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Frogs & Toads

About the cover

Ventral view of female *Centrolenella colymbiphyllum* showing transparent belly and heart, eggs, stomach, etc. Fig. 1.

Glass Frog Romance A

by **Roy W. McDiarmid**

photos by the author

To most people, the wet low-land forests of the Tropics connote an image of an impenetrable tangle of vines and other plants commonly described by Hollywood as a "jungle." A jungle to many brings to the mind deadly poisonous snakes, myriads of biting and stinging insects, blood drinking bats, and similar vermin too unpleasant to discuss, much less see. Yet these *tierras incognitas* have attracted many distinguished naturalists in the past, including such notable people as Alexander von Humboldt, Charles Darwin, Alfred Russel Wallace and Henry Walter Bates to name a few, and they continue to attract numerous botanists and zoologists today. Whether it is the mating displays of brightly colored birds, the raiding columns of army ants on the march, or the intricate pollination systems of exotic orchids, most biologists are drawn to the Tropics by the lure of the unknown and their desire to study in nature, some of the most amazing and interesting organisms known.

Among the thousands of species of animals living in the tropical rainforests of the world, perhaps none are as interesting and diverse as the frogs. There are some frogs that live high in the tree tops and never come to ground, others that hop around in the leaf litter on the forest floor among the buttresses of giant trees, never venturing more than a few inches above the ground. Some species may weigh several pounds, while others weigh less than an ounce. A few are as big as dinner plates, others smaller than a dime. Some tropical frogs are marked in contrasting colors of reds, greens, blacks and oranges; others are dull shades of brown or tan. Most put their eggs in the water where they hatch into tiny tadpoles. The tadpoles feed and grow in their aquatic environment, eventually changing into small froglets that grow into adults and repeat the cycle. There are many modifications of this better known reproductive pattern that are found in tropical frogs. Some species put their eggs on land where they develop and hatch into a small copy of the adults, completely bypassing the tadpole stage. Some species carry their eggs or tadpoles around on their backs, in pouches on their backs, in their mouths or, as was recently reported for an Australian frog, in their stomachs. It was some of these interesting aspects of frog biology that led

Fig. 3. Male *Centrolenella granulosa* sitting on leaf surface well above the stream.

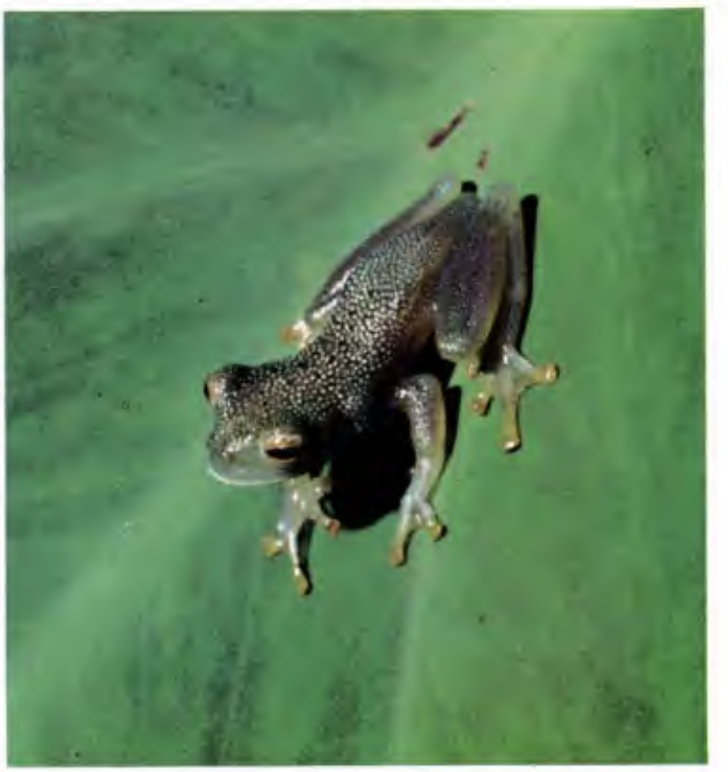

Fig. 4. Male *Centrolenella fleischmanni* sitting on lower surface of a leaf above stream.

Fig. 2. Lowland forest stream and the overhanging vegetation used as call sites by frogs of the genus *Centrolenella*.

long a Tropical Stream.

me into the lowland forests of Central America to learn more about the reproductive behavior and ecology of tropical species.

