

Unique Sulawesi frog gives birth to tadpoles

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L. larvaepartus (male, left, and female) from the island of Sulawesi in Indonesia. It is the only frog known that gives direct birth to tadpoles. Credit: Jim McGuire

University of California, Berkeley, herpetologist Jim McGuire was slogging through the rain forests of Indonesia's Sulawesi Island one night this past summer when he grabbed what he thought was a male frog and found himself juggling not only a frog but also dozens of slippery, newborn tadpoles.

He had found what he was looking for: direct proof that the female of a

[new species](#) of frog does what no other frog does. It gives birth to live tadpoles instead of laying [eggs](#).

A member of the Asian group of fanged frogs, the new species was discovered a few decades ago by Indonesian researcher Djoko Iskandar, McGuire's colleague, and was thought to give direct birth to tadpoles, though the frog's mating and an actual birth had never been observed before.

"Almost all frogs in the world - more than 6,000 species - have external fertilization, where the male grips the female in amplexus and releases sperm as the eggs are released by the female," McGuire said. "But there are lots of weird modifications to this standard mode of mating. This new frog is one of only 10 or 12 species that has evolved internal fertilization, and of those, it is the only one that gives birth to tadpoles as opposed to froglets or laying fertilized eggs."

Iskander, McGuire and Ben Evans of McMaster University in Ontario, Canada, named the species *Limnonectes larvaepartus* and fully describe it in this week's issue of the journal *PLOS ONE*.

External vs. internal fertilization

Frogs have evolved an amazing variety of reproductive methods, says McGuire, an associate professor of integrative biology and curator of herpetology at UC Berkeley's Museum of Vertebrate Zoology. Most male frogs fertilize eggs after the female lays them. About a dozen species, including California's tailed frogs, have evolved ways to fertilize eggs inside the female's body. However, the mechanisms of internal fertilization are poorly understood in all but California's two species of tailed frogs, the latter of which have evolved a penis-like organ (the "tail") that facilitates sperm transfer. Whereas the tailed frogs deposit their fertilized eggs under rocks in streams, the other frogs previously

known to have internal fertilization give birth to froglets - miniature replicas of the adults.



A male of the newly described species of fanged frog, *Limnonectes larvaepartus*, sits next to a pool containing tadpoles (yellow circle), and may be guarding them, a typical male behavior in some frog species. Credit: Jim McGuire, UC Berkeley

Although internal fertilization is extremely rare among frogs, there are many other bizarre reproductive variations. Some frogs carry eggs in pouches on their back, brood tadpoles in their vocal sac or mouth, or transport tadpoles in pits on their back. The two known species of female gastric brooding frogs, both of which are now extinct, were famous for swallowing their fertilized eggs, brooding them in their stomach, and giving birth out of their mouths to froglets. Two genera in Africa engage in internal fertilization and give birth to froglets without going through a free-living tadpole stage.

Fanged frogs - so-called because of two fang-like projections from the lower jaw that are used in fighting - may have evolved into as many as 25 species on Sulawesi, though *L. larvaepartus* is only the fourth to be formally described. They range in size from 2-3 grams - the weight of a couple of paper clips - to 900 grams, or two pounds. *L. larvaepartus* is in the 5-6 gram range, McGuire said.

The new species seems to prefer to give birth to tadpoles in small pools or seeps located away from streams, possibly to avoid the heftier fanged frogs hanging out around the stream. There is some evidence the males may also guard the [tadpoles](#).

Sulawesi a biodiversity hotspot

McGuire first encountered the newly described frog in 1998, the year he began studying the amazing diversity of reptiles and amphibians on Sulawesi, an Indonesian island east of Borneo and south of the Philippines. The island is a geographical hodgepodge, having formed from the merger of several islands about 8-10 million years ago.

"Sulawesi is an incredible place from the standpoint of species diversity endemic to the island as well as in situ diversification," he said, noting that most places on the island are home to at least five species of fanged frogs living side by side.



Two tadpoles, each about 10 millimeters long, shortly after birth. The newly described species *Limnonectes larvaepartus* is the only species of frog known to birth live tadpoles. Credit: Jim McGuire, UC Berkeley

Although many vertebrate species have diversified on the island after arriving by overwater "sweepstakes" dispersal, most - such as the flying lizards and black-crested macaque monkeys - have speciated in such a way that their geographic ranges are non-overlapping, with their ranges meeting like pieces in a jigsaw puzzle. The fanged frogs are special, McGuire says, because they appear to represent a virtually unexplored adaptive radiation with many species occurring at the same sites but adapted to occupy distinct ecological niches.

"We are really interested in understanding how much of Sulawesi's in situ diversification was initiated on the paleo-islands, or if much or even all of the diversification was postmerger," he said.

Much of McGuire's work to date has been with the simpler non-adaptive radiations of the flying lizards and macaques. Fanged frogs present an even more exciting challenge, he says, because their diversification likely was influenced not only by the dynamic tectonics of Sulawesi, but also by adaptive radiation via ecological diversification.

McGuire and his colleagues and students have collected reptiles and amphibians throughout the island - flying lizards are his particular love - and taken genetic samples to reconstruct the evolution of [species](#) over time and perhaps shed light on how and when the islands came together.

He also is working with Iskandar to prepare a monograph on the identification, distribution and biology of the fanged [frogs](#) on the island.

Provided by University of California - Berkeley

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