

# CHAPTER 14-5

## ANURANS: CENTRAL AND SOUTH AMERICAN MOSSY HABITATS

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# CHAPTER 14-5

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Figure 1. Waterfalls at Quebrada Cataguana Honduras, home to many disappearing anurans. Photo by Josiah Townsend, with permission.

Central and South American mossy habitats provide good places for tiny frogs. Some of these frogs are primarily stream dwellers that go ashore to feed as adults (Figure 1). Others live on the forest floor of mossy forests, or in the Páramo. But the most elusive are the ones that live in trees where mosses provide cover and moisture, as well as protection from UV light.

### Strabomantidae

The giant genus *Eleutherodactylus* has been divided not only into a number of smaller genera, but also into several families. One of these is the **Strabomantidae**.

#### ***Bryophryne abramalagae* (Strabomantidae)**

*Bryophryne* species inhabit the cloud forests in Peru, on the eastern slopes of the Andes (Leandro 2011). *Bryophryne abramalagae* is primarily known from its type locality of Abra Málaga at 4000 m asl, in the puna, Provincia de La Convención, Región Cusco, Peru (Lehr & Catenazzi 2010). The males call from inside moss, maintaining their cover during this vulnerable time. The mosses also provide a reproductive site for members of the genus.

#### ***Bryophryne flammiventris* (Strabomantidae)**

This species occurs along the road between Vilcabamba and Pampaconas, Provincia de La Convención, Región Cusco, Peru, at 3800-3850 m asl (Lehr & Catenazzi 2010). There is some suggestion that *B. flammiventris* was adapted to the habitat by having coloration on the ventral side similar to that of the tree roots where the mosses were providing habitats. The male calls, made at 10:00-16:00 hours, were made from within the moss clumps and could be heard on the other side of the valley.

#### ***Bryophryne bustamantei* (Strabomantidae)**

*Bryophryne bustamantei* (Figure 2) inhabits the transitional zone from the cloud forest to the humid grassy puna in the Umasbamba Valley, Provincia de La Convención, Peru, at 3555-3950 m asl (Lehr & Catenazzi 2008; Frost 2011). The frogs are active in both the rainy and dry seasons, living under stones, in bushes and grass, and under mosses (Chaparro *et al.* 2007; Lehr & Catenazzi 2008). They lack a tympanum, separating them from several members of the genus (Lehr & Catenazzi 2008). Despite the lack of this special hearing organ, the males



call from bushes (Chaparro 2008), suggesting they are still able to hear. Like many other terrestrial anurans, their development is presumed to be direct, lacking a tadpole stage. The species is endangered due to encroachment of human activities in its narrow habitat range.



Figure 2. *Bryophryne bustamantei* on a leaf. Note the absence of a tympanum. Photo by Alessandro Catenazzi, with permission.

### ***Bryophryne zonalis* (Strabomantidae)**

*Bryophryne zonalis* (Figure 3) lives in the upper Marcapata valley, at elevations of 3129-3285 m asl along the road from Huallahualla to Quincemil, Quispicanchis, Peru (Frost 2011). This frog lays her eggs in moist habitats such as under mosses (Leandro 2011). The embryos do not become tadpoles, but rather become minute terrestrial froglets. The female remains nearby the eggs to tend them, protecting them from predation and desiccation. The 18-25 eggs are only 4-5 mm in diameter, with the hatchlings measuring about 5 mm snout to vent.



Figure 3. *Bryophryne zonalis* on a leaf. Photo by Alessandro Catenazzi, with permission.

### ***Bryophryne gymnotis* (Strabomantidae)**

*Bryophryne gymnotis* (Figure 4) is known only from the montane cloud forest in its type locality, San Luis, at 3272-3354 m asl, Provincia de La Convención, Región Cusco, Peru (IUCN 2013). Its habitat is mossy and it calls from mosses, like other members of its genus (Lehr &

Catenazzi 2010). Leandro (2011) reported that it is the only member of the genus with a tympanum. And like *B. zonalis*, the female tends the eggs, which hatch into froglets, often among mosses (Leandro 2011).



Figure 4. *Bryophryne gymnotis*. Photo by Alessandro Catenazzi, with permission.

### ***Bryophryne cophites* (formerly *Phrynopus cophites*) (Cuzco Andes Frog, Strabomantidae)**

In the species *Bryophryne cophites*, the name *cophites* means "deaf" and refers to the absence of the middle and external ear (tympanum) in this species (Figure 5), separating it from several other members of the genus.



