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No Evidence of Fine Scale Thermal Adaption in Green Turtles

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Studying temperature dependent sex determination in regard to a heating climate

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Temperature dependent sex determination is the process in which the temperature of an embryo's environment influences its sexual development. This evolutionary approach is found in a variety of vertebrates— predominantly reptiles— and has been suggested as an adaptive mechanism for changing climatic conditions. With warming temperatures due to climate change, temperature dependent sex determination could shift population dynamics until sustainable reproduction is not viable. New research is looking into the possibility of localized adaptations in organisms with temperature dependent sex determination, like sea turtles, as a response to climate change.

Researchers hypothesize that sea turtles are adapted to the conditions of their nesting beaches and have subsequently developed locally adapted temperature tolerances. Green sea turtles have a pivotal temperature, or temperature range where the ratio of male to female offspring changes, of approximately 28.5-30 °C. On average, nests at temperatures over 30 °C will produce more female hatchlings and nests at temperatures under 28.5 °C produce more male hatchlings. Nests with temperatures ranging between these two pivotal temperatures produce a balanced proportion of offspring. Current research suggests that turtles of the same species that nest on beaches with widely varying climates will have notably different pivotal temperatures. If the pivotal temperatures are different, then their offspring will have different gender ratios at the same temperature.

In order to explore this hypothesis, Tilley et al. studied two groups of nesting green sea turtles to determine if their thermal tolerance and pivotal temperatures varied under laboratory conditions. Over the course of two nesting seasons, 880 hatchlings from two thermally different beaches were collected and their sex was determined using histological criteria. Simultaneously, 528 unhatched eggs were collected from these two sites and incubated in a laboratory setting at three predetermined temperatures between 29-31°C. Once hatched, their sex was determined and recorded for later comparison.

The researchers used generalized linear mixed models to evaluate the sex ratio data, which allowed them to determine the significance of nest temperature and/or beach of origin on hatchling sexes. Contrary to their hypothesis, there was no significant difference in the pivotal temperature of sea turtle embryos between the thermally different beaches. This indicates that sea turtles are unable to adapt their temperature dependent sex determination to changing climates, and that nests will have higher ratios of female hatchlings as the climate warms.

Though the data did not support the original hypothesis, it shows that higher temperatures resulted in reduced hatch, regardless of egg origin. These findings have greater implications for the future reproduction success and population health of species that utilize temperature dependent sex determination. Increasing temperatures may not only shift the sex ratios of sea turtle populations, but also reduce overall hatchling success rates for species that already face numerous challenges.

Citation: Tilley, D., Ball, S., Ellick, J., Godley, B. J., Weber, N., Weber, S. B., & Broderick, A. C. (2019). No evidence of fine scale thermal adaptation in green turtles. Journal of Experimental Marine Biology and Ecology, 514, 110-117.