

# CHAPTER 15

## REPTILES

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# CHAPTER 15

## REPTILES



Figure 1. A hatchling Spotted Turtle, *Clemmys guttata*, traversing mosses near its wetland home. Photo courtesy of Steve Soldan, Woodlot Alternatives.

### Vertebrates

A chipmunk scampers across a log. A bird builds a nest in the tree above. A toad awakens from its winter nap. A bear gathers grubs to fill its empty gut. These and many more animals have interacted in secret ways with the bryophytes of the forest, dispersing them, using them for nesting and bedding, escaping the cruel crystals of ice by hiding beneath them, eating the tiny invertebrates among them. Reptiles are no exception, using them for nesting sites and hibernacula. So many animals use the mosses in so many untold ways. And surely many more secrets remain to be discovered.

With reptiles I must face a capitalization dilemma. Whereas only proper nouns in plant names are generally capitalized, reptiles, like birds, have official English names that are capitalized. Hence, I shall be inconsistent and capitalize these names, although it bothers me, and I will not capitalize those of plants.

### Order Testudines – Turtles

The moist environs of the *Sphagnum* peatlands (Figure 2) make ideal habitats for aquatic turtles like the

Spotted Turtle *Clemmys guttata* (Figure 1; Wright 1919; Folkerts & Skorepa 1967) and the Painted Turtle *Chrysemys picta* (Krawchuk & Brooks 1998; Rydin & Jeglum 2006) and their eggs (Figure 3).



Figure 2. Virus raised bogs, Estonia. Photo by Lysy, through Creative Commons.



### ***Clemmys guttata* (Spotted Turtle, Emydidae)**

*Clemmys guttata* (Figure 1) is globally endangered (IUCN 2011). In New York, USA, *Clemmys guttata* is rare in *Sphagnum* peatlands (Figure 2), particularly those suitable for cranberries. But in Pennsylvania, USA, it has been known to congregate on the peatlands in May and June (Netting 1936). In the Georgian Bay, Ontario, Canada these animals hibernate in the *Sphagnum* swamps from September until April (Litzgus & Brooks 2000). Litzgus *et al.* (1999) found that the turtles actually have two types of hibernation niches in Georgian Bay: *Sphagnum* hummocks with cave-like spaces created by tree roots (Figure 4) and rock caverns at the shores of the swamps (Figure 5), both requiring *Sphagnum* peatlands. The stable temperature of the hummocks protects the turtles from freezing, permitting them to maintain a body temperature of 0.3-3.9°C at the northern limits of their range, despite air temperatures that reach -35°C.



Figure 3. Eggs of the Painted Turtle, *Chrysemys picta*, exposed from their underground home. Photo by John White, with permission.

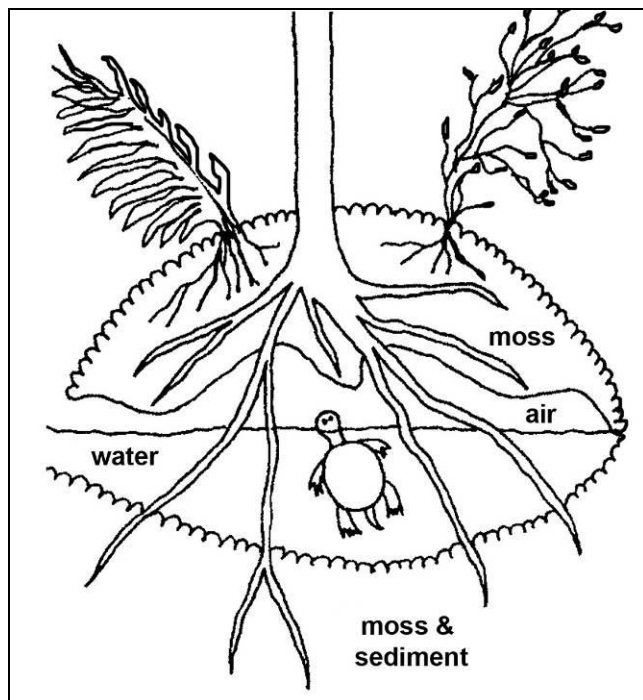


Figure 4. Spotted Turtle, *Clemmys guttata* in air pocket beneath moss hummock, with body submersed and head above water. Redrawn from Litzgus *et al.* 1999.