Figure 5. *Bryophryne cophites* on bark, showing the absence of a tympanum. Photo by Tiffany Kosch, with permission.

The species is endemic to its type locality in the Páramo and elfin forest habitats on both north and south slopes of the Abra Acanacu on the northwestern end of the Cordillera Carabaya, Peru, at 3400-3450 m asl (Frost 2011). Mosses serve as a substrate for the eggs. Its narrow distribution and continuing decline of its Peruvian Andes habitat cause it to be classified as endangered (IUCN 2010).

Catenazzi *et al.* (2011) found that the introduced fungal pathogen *Batrachochytrium dendrobatidis* (see Chapter 14-1) caused **chytridiomycosis**, which accounted for a large portion of amphibian decline in the Andes of Peru, further endangering this species.

### ***Bryophryne hanssaueri* (Strabomantidae)**

The endemic species *Bryophryne hanssaueri* (Figure 6) is known only from the immediate vicinity of the type



locality (Acjanaco, Manu National Park, Paucartambo, Peru) at 3266-3430 m asl (Frost 2011). The female tends her eggs (Figure 7), which develop directly into froglets (Figure 8). It lives in mossy habitats but, like many of these tropical species, its use of the moss remains a matter of speculation.



Figure 6. *Bryophryne hanssaueri*, an endemic species from cloud forests in southeastern Peru. Photo by Alessandro Catenazzi, with permission.



Figure 7. *Bryophryne hanssaueri* female tending her eggs. Photo by Alessandro Catenazzi, with permission.



Figure 8. *Bryophryne hanssaueri* hatching froglet. Photo by Alessandro Catenazzi, with permission.

### ***Bryophryne nubilosus* (Strabomantidae)**

*Bryophryne nubilosus* (Figure 9) lives in the mossy montane cloud forest and montane scrub at 2350-3215 m asl in the vicinity of Esperanza, in the Cosñipata Valley, Provincia de Paucartambo, Región Cusco, Peru (Frost 2011). Its relationship to mosses needs to be verified, but it seems to be sitting on a liverwort in the picture by Alessandro Catenazzi (Figure 9).



Figure 9. *Bryophryne nubilosus*. Photo by Alessandro Catenazzi, with permission.

### ***Noblella pygmaea* (Noble's Pygmy Frog, Strabomantidae)**

Noble's Pygmy Frog (Figure 10) has already been discussed in Chapter 14-1. This tiny frog is known only from its type locality in the Cusco Region, Peru, 3100 m asl (Frost 2011). It has not yet been rated by the IUCN (2012), but it is certainly endangered with such a small distribution. However, its tiny size and presence among mosses (Lehr & Catenazzi 2009) suggest it might be more widespread but not yet detected.



Figure 10. *Noblella pygmaea* (Noble's Pygmy Frog), a tiny moss-dweller. Photo by Alessandro Catenazzin, with permission.

### ***Psychrophrynella* (formerly *Phrynopus*) (Andes Frogs, Strabomantidae)**

This genus has already been discussed because many of its species call from bryophytes, often from within the moss mat. The eggs are laid under mosses and stones, where they are seldom found. They presumably undergo direct development.



The **páramo** occurs at high elevations from about 2000 m asl (the upper forest line) to 5000 m (the permanent snow line), creating a uniquely harsh environment. In the páramo at Cotapata, Bolivia, members of *Psychrophrynella* (**Strabomantidae**, formerly members of *Phrynosopus*) live under stones or among the grasses and mosses (De la Riva 2007). For example, *P. condoriri* spends the day under stones in a humid area of the páramo that has abundant mosses; *P. illimani* lives at the border of the elfin forest and wet páramo where both the ground and rocks are covered with mosses; *P. katantika* was even found among mosses and ferns on old walls and ruins. Likewise at Cotapata, *P. guillei* calls from deep within moss clumps and *P. iani* calls from under stones and among mosses. But *P. iatamasi* stays in the forest floor mosses, calling from there during the day (Aguayo & Harvey 2001). This genus deposits its eggs under mosses and stones, but these are rarely found (De la Riva 2007). As noted earlier, the mosses provide cover for calling males, who call day or night or both.

*Psychrophrynella kempffi* (Figure 11) usually occurs among the mosses or under stones and logs of the cloud forest. The latter species calls with a short whistle and is difficult to locate (De la Riva 1992), perhaps because it is hidden by the mosses.



