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Evolution of the developmental plasticity and a coupling between left mechanosensory neuromasts and an adaptive foraging behavior

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Abstract

Many animal species exhibit laterality in sensation and behavioral responses, namely, the preference for using either the left or right side of the sensory system. For example, some fish use their left eye when observing social stimuli, whereas they use their right eye to observe novel objects. However, it is largely unknown whether such laterality in sensory-behavior coupling evolves during rapid adaptation processes. Here, in the Mexican tetra, *Astyanax mexicanus*, we investigate the laterality in the relationship between an evolved adaptive behavior, vibration attraction behavior (VAB), and its main sensors, mechanosensory neuromasts. *A. mexicanus* has a surface-dwelling form and cave-dwelling forms (cavefish), whereby a surface fish ancestor colonized the new environment of a cave, eventually evolving cave-type morphologies such as increased numbers of neuromasts at the cranium. These neuromasts are known to regulate VAB, and it is known that, in teleosts, the budding (increasing) process of neuromasts is accompanied with dermal bone formation. This bone formation is largely regulated by endothelin signaling. To assess the evolutionary relationship between bone formation, neuromast budding, and VAB, we treated 1-3 month old juvenile fish with endothelin receptor antagonists. This treatment significantly increased cranial neuromasts in both surface and cavefish, and the effect was significantly more pronounced in cavefish. Antagonist treatment also increased the size of dermal bones in cavefish, but neuromast enhancement was observed earlier than dermal bone formation, suggesting that endothelin signaling may independently regulate neuromast development and bone formation. In addition, although we did not detect a major change in VAB level under this antagonist treatment, cavefish did show a positive correlation of VAB with the number of neuromasts on their left side but not their right. This laterality in correlation was observed when VAB emerged during cavefish development, but it was not seen in surface fish under any conditions tested, suggesting this laterality emerged through an evolutionary process. Above all, cavefish showed higher developmental plasticity in neuromast number and bone formation, and they showed an asymmetric correlation between the number of left-right neuromasts and VAB.

Keywords

Endothelin, ET, neuromast, lateral line, adaptation, laterality, flow dynamics, foraging, prey location