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Cannibalism and scavenging by *Hyliola regilla* Baird and Girard, 1852 tadpoles in California

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Tadpoles are typically characterised as microphagous, as they usually feed on algae, bacteria, protozoans, and diverse small particles suspended in the water column (Stebbins and Cohen, 1995). Their feeding mechanism generally consists of drawing particles into the mouth via pumping action and internal filtration or by scraping food from surfaces (Duellman and Trueb, 1986). Some spadefoot toad tadpoles, genus *Scaphiopus*, are known for being predatory, either feeding on injured prey or as cannibals (Bragg, 1965; Stebbins and McGinnis, 2012). Relatively recently, tadpole cannibalism has been reported in a variety of additional frog species from disparate areas of the globe, including Brazil, India, Romania, and several regions of the United States (Jordan et al., 2004; Silva et al., 2005; Kovács and Sas, 2009; Alvarez, 2013; Mahapatra et al., 2017). Several researchers have reported cannibalism when larval conspecifics are injured or dead, which suggests that some species are predators and scavengers of conspecifics (Jordan et al., 2004; Alvarez, 2013). Kirchmeyer et al. (2015) stated that they had "the first report of opportunistic scavenging by a tadpole" when they observed that the Striped Toad (*Rhinella crucifer*) scavenged a dead Blacksmith Treefrog (*Hypsiboas faber*) in Brazil. Herein, we report on the opportunistic scavenging and cannibalism on a dead Pacific Treefrog (*Hyliola regilla*) by a conspecific in California, USA. We believe that this is the first report of scavenging, carnivory, and cannibalism by this species.

In August 2017, we used dip nets and plastic buckets to collect approximately 15–20 *Hyliola regilla* tadpoles from a small rain-filled pool in coniferous forest habitat near Michigan Bluff, California, USA (39.0379°N, 120.7345°W, elevation 1070 m). Tadpoles were transferred to a small aquarium to be identified visually. A small tadpole (approximately Gosner Stage 25) lay at the bottom of the clear aquarium and appeared alive but was injured from unknown causes. Within approximately 2–3 s, one and occasionally two conspecifics began feeding on the injured larva (Fig. 1). This behaviour was observed for 2–3 min, during which one or more of the conspecific larvae continued to actively feed on the then-dead conspecific. We acknowledge that the larva in this situation was not in natural habitat and that our observations of this behaviour were possibly conditioned by displacement (in a non-natural situation). After thorough identification of all animals collected, we released the larvae at the site of capture.

Tadpoles native to California are known to feed on conspecifics and sympatric species. Specifically, *Anaxyrus boreas* was reported to prey upon live Cascades Frog (*Rana cascadae*) and *H. regilla* in Oregon, USA (Jordan et al., 2004). These authors also reported observations of cannibalism by *A. boreas* at the same location. Alvarez (2013) observed a California red-legged frog (*Rana draytonii)* tadpole cannibalizing a conspecific. Alvarez and Wilcox (in press) recently observed *A. boreas* scavenging the carcass of an American bullfrog (*Lithobates catesbeianus*). In addition, the western spadefoot (*Scaphiopus hammondi)*, a sympatric species of *H. regilla*, has been reported to be a facultative carnivore (Stebbins and McGinnis, 2012). Jordan et al. (2004) suggested that the behaviour they witnessed would "confer growth or survival benefits" to larvae that engaged in carnivory. Additionally, Kupferberg (1997) stated that "tadpoles can select the foods they grow best on." Further, Crump (1990) suggested that growth enhancements were possible in those individual tadpoles that utilized animal protein in their diet.

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It appears *H. regilla* tadpoles may opportunistically select food items that include injured and dead conspecifics. Although the driver for this behaviour is unclear, it appears that several native California tadpoles utilize scavenging and cannibalism to supplement their diet. However, we see a potential cost to scavenging/cannibalism, which may easily transmit disease from an infected tadpole to scavenging or cannibalizing conspecifics. González-Mollinedo and Mármol-Kattán (2019) suggested that scavenging may increase the risk of exposure and transmission of chytridiomycosis to the scavenger tadpole. This could be a contributing factor in the spread of pathogens when tadpoles of *H. regilla*, or other tadpole scavengers, prey on or cannibalize tadpoles that may be infected with chytridiomycosis, ranavirus, or other pathogens. Although host-pathogen transmission was modelled by Rudolf and Antonovics (2007) suggesting that this form of transmission is rare, Pfenning et al. (1991) noted that cannibalistic tiger salamander larvae were more likely to become

