats in the Banda Sea, Sulawesi, Indonesia. *Australian Journal of Zoology*. 57, 357–362.

Taylor, J., Cook, M., Kirkpatrick, A., Galleher, S., Eme, J., and Bennett, W.A., 2005. Thermal tactics of air-breathing and non air-breathing gobiids inhabiting mangrove tidepools on Pulau Hoga, Indonesia. *Copeia* 2005, 885–892.