Experiments simulate possible impact of climate change on crabs

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Developing eggs of *L. thayeri* (left) and ovigerous female (right). Credit: Juan Pardo

Albeit very small, with a carapace width of only 3 cm, the Atlantic mangrove fiddler crab Leptuca thayeri can be a great help to scientists seeking to understand more about the effects of global climate change. In a study published in the journal *Estuarine, Coastal and Shelf Science*, Brazilian researchers supported by São Paulo Research Foundation (FAPESP) show how the ocean warming and acidification forecast by the end of the century could affect the lifecycle of these crustaceans.

Embryos of L. thayeri were exposed to a temperature rise of 4 °C and a

pH reduction of 0.7 against the average for their habitat, growing faster as a result. However, a larger number of individuals died before reaching the final embryonic stage compared with those allowed to remain in conditions typical for the environment normally inhabited by the species.

"This crab is very important ecologically. Its burrows contribute to the organic matter cycle, and its larvae serve as food for many other species. We can therefore assume that the alterations to its embryos caused by climate change will have a cascade effect. Animals like these with a longer embryonic stage are particularly endangered," said Tânia Márcia Costa, principal investigator for the project. Costa is a professor at the Bioscience Institute of São Paulo State University's Coast Campus (IB-CLP-UNESP) in São Vicente.

The temperature rise simulated in the experiments was based on the forecast for the end of the century made by the Intergovernmental Panel on Climate Change (IPCC). The parameter for the change in pH came from a study published in *Nature* in 2003 by researchers from United States.

L. thayeri is tiny and extremely abundant, with a typical mangrove serving as home for some 100 individuals per square meter. The species is often called an "ecosystem engineer" because to build chimney burrows in which to shelter, reproduce and incubate eggs, it moves organic matter from deep mud to the surface, where smaller organisms feed on the nutrients, as shown by the São Vicente group in an article published in 2017.

"More research is needed to understand the combined effects of climate stressors on organisms, especially in the initial stages of their lives. These are usually the most sensitive to warming, falling pH levels and other stresses associated with climate change. The few studies that have been done used very generic values for temperature and acidity, whereas

mangroves are highly dynamic and have their own microclimate," said Juan Carlos Farias Pardo, currently a Ph.D. candidate at Norway's University of Agder (UiA) and the Norwegian Institute for Water Research (NIVA).The study was conducted as part of his master's research at IB-CLP-UNESP with a scholarship from FAPESP.

In the laboratory

To reproduce the crab's habitat as accurately as possible, the researchers spent months going into the field to measure temperature, salinity and acidity in the burrows where ovigerous (egg-laying) females live. The data was used for control in the laboratory experiments.

Eggs were removed from females and placed in water with the same salinity as in the habitat. Embryos were exposed to different combinations of temperature (26 °C or 30 °C) and pH (6.9 or 6.2). Observations were conducted for ten days. Embryos of this species are expected to develop completely in this timeframe, with fully formed eyes and strong heartbeats.

In the experiments, embryos developed faster in warmer, more acid water than the control group but also died more than embryos kept in conditions equivalent to those of the habitat. Egg volume was smaller in warmer water (30 °C) with normal acidity, and larger in similarly warm but more acid water.

"We concluded that faster development isn't necessarily better. They grew faster in response to the stressors but died more frequently. Larger egg volume in more acid water may have been a consequence of less efficient gas exchange, making them swell up," Pardo said, adding that the group is preparing more experiments to investigate later stages of development in the same species.

"Even if 100% of the embryos survive these climate changes, this is only the first stage of development. Mortality is naturally high before they reach adulthood because of their many predators. In any case, we don't know how this level of stress on the embryo will affect later stages," Costa said.

Previous research by the group showed how rising temperatures force physiological adaptations in two other species of fiddler crab, and influence territorial expansion in a third.

In a new project supported by FAPESP, Costa will investigate how stresses deriving from climate change affect interactions between herbivores and plants, predators and prey.

More information: Juan C.F. Pardo et al, Multiple-stressor effects of warming and acidification on the embryonic development of an estuarine fiddler crab, *Estuarine, Coastal and Shelf Science* (2021). DOI: 10.1016/j.ecss.2021.107296

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