One of the more interesting groups restricted to the tropical forests of Central and South America are the glass frogs of the family Centrolenidae. These small emerald green frogs often have transparent bellies (Fig. 1) and green bones. They are nocturnal and restricted to the margins of small rivers and streams. During the rainy season as many as seven species of *Centrolenella* frogs may be heard calling along a stream flowing through the wet lowlands of Costa Rica (Fig. 2). Since all of the species are active at night, one must rely on a portable light to observe their behavior. I use a battery powered head lamp which not only provides adequate light but also frees my hands to take pictures, make measurements, record their calls on a portable tape recorder and accomplish many of the other routine things required by this kind of a study. It is always best to scout a stream by daylight to locate all the particularly slippery rocks, deep pools, impassable logs and other hazards. Sometimes this is impossible and more often than not it results in an unexpected cold dunking.

The frogs are located by walking up a stream and listening for the vocalizations of males. These calls vary between species from high pitched bell-like "tink tink tinks" and soft whistling "pseets" to relatively loud, fast "screp screp screps." Since the males call from leaves of plants along the stream from heights very near the water to over five meters above the stream, the localization of the calling males often is very difficult. In densely vegetated sections of some streams I have spent more than an hour on several occasions trying to locate a single, sporadically calling male. Males of some species call from the upper surface of leaves (Fig. 3) and others call from beneath leaves (Fig. 4). Males of species that call from the lower surface are located more easily if their call sites are head high or higher; if they are calling from a site close to the water, one must get down on one's hands and knees, often in the water, to see the males. The reverse is true for those species that call from leaf tops. Clambering up steep banks or climbing small trees is often the only way to locate these males calling above eye level; those closer to the water are located more easily. The best nights to hear and see centrolenid frogs are during the dark phase of the moon during a

Fig. 5. Male *Centrolenella colymbiphyllum* asleep beneath a leaf well back from the stream.

Fig. 6. A female *Centrolenella prosoblepon* moving to the stream near a calling male.

light rain. This combination of conditions stimulates the males into active calling, sometimes lasting through the night. All males cease singing as the first light of dawn filters through the overhead forest canopy and lights the stream below. In some species the males pull in their legs, close their eyes, and spend the daylight hours on the same leaf they use as a call site. Others move back and up into the vegetation to more concealed sites (Fig. 5). As the day fades, they become active again. Many return to the same leaf used the previous night and commence calling with the arrival of darkness.

The calls of each species are distinct. The calls inform males of the same species where individuals are located and thus function to keep males spaced along the stream. The calling males also announce their location to females for purposes of reproduction.

There is a minimum distance between calling sites within which males will not tolerate other calling males of their own species. On several occasions I have heard two males engage in calling bouts, apparently each trying to call louder and more often than his neighbor. These "shouting matches" may go on for two to three nights. Eventually one of the males abandons his calling site and moves to a new leaf at a greater distance from the other male where he resumes calling. The calls function to increase the dispersal of males along a stream and thus to reduce the amount of time males spend interacting with other males for a call site, and allow each to spend more time attracting females (Fig. 6). The females rarely are encountered except when they come to the stream to mate. Apparently they spend most of their time in the forest, perhaps high in the canopy, feeding and producing their eggs. It is not known whether the females choose a male because of his song or choose a call site as a good place to deposit their eggs. I suspect both are important, perhaps the site being most important.

When a male successfully attracts a female to his leaf, he begins to give a different series of encounter vocalizations. These encounter calls, distinct from the previously described calls, are given only when another frog, usually a female, hops onto the calling male's site. After a series of calls and posturing movements, the male mounts the female in amplexus (Figs. 7 and 8). The frogs remain in amplexus for up to several hours, until the female begins to

Fig. 7. An amplexing pair of *Centrolenella colymbiphyllum*, showing smaller size of male.

Fig. 8. An amplexing pair of *Centrolenella albomaculata.*

Fig. 9. Male *Centrolenella valerioi* keeping a watchful eye on his eggs during the day. Males often sit with their hand resting on the edge of their clutch.

deposit her eggs. As the eggs are extruded, the male fertilizes them. The number of eggs in a clutch varies among species from about a dozen to as many as seventy-five. The eggs are encased in varying amounts of clear jelly and stick (Fig. 9) or hang (Fig. 10) from the leaf surface. After fertilization, the pair breaks amplexus and the female leaves the stream and returns to the forest. In some species the males have no interest in the developing eggs and leave the nest site to begin calling from another leaf in an attempt to attract additional females. In other species the males stay with the eggs day and night or leave the site during the day but return each night. Males of the latter species may attract up to seven females to a specific leaf and be found guarding (Fig. 11) the active clutches in varying stages of development.

