9.1: The Evolution of Frog Life History Strategies

Frog reproduction is one of the most bizarrely interesting topics in all of biology. Across the nearly 6,000 species of living frogs, one can observe a bewildering variety of reproductive strategies and modes (Zamudio et al., 2016). As children, we learn of the “classic” frog life history strategy: the female lays jellied eggs in water, which hatch into tadpoles, then later metamorphose into their adult form [e.g. Rey (2007); Figure 9.1A]. But this is really just the tip of the frog reproduction iceberg. Many species have direct development, where the tadpole stage is skipped and tiny froglets hatch from eggs. There are foam-nesting frogs, which hang their eggs from leaves in foamy sacs over streams; when the eggs hatch, they drop into the water [e.g. Fukuyama (1991); Figure 9.1B]. Male midwife toads carry fertilized eggs on their backs until they are ready to hatch, at which point they wade into water and their tadpoles wriggle free [Marquez and Verrell (1991); Figure 9.1C]. Perhaps most bizarre of all are the gastric-brooding frogs, now thought to be extinct. In this species, female frogs swallow their fertilized eggs, which hatch and undergo early development in their mother’s stomach (Tyler and Carter 1981). The young were then regurgitated to start their independent lives.
The great diversity of frog reproductive modes brings up several key questions that can potentially be addressed via comparative methods. How rapidly do these different types of reproductive modes evolve? Do they evolve more than once on the tree? Were “ancient” frogs more flexible in their reproductive mode than more recent species? Do some clades of frog show more flexibility in reproductive mode than others?

Many of the key questions stated above do not fall neatly into the Mk or extended-Mk framework presented in the previous characters. In this chapter, I will review approaches that elaborate on this framework and allow scientists to address a broader range of questions about the evolution of discrete traits.

To explore these questions, I will refer to a dataset of frog reproductive modes from Gomez-Mestre et al. (2012), specifically data classifying species as those that lay eggs in water, lay eggs on land without direct development (terrestrial), and species with direct development (Figure 9.2).
Figure 9.2. Ancestral state reconstruction of frog reproductive modes. Data from Gomez-Mestre et al. (2012). Image by the author, can be reused under a [CC-BY-4.0](https://creativecommons.org/licenses/by/4.0) license.