Figure 11. *Psychrophrynella kempffi*. Photo by Ignacio De la Riva, with permission.

#### ***Psychrophrynella usurpator* (Strabomantidae)**

*Psychrophrynella usurpator* (Figure 12) is another tropical frog, known only from the vicinity of Abra Acjanacu Peru at 3270-3539 m asl, a high pass in the Cordillera de Paucartambo, which is the easternmost Andean range facing the Amazonian lowlands in Departamento Cusco, Peru (Frost 2011).



Figure 12. *Psychrophrynella usurpator* on a bed of mosses. Photo by Alessandro Catenazzi, with permission.

#### ***Pristimantis* (South American Rain Frogs; Strabomantidae)**

If you do your searching in the daytime, you might miss some of the moss dwellers. At elevations of 2500-3275 m in the Cordillera Oriental of the central Peruvian Departamentos Huainuco, Junin and Pasco, Lehr *et al.* (2006) found *Pristimantis platydactylus* (formerly *Eleutherodactylus platydactylus*) (**Strabomantidae**) on low vegetation and moist moss at night. However, during the day they were under dry leaves on the ground or in terrestrial bromeliads. In western Ecuador, *Pristimantis quinquagesimus* (previously *Eleutherodactylus quinquagesimus*) has been seen at night on leaves and mossy branches less than 2 m above the ground in cloud forests between 2000 and 2700 m asl in Provincias Imbabura and Pichincha (Lynch & Trueb 1980). Many of these frogs are nocturnal, as witnessed by their night-time calling.

One adult female of *Pristimantis vanadise* (formerly *Eleutherodactylus vanadise*) (**Strabomantidae**) was captured on mosses on the walls of a creek canyon in the cloud forest of the mountains of Merida, western Venezuela (La Marca 1984). All the males and some juvenile females, on the other hand, were found among the litter on the forest floor, possibly including mosses, but not near the stream.

In Ecuador, *Pristimantis simonbolivari* (formerly *Eleutherodactylus simonbolivari*) spends the daytime under mosses on logs as well as in leaf litter and under rotten logs (Wiens & Coloma 1992). Near a small creek, *Pristimantis appendiculatus* (formerly *Eleutherodactylus appendiculatus*) (Figure 13) sits on moss-covered stems or exposed fern fronds at the edge of the road at night (Miyata 1980).



Figure 13. *Pristimantis appendiculatus* (Pacific Robber Frog) on a moss-covered tree trunk. Photo by William Duellman, courtesy of Biodiversity Institute, University of Kansas.

Some species rest on leaves that have **epiphylls** (plants living on leaves), including bryophytes, especially leafy liverworts in the **Lejeuneaceae**. The ability of epiphylls to hold moisture may provide a moist niche for some frogs. *Pristimantis ridens* (Figure 14) is a tiny frog that spends time on epiphyll-covered leaves in Costa Rica, Honduras, and Colombia from sea level to 1600 m asl (Solís *et al.* 2010a).





Figure 14. *Pristimantis ridens* with epiphylls on a palm leaf. Photo by Jason Folt, through Creative Commons.

Duellman and Hedges (2005) found *Pristimantis stictogaster* (formerly *Eleutherodactylus stictogaster*) on the western slopes of the Cordillera Yanachago in central Peru nestled under a moss on the ground. *Pristimantis aniptopalmatus* (formerly *Eleutherodactylus aniptopalmatus*) occurred at 2300-2600 m, also on the western slopes, where it is known only from under moss on tree trunks and under moss on the ground in the cloud forest.

The **Santa Cecilia Robber Frog** (*Pristimantis croceoinguinis*; Figure 15) is a nocturnal frog that lives in the eastern Amazonian lowland rainforest of Ecuador and central Peru (Panguana, 200 m asl, Huanuco, southern Peru; Pakitza, 350 m asl (Madre de Dios); and Tavara (Puno) (Castro *et al.* 2004b). In Colombia it occurs mostly in the Departamento de Putumayo at 400 m asl, but also is able to survive in the low cloud forest at the base of the Pastaza trench. Although its primary habitat is the lowland primary rainforest, it is able to invade low cloud forests as well. Typically, it occurs on low vegetation 0.5-1.5 m from the ground. Its development is unknown, but it is most likely directly into tiny frogs with no free-living tadpole stage.



