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WHY THIS RESEARCH MATTERS

Delta smelt population has declined dramatically to the point to be declared as a critically endangered fish. One hypothesis for the recent decline is that pollutants can disrupt the fish's sensory ecology and make them more susceptible to predation. Since fish rely on their olfactory system to assess predation risk and avoid predators this could have serious consequences on the survival of the species. The study of the olfactory biology of delta smelts and the effects of a common water pollutant (copper) on its sensory ability will help to further our understanding on the biology and conservation of this endangered fish.

*Effects of copper exposure on the olfactory response of delta smelt (*Hypomesus transpacificus*): Investigating linkages between morphological and behavioral anti-predator response*



Behavioral testing of the antipredatory alarm response of Delta Smelts at The Center of Aquatic Biology and aquaculture (CABA) and the Aquatic health program at UC Davis. (Credit: Monica Rincón, 2019)

PROJECT

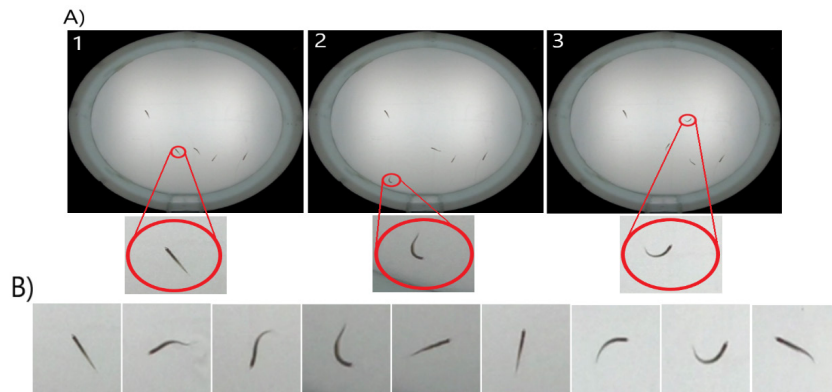
This study aimed to address the question of how water-borne copper can affect the ability of delta smelt to detect predator related odorants and conduct essential behaviors. To do this, the project included a thorough morphological and cytological study of the delta smelt olfactory organ, which had previously not been well-studied. The researchers also characterized the olfactory mediated antipredatory response to alarm cues and assessed the effects of copper exposure on the anti-predator behavior and morphology of the olfactory rosette of delta smelt.

RESULTS

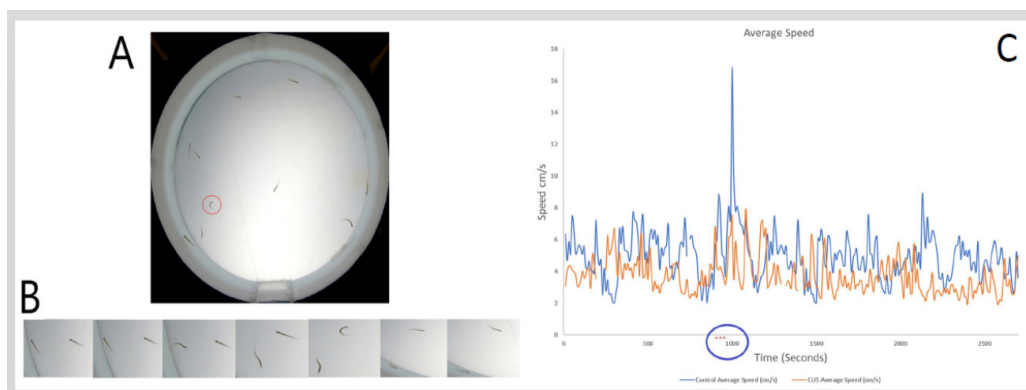
Delta smelts have a highly sophisticated and sensitive olfactory system. They can assess the likelihood of being predated based on the concentrations of alarm cues in the water and behave accordingly to avoid predation risk. In other words, they can smell "danger." Delta smelts are highly susceptible to water-borne copper and showed morphological alterations in the olfactory organ and impairment of their olfactory-mediated anti-predatory behavior upon exposure to low concentrations of copper which can be found in the San Francisco Estuary. To enable these analyses, the study included the basic morphological and physiological research necessary to assess the impacts of copper on the delta smelt's olfactory response. The project produced a morphologic characterization of the delta smelt olfactory organ, and a standardized odorant-response curve which will allow researchers to use behavioral studies to assess olfactory-mediated anti predatory response.

MANAGEMENT APPLICATIONS

This project improves our understanding of basic anatomy and behavior of delta smelt, as well as specific findings on the impact of copper pollution on this endangered species. The anatomical and behavioral findings lay an important groundwork for future applied research on pollutants and other stressors, while the research on copper exposure provides information that can be used by managers of the state and federal agency and the Interagency Ecological Program to better prioritize the mechanistic and ecological effects of pollutants in the San Francisco Estuary. This project was shared in the state of the San Francisco estuary conference with managers from different institutions.



Left: Arena for behavioral trials showing the recording frame in which the alarm behavior was observed. A) The red circle indicates in 1 the moment before the detection of the alarm cue, 2 and 3 a Delta Smelt showing the normal characteristic “C” or “S” shape with sudden bending of the body that propels the fish away to avoid or escape predation. B) From left to right individual recording frames represent the sequence of behaviors adopted by Delta smelts when they detect alarm cues in the water. There is a sudden change in the swimming direction, characterized by bending of the body followed by an increase in the swimming speed, and sometimes by a period of immobility or slow swimming. The diameter of the arena is 1 meter. (Credit: Pedro Alejandro Triana Garcia, 2019)



Above: The olfactory mediated alarm response is inhibited by copper exposure in Delta smelt. A) Arena for behavioral trials showing the recording frame in which the alarm behavior was observed. The red circle indicates a Delta Smelt showing the normal characteristic “C” shape or sudden bending of the body movement to avoid or escape predation. B) From left to right individual recording frames represent the sequence of behaviors adopted by Delta smelts when they detect alarm cues in the water. There is a sudden change in the swimming direction, characterized by bending of the body followed by an increase in the swimming speed, and sometimes by a period of immobility or slow swimming. C) Speed dynamics during the behavioral trial. Note the peak and increase in speed in the fish not exposed to copper compared to the fish exposed to copper. The Blue circle and the arrowheads represent the time intervals in which the alarm cue was added to the arenas. (Credit: Pedro Alejandro Triana Garcia, 2019)

SELECT PUBLICATIONS AND PRESENTATIONS

Triana Garcia, PA. 2019. Effects of copper exposure on the olfactory organ of delta smelts: From tissues to behavior. State of the San Francisco Estuary Conference. Oakland, CA. October 21, 2019.

Triana Garcia PA, Teh S. 2019. The histopathological effects of copper exposure on the olfactory organ of delta smelts: Linking pathology with behavior in an endangered fish. ACVP Meeting, Brookings SD. November 10, 2019.

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