The eggs develop on the leaf and after about two weeks begin to hatch (Fig. 12), often during a rain. The small tadpoles drop into the water below and seek shelter among the dead leaves and debris that often accumulate in the slow backwaters of the stream. Here they feed and grow much the same as tadpoles of our local frogs. Most of the Centrolenid tadpoles known are elongate and fiery red. After a period of several months during which time the tadpoles grow, develop hind legs and then front legs, and green color, they begin to metamorphose and crawl out of the water. It is not unusual to find tiny green froglets still with long tails sitting on a leaf at night along a stream. Soon the tail is absorbed completely, and the small frog begins to feed and grow eventually to take its place among the adults and repeat the reproductive process.

While egg laying and subsequent early development of tadpoles out of the water avoid some of the dangers of an aquatic existence, like storms which turn the streams into raging torrents or predation of these susceptible stages by aquatic insects and fish, hazards still exist. Even though the eggs are surrounded by a viscous, hydrophilic jelly, they are subject to desiccation should an untimely dry period develop. Predation and parasitism of the eggs are major problems. During the day, wasps and other predaceous insects eat the eggs or developing tadpoles or use them to provision their nests. At night the predator pressure is even greater. Small arboreal snakes, large centipedes, spiders, long-horned grasshoppers, ants and many other kinds of insects feed on the eggs and de-

Fig. 10. Well developed tadpoles in egg mass of *Centrolenella granulosa*. The egg mass is attached to the upper surface of the leaf but hangs over the leaf tip forming a drip tip to insure that water constantly bathes the developing tadpoles.

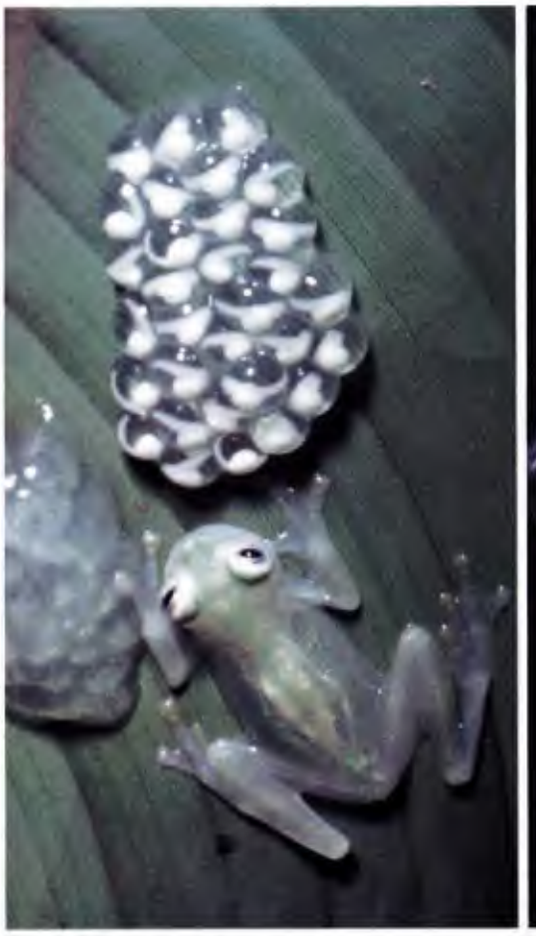

Fig. 11. Male *Centrolenella valerioi* guarding newest egg clutch. Jelly mass from old egg clutch remains for several days after the tadpoles have hatched.

Fig. 12. Egg mass of *Centrolenella pulverata* beginning to hatch.

veloping tadpoles. Occasionally the male and an entire clutch or clutches will disappear in a night, probably the result of a large predator such as a snake. Sometimes the attending male is able to protect his eggs from smaller predators, like ants, some spiders. This protective ability probably accounts for the differences in site tenacity and guarding behavior between the species of *Centrolenella*.

Walking up a tropical forest stream at night looking for glass frogs can be an exciting experience. In addition to learning about the love life of these beautiful frogs, you may have a chance to observe the foraging activity of some of the forest rodents or aquatic opossums that frequent the streamside habitats, or come across a column of army ants on a nightly emigration, or have the opportunity to watch the courtship behavior of long-horned grasshoppers. Most certainly you will see close at hand, several diurnal insects, frogs, lizards, snakes and birds asleep on leaves or branches along the stream.

The sights and sounds on a stream at night are very different from those during the day. Only the sound of the stream and raindrops on the leaves are the same. If your light does not burn out or the rain become too hard, you soon become completely engrossed in what is going on around you. More often than not, the unexpected will add to your experience. The unexpected and silent descent of a large spider on a thin silk thread from the canopy above, or the eerie glow of a bioluminescent fungus that appears when you turn out your light in response to a feeling of being watched — all add to the experience. Do not let the swish of bat wings next to your ear or the occasional encounter with a large poisonous snake discourage you. If the opportunity ever presents itself, walk up a tropical forest stream some night. Maybe you will see a glass frog!

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