Figure 15. *Pristimantis croceoinguinis* (Santa Cecilia Robber Frog) in a bed of mosses. Photo by Andreas Nöllert, with permission.

In Panama, *Pristimantis museosus* (Robber Frog; Figure 16-Figure 18) is a moss-dweller whose name (*museosus*) means mossy. Also named the Vanishing Frog, it is a moss mimic, with disruptive warts, green body, and disruptive patches of darker green and brown (Figure 16-Figure 17). I suspect it can vanish in plain view among the

bryophytes. It lives among low vegetation, including the mossy forest floor of humid montane forests (IUCN 2010) of the Cordillera Central of Panama at 700-1000 m asl (Frost 2011). Its egg deposition niche is unknown. This unique frog is on the IUCN endangered list due to a fragmented habitat and narrow distribution (IUCN 2010).



Figure 16. *Pristimantis museosus*, a Panamanian moss mimic. Photo by Justin Touchon, Smithsonian Tropical Research Institute, through Public Domain.



Figure 17. *Pristimantis museosus* on a twig, exposing the white ventral side. If this works as it is supposed to in birds, it would make the frog less conspicuous when viewed from below against a light-colored sky, while maintaining camouflage above against moss-covered bark. Photo by Marcos Guerra, Smithsonian Tropical Research Institute, through public domain.



Figure 18. *Pristimantis museosus* head, showing the tubercles and color patterning that provide it with good camouflage among the bryophytes. Photo by Justin Touchon, Smithsonian Tropical Research Institute, through public domain.



*Pristimantis nervicus* (Figure 19) lives in extreme southeastern Costa Rica to eastern Panama, and central Colombia from 20 to 200 m asl (Savage 2002). It maintains its moisture by being night-active and living in primary humid lowland and secondary forest. Adults live under surface debris (presumably including bryophytes) and in leaf litter, often near or in caves and rocky streambanks. Its development is directly from egg to froglet.



Figure 19. *Pristimantis nervicus* among mosses (*Thuidium* sp.). Photo by Rafael Marquez, with permission.

*Pristimantis gaigei* (Fort Randolph Robber Frog; Figure 20) lives in drainage lowlands in extreme southeastern Costa Rica to Panama and central Colombia (Frost 2011) from 20-200 m asl (Savage 2002). This nocturnal species occupies humid lowland and secondary forests under surface debris and leaf litter near rocky stream banks where it is likely to encounter bryophytes.



Figure 20. *Pristimantis gaigei* (Fort Randolph Robber Frog). Photo by Esteban Alzate, through Creative Commons.

*Pristimantis cerasinus* (Limon Robber Frog; Figure 21-Figure 22) lives in Atlantic lowlands and premontane slopes of Nicaragua, Costa Rica, and Panama, western and central Panama, and northeastern Honduras at 19-1500 m asl (Savage 2002; Frost 2011). The adults live among the leaf litter in the daytime, but at night they roam among the vegetation, most likely including bryophytes (Pounds *et al.* 2004). They deposit their eggs on this low vegetation.



Figure 21. *Pristimantis cerasinus* (Limon Robber Frog). Is that a bryophyte or a fern under it? Photo by Jason Folt, through Creative Commons.



Figure 22. *Pristimantis cerasinus* (Limon Robber Frog). Photo by Brian Gratwicke, through Creative Commons.

*Pristimantis bacchus* (Wine Robber Frog; Figure 23) lives in Colombia at 1740-2300 m asl. This rare species was last seen in 2002 (Castro *et al.* 2004a). Its home among ground vegetation of cloud forests makes it difficult to locate. It is unlikely that it can avoid travelling among bryophytes in this habitat, but its further use is not known.



Figure 23. *Pristimantis bacchus* (Wine Robber Frog) on a thick moss bed. Photo by Esteban Alzate, through Creative Commons.



### ***Pristimantis mutabilis* (Strabomantidae) – A new kind of camouflage**

This unusual frog stumped its collectors. They found it among mosses in the Ecuadorian Andes and brought it back to the house in a cup (Quenqua 2015). It was unusual in having tubercles that helped it blend in with its mossy habitat (Figure 24). But when they next looked in the cup, the tubercles were gone (Figure 25) and they at first thought they had collected the wrong frog. But when they added some mosses to the cup, the tubercles returned.



Figure 24. *Pristimantis mutabilis* on mosses, showing the protruding tubercles. Photo by Tim Krynak, with permission.



