

Vibrational Cues Alter Developmental Timing

The phenotypic changes induced by environmental cues are not confined to anatomical structures. They can also include the timing of developmental processes. As mentioned in the text, embryos of the Costa Rican red-eyed tree frog (*Agalychnis callidryas*) use vibrations transmitted through their egg masses to escape egg-eating snakes. These egg masses are laid on leaves that overhang ponds. Usually, the embryos develop into tadpoles within 7 days, and these tadpoles wiggle out of the egg mass and fall into the pond water. However, when snakes feed on the eggs, the vibrations they produce cue the remaining embryos inside the egg mass to begin the twitching movements that initiate their hatching (within seconds!) and dropping into the pond. The embryos are competent to begin these hatching movements at day 5 (Figure 1). Interestingly, the embryos have evolved to respond this way only to vibrations given at a certain frequency and interval (Warkentin et al. 2005, 2006; Caldwell et al. 2009). Up to 80% of the remaining embryos can escape snake predation in this way, and research has shown that these vibrations alone (and not smell or sight) cue these hatching movements in the embryos. There is a trade-off here, too. Although these embryos have escaped their snake predators, they are now at greater risk from waterborne predators than are fully developed embryos because the musculature of the early hatchers is underdeveloped.

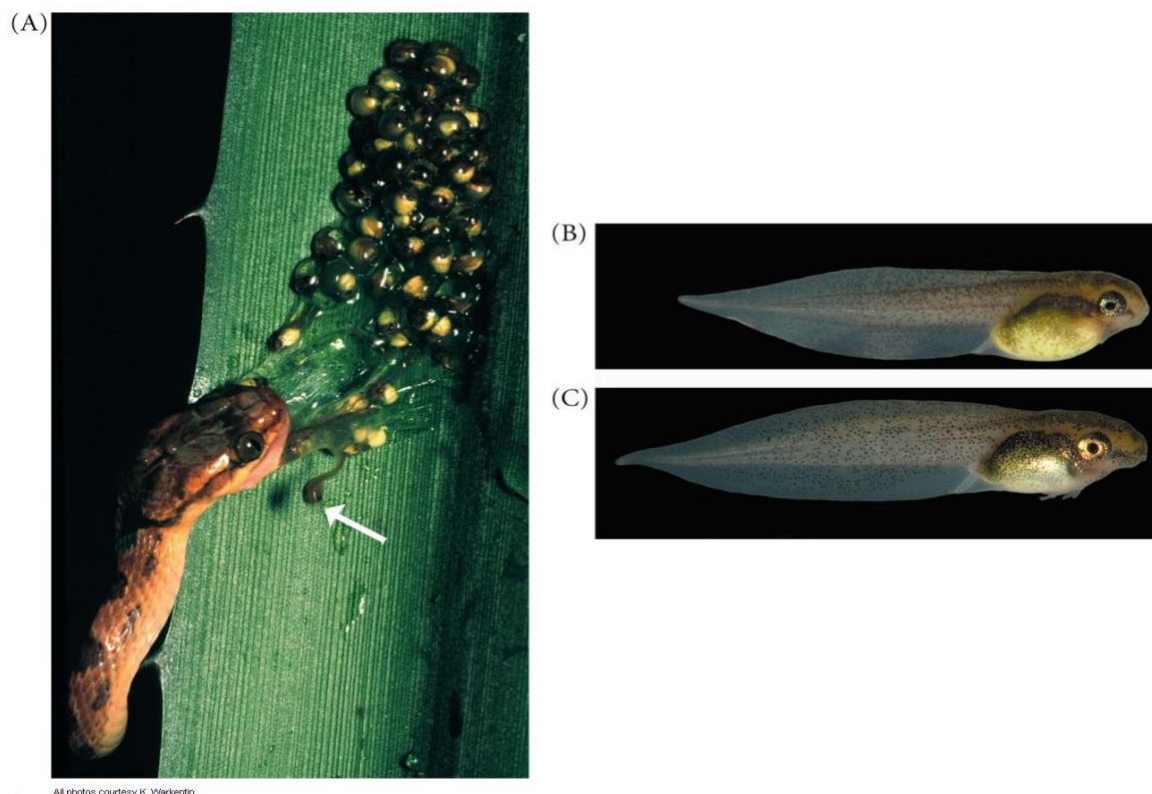


Figure 1 Predator-induced polyphenism in the red-eyed tree frog (*Agalychnis callidryas*). (A) When a snake eats a clutch of

Agalychnis eggs, most of the remaining embryos inside the egg mass respond to the vibrations by hatching prematurely (arrow) and falling into the water. (B) Immature tadpole, induced to hatch at day 5. (C) A normal tadpole hatches at day 7 and has better-developed musculature. (Courtesy of K. Warkentin.)

There are numerous other instances of vibrations being used as developmental signals. Most of the cues known for larval settlement and metamorphosis involve chemicals emanating from the substrate; these chemicals can signal the presence of a food source or potentially induce larval metamorphosis. However, in at least one case, vibrational cues appear to direct marine larvae to coral reefs. Coral reefs are the largest biological structures on Earth, and they grow by recruiting planktonic coral (cnidarian) larvae. While chemical cues work within a small distance of the reef, it is the “noise of the reef”—the snapping of shrimp claws and the noises made by thousands of reef fish—that attract coral larvae from long distances. Vermeij and colleagues (2010) made recordings of Caribbean reefs and found that the larvae swam to the source of the sound, even in the laboratory. These findings mean that coral reefs face danger from noise pollution as well as from thermal and chemical pollution. Steve Simpson (2010), who headed the study, has warned, “Anthropogenic noise has increased dramatically in recent years, with small boats, shipping, drilling, pile driving and seismic testing now sometimes drowning out the natural sounds of fish and snapping shrimps.”

It is even possible that sound vibrations can be used to alter development. When embryonic zebra finches, still in their eggs, hear their parents' heat-related call, they grow in a manner to best deal with hot temperatures (Mariette et al 2018). In some birds and crocodilians, vocalizations of the embryos inside their eggs can lead to synchronous hatching. In turtles (which don't vocalize) the vibrations caused by one turtle hatching may lead to the entire clutch leaving their eggs simultaneously (Doody et al 2012.)

One new area of research concerns whether microwave vibrations from cell phone towers or devices can harm developing embryos (Ye et al. 2016; Zhou et al. 2016).

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