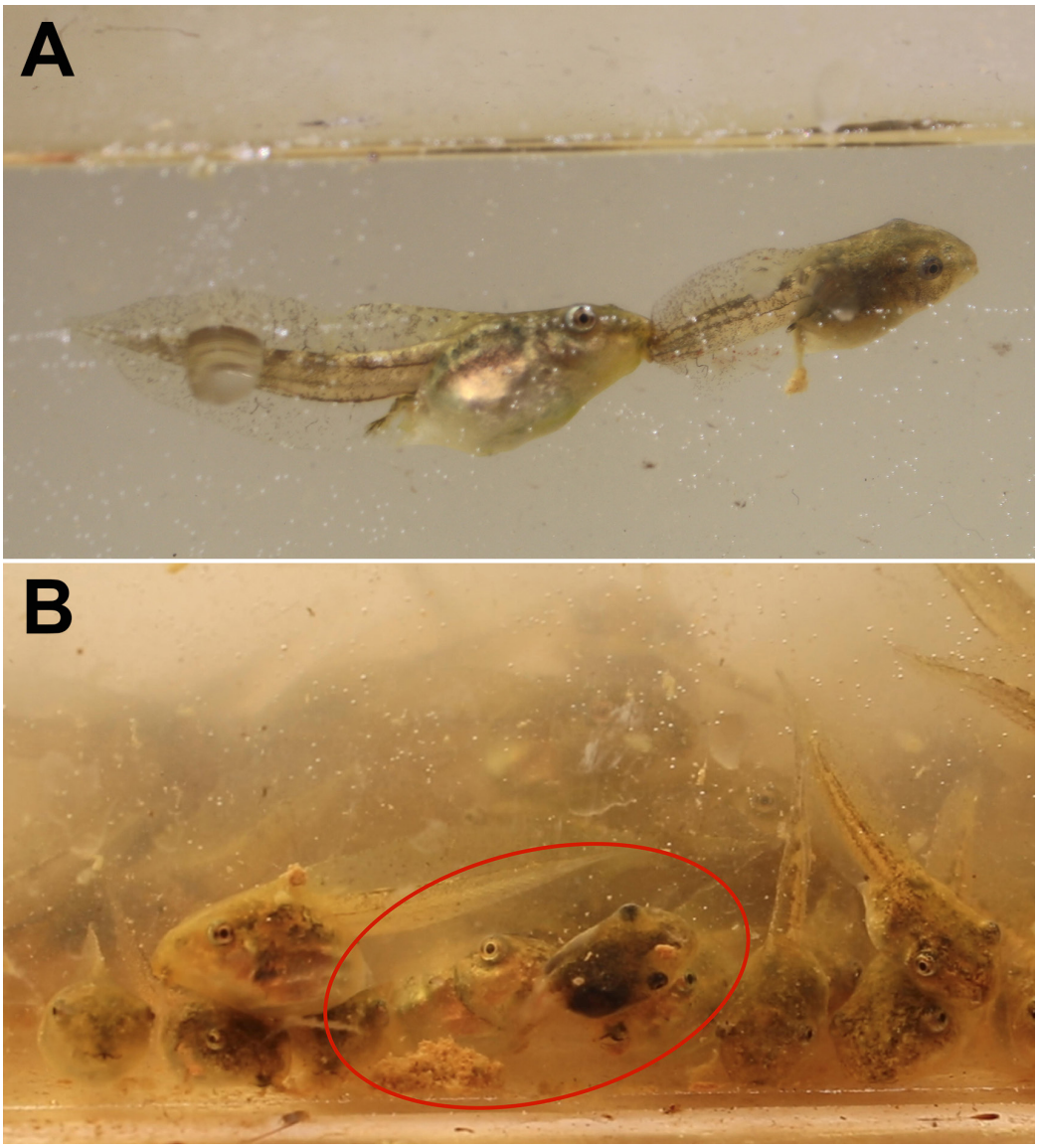

Figure 1. (A) *Hyliola regilla* cannibalizing a conspecific in Michigan Bluff, California, USA. (B) *Hyliola regilla* scavenging on a dead conspecific (red oval).

infected by previously infected conspecifics and die thereafter. One of the pathways in which amphibians spread chytridiomycosis appears to be skin to skin contact, which is obligatory for larvae when scavenging and cannibalizing (Rowley and Alford, 2007). We therefore suggest that the mechanism and efficacy of disease transmission through inter- and intra-specific scavenging, predating, and cannibalizing in anurans should be more carefully investigated.

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