Figure 25. *Pristimantis mutabilis* on a leaf, showing the disappearance of tubercles. Photo by Tim Krynak, with permission.

Ranging 17-23 mm, this frog was a new species and an interesting anomaly (Guayasamin 2015). But the researchers wondered if this anomaly occurred elsewhere. Hence, they re-examined *Pristimantis sobetes*, a member of a different species group. And there were the tubercles when the frog sat among mosses, but gone they were on other types of substrata. Might there be other moss mimics with this peculiar behavior?

Both species live in montane cloud forests that have abundant epiphytes and bryophytes.

### ***Yunganastes ashkapara* (Strabomantidae)**

In Peru and Bolivia, *Yunganastes ashkapara* (formerly *Eleutherodactylus ashkapara*; **Strabomantidae**; Figure 26) in the *Yunganastes fraudator* group is a **nocturnal arboreal** species that apparently finds some advantage other than moisture among the mosses. This

species calls from 2.5-10 m height during the rainy season, sitting inside mosses of the cloud forest canopy (Köhler 2000; Padial *et al.* 2007). Little information seems to be available on *Y. pluvicanorus* (Figure 27), but it appears to occupy similar mossy habitats.



Figure 26. *Yunganastes ashkapara* on a bed of mosses. This species calls from within thick moss mats. Photo by Jörn Köhler, with permission.

### **Craugastoridae**

Other members of the former *Eleutherodactylus* genus, such as *Craugastor catalinae* (formerly *Eleutherodactylus catalinae*) (**Craugastoridae**) in Middle America (Panama to Mexico), may conserve their moisture when they sit at night on moss-covered boulders midstream where a rapid retreat into the water is possible (Campbell & Savage 2000).



Figure 27. *Yunganastes pluvicanorus* on a bed of mosses. This species calls from within thick moss mats. Photo by Jörn Köhler, with permission.

*Craugastor lineatus* (**Montane Robber Frog**; Figure 28) has been recorded from elevations of 300-2000 m asl on the Atlantic side from Guerrero, Oaxaca, and Chiapas, Mexico, southeast to Guatemala. On the Pacific side it occurs from eastern Oaxaca through Chiapas to the southwestern highlands of Guatemala, at elevations of 300-2000 m asl (Santos-Barrera *et al.* 2004). It occupies lower montane evergreen forests and requires nearby streams for development. Unfortunately, it is rapidly declining in



Mexico, probably due to the fungal infection **chytridiomycosis**. Habitat loss through agriculture, logging, and urbanization also threaten its survival.



Figure 28. *Craugastor lineatus* sitting on a bed of *Sphagnum* at La Chinantla, Oaxaca, Mexico. Photo by Omar Hernandez-Ordoñez, with permission.

*Craugastor noblei* (Noble's Robber Frog; Figure 29) lives in lowland and premontane evergreen forests of extreme eastern Honduras, through Nicaragua and Costa Rica, both slopes in central Panama, and in the lower portion of the premontane zone of southwestern Costa Rica, at 4-1200 m asl (Frost 2011). With its diurnal habit (Solís *et al.* 2010b) and brown color, it is dangerously visible on bryophytes, although its shape makes it look like a leaf.



Figure 29. *Craugastor noblei* (Noble's Robber Frog) on a mat of mosses in Costa Rica. Photo by Andrew J. Crawford, through Creative Commons.

*Craugastor bransfordii* (Bransford's Robber Frog; Figure 30-Figure 31) lives in humid lowlands and adjacent premontane slopes on the Atlantic mountainside from eastern Honduras and Nicaragua to central Costa Rica, 60-880 m asl (Frost 2011). It is a forest floor species, where it typically lives among leaf litter. However, as seen in

Figure 30-Figure 31, it can traverse bryophytes and most likely finds a moist resting spot there.



Figure 30. *Craugastor bransfordii* (Bransford's Robber Frog) on a bed of mosses. Photo by Jason Folt, through Creative Commons.



Figure 31. *Craugastor bransfordii* (Bransford's Robber Frog) on a bed of mosses. Photo by Brian Gratwicke, through Creative Commons.

*Craugastor crassidigitus* (Isla Bonita Robber Frog; Figure 32) lives in northern Costa Rica, through Panama to the extreme northwestern border of Colombia, at 10-2000 m asl (Frost 2011). Its habitat is the humid lowland and premontane forests (Solís *et al.* 2004a).



Figure 32. *Craugastor crassidigitus* (Isla Bonita Robber Frog) on a bed of mosses. Photo by Sean Michael Rovito, through Creative Commons.



*Craugastor gollmeri* (Evergreen Robber Frog; Figure 33-Figure 35) lives in the lowland and premontane humid forests of Panama at 10-850 m asl and in eastern Costa Rica at 10-1520 m asl (Savage 2002). It lives among the leaf litter (Solís *et al.* 2004b), but where bryophytes are present they too can serve as cover or substrate during travels. Females attend the nest in this genus, but nesting sites of this species are not known.



Figure 33. *Craugastor gollmeri* (Evergreen Robber Frog) showing its leaf-like appearance. Photo by Brian Gratwicke, through Creative Commons.



Figure 34. *Craugastor gollmeri* (Evergreen Robber Frog) sitting on bryophytes. Photo by Brian Gratwicke, through Creative Commons.



Figure 35. *Craugastor gollmeri* (Evergreen Robber Frog) showing its underbelly coloration. Photo by Brian Gratwicke, through Creative Commons.

## Cycloramphidae

### *Alsodes vittatus* (Cycloramphidae)

It appears that some genera of **Cycloramphidae** in La Picada, Chile, may be dependent on mosses. *Alsodes vittatus* (formerly *Eupsophus vittatus*) (Malleco Spiny-chest Frog; see Figure 36) and *Eupsophus roseus* (Cycloramphidae; Figure 37) can be found under mosses, predominantly *Hygroamblystegium* (Figure 38; Formas & Vera 1980). The males of *Alsodes vittatus* (Cycloramphidae) occur under *Sphagnum* in water-filled cavities. Tadpoles were collected in water-filled cavities (pH 5.0) under *Hygroamblystegium* at the edge of a stream, with fifty tadpoles in one and sixteen in another cavity (Formas & Pugin 1978). Two clutches of eggs were found in similar *Sphagnum*-covered water-filled cavities. Formas and Vera (1980) considered these two species to be derived from pond breeders, with the deposition of eggs and development of tadpoles in water-filled cavities under mosses as a derived character.



Figure 36. *Alsodes igneus* on a bed of bryophytes. Photo © Danté B. Fenolio <[www.anotheca.com](http://www.anotheca.com)>, with permission.



Figure 37. *Eupsophus roseus* on a bed of bryophytes. Photo © Danté B. Fenolio <[www.anotheca.com](http://www.anotheca.com)>, with permission.





Figure 38. *Hygroamblystegium tenax* from a dry streambed in a north-temperate stream. Photo by Janice Glime.

### ***Eupsophus* (Cycloramphidae)**

In a temperate forest in southern Chile, *Eupsophus emiliopugini* calls from within clumps of the moss *Racomitrium* (Figure 39), and in bogs they excavate burrows where they can make their calls without being seen (Penna *et al.* 2005).



Figure 39. *Racomitrium canescens* in Iceland, demonstrating the types of mounds it can make – suitable for frogs to hide and call. Photo by Janice Glime.

### ***Rhinoderma darwinii* (Darwin's Frog, Cycloramphidae)**

Protection of eggs from desiccation seems to have been one of the primary drivers in the evolution of terrestrial frogs. One of the strangest egg incubation techniques is that of the Darwin's Frog (*Rhinoderma darwinii*; Figure 40-Figure 46), a vulnerable species from Argentina and Chile. In southern Chile, these frogs live in the beech forests (Fogden & Fogden 1989). The female lays her eggs where it is somewhat damp, under litter or mosses. She abandons the eggs and several males take over the care for about 20 days (Vocal Sac-Brooding Frogs: Rhinodermatidae 2011), an unusual trait in itself. The

males then each put a few eggs into their vocal sacs. Since calling season is over, the vocal sac is no longer needed for calling, so it makes a moist incubation pouch. The larvae feed on their own yolk (Jorquera 1982), but Goicoechea *et al.* (1986) used tracers to demonstrate that there is also a transfer of substances from the male to the developing larvae. In the sac for the next 50-70 days, these eggs hatch and the tadpoles complete their juvenile development (talk about a tickle in your throat!), leaving the males' mouths as froglets! (Vocal Sac-Brooding Frogs: Rhinodermatidae 2011). The males may gather a few eggs from several different clutches and not all the young will be at the same developmental stage. Meanwhile, the presence of the developing frogs makes the male look as if he is pregnant! (Figure 40).

The **Darwin's Frog** is a prey organism to birds, rodents, and snakes (Wikipedia 2011). It is protected from such attacks by camouflage. It comes in many combinations of greens and browns, typically looking like a leaf fallen on a moss, or just a leaf (Figure 46). Crump (2002) demonstrated that it selected substrate color based on its own color. Brown frogs selected brown substrata significantly more often than they selected green, and bicolored frogs likewise selected substrata that matched their color patterns. Green **Darwin's Frogs** (Figure 41), however, actually occurred less often on a green substrate, perhaps gaining an advantage by looking like a fallen green leaf or a plant on soil or other brown surface. Brooding males appeared on warmer surfaces than did non-brooding males or females.



Figure 40. Male **Darwin's Frog** (*Rhinoderma darwinii*) carrying developing tadpoles in its vocal sac, hence appearing to be pregnant. Photo by Claudio Soto-Azat, with permission.





Figure 41. Green variant of *Rhinoderma darwinii*, blending in with the mosses and liverworts. Photo © Danté B. Fenolio <www.anotheca.com>, with permission.

This camouflage serves a second purpose. These frogs are ambush hunters, so they are able to sit undetected among the bryophytes to watch and wait for their own dinner (Figure 42).

One might ask why so many different patterns are necessary, but perhaps the predator would be able to learn a pattern if only one existed. If the frog is detected, it rolls over on its back and plays dead (Figure 43). The underside is black with white spots, a pattern recognized as warning coloration. If water is nearby, the frog jumps into the water, then floats downstream – on its back!



Figure 42. Darwin's frog (*Rhinoderma darwinii*) sitting on damp mosses in Chile. While this animal "leaf" sits still, an insect may land, unaware of the danger. At the same time, its predators often pass it by without noticing that it is a frog. Photo by Filipe Osorio, with permission.

### Ceratophryidae

In Peru and Bolivia, *Telmatobius timens* (Ceratophryidae; similar species in Figure 44-Figure 45) lives in the páramo, where it spends the night sitting on rocks, on the ground, or in crevices and under mats of mosses along streams (Riva *et al.* 2005).

The specific name *timens* means frightened, scared, or alarmed (timid) and refers to the possible arrival of the

infectious fungal disease **chytridiomycosis** to Bolivia (Riva *et al.* 2005). This disease has already devastated many amphibian species, including *Telmatobius* in Ecuador and Peru.



Figure 43. Darwin's Frog (*Rhinoderma darwinii*) playing dead by rolling on its back and exposing its black and white warning coloration. Photo by Claudio Soto-Azat, with permission.



Figure 44. *Telmatobius culeus* (Titicaca water frog) juvenile. Photo by Joshua Stone, through Wikimedia Commons.



Figure 45. *Telmatobius* sp. from northern Chile. Some members of this genus spend the night under mats of mosses near streams. Photo by José Grau de Puerto Montt, through Wikimedia Commons.





Figure 46. Color and pattern variants of Darwin's Frog, *Rhinoderma darwinii*. Some color forms blend well with bryophytes while others are more suitable for leaf litter or other substrata. Photos by Claudio Soto-Azat, with permission.



## Summary

Bryophytes offer opportunities for anurans to live in places where they might not otherwise survive. Among these are waterfalls where bryophytes provide a foothold and place to deposit eggs.

*Pristimantis mutabilis* is especially adapted to living among mosses by projecting tubercles that help it blend in with mosses, but withdrawing them when it is on a smooth substrate. In the cloud forests, genera such as *Bryophryne*, *Noblella*, *Psychrophrynella*, *Pristimantis*, *Yunganastes* use bryophytes for egg-laying, calling sites, and cover. *Craugastor* is more common in lowland and premontane forests where bryophytes can be common ground cover, providing moisture during travels. *Alsodes vittatus* lives under *Sphagnum* in water-filled cavities. *Eusophus* species call from within clumps of mosses in temperate forests in Chile. Darwin's Frog (*Rhinoderma darwinii*) has multiple color phases that permit the species to blend with a wide range of habitats, including bryophytes. In the páramo, *Telmatobius timens* finds refuge under moss mats.

In Australia, the Darwin's Frog (*Rhinoderma darwinii*) lays eggs in the mosses, then leaves them for the male to incubate, which they do in their vocal sacs after about a week of maternal care.

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