*Clemmys guttata* (Figure 1, Figure 6-Figure 7), a shallow-water turtle, prefers a soft bottom substrate with both submerged and emergent vegetation. Therefore, boggy ponds, fens, and *Sphagnum* (Figure 2) seepages provide suitable habitats. In the spring the turtles travel to seasonal pools, then search for suitable nesting sites (Milam & Melvin 2001). Babcock (1938) reported finding nests among damp logs and moss. Nesting sites include *Sphagnum*, among others (Hunter *et al.* 1992; Ernst *et al.* 1994). Dick Andrus (pers. comm.) found "a bunch of little ones buried in a *Sphagnum* hummock (Figure 13) once on Long Island." In summer, the turtles frequently wander onto land between their wetlands, where they may aestivate for weeks at a time (Figure 6) (Ernst *et al.* 1994; Harding 1997, 2002). They seldom wander very far; turtles in a Massachusetts, USA, study travelled an average maximum distance of 265 m from their winter hibernacula, although some travelled as far as 1025 m (Milam & Melvin 2001).

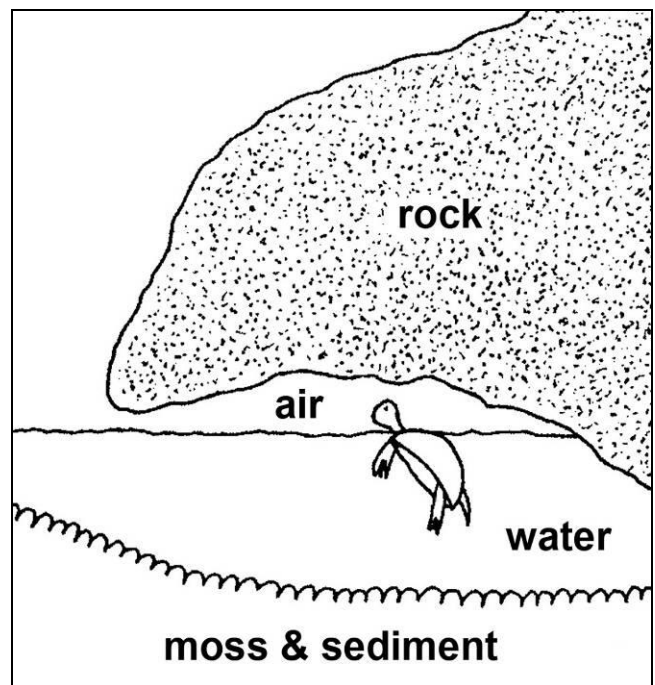


Figure 5. Relationship of hibernating Spotted Turtle, *Clemmys guttata*, in an air pocket under the safety of a rock. Redrawn from Litzgus *et al.* 1999.

Milam and Melvin (2001) demonstrated that even though these turtles do not wander far from their winter hibernacula in the peatlands, they wander farther than the buffer protected by the Massachusetts' Wetlands Protection Act. The act provides buffers of 30 and 60 m in uplands around the wetlands, but in this study, females nested 75 – 312 m from the wetlands and aestivated at distances up to 412 m. To maintain turtle populations, larger surrounding areas will need to be preserved along with the wetlands.

But not all Spotted Turtles spend their lives in association with peatlands. In Georgian Bay, Ontario, Canada, one island population of Spotted Turtles placed their nests in shallow soil of exposed Precambrian Shield rock outcrops (Litzgus & Brooks 1998). Although there were patches of lichens and mosses among the rocks, it is doubtful that these were large enough to provide habitat for the turtle. On the other hand, the low-lying *Sphagnum* interspersed among the rocks may have been essential for



maintaining hydration and could provide a suitable nesting site. The authors speculated that the rocks provided the warmth needed for incubation. Milam and Melvin (2001) found that the dominant ground cover in the habitat of spotted turtles in their Massachusetts, USA, study was *Sphagnum* spp, although they only mentioned three (out of 19) hibernacula in abundant *Sphagnum*, in an area of shrub wetlands where there was a slow current of shallow water.



Figure 6. This sleepy-looking fellow is a hatchling Spotted Turtle, *Clemmys guttata*, and he is wearing a radio transmitter. Photo courtesy of Steve Soldan, Woodlot Alternatives.



Figure 7. *Clemmys guttata* sunning on a rock. Photo by S. Duranceau, through Wikimedia Commons.

### ***Chrysemys picta* (Painted Turtle, Emydidae)**

Although the Painted Turtle (*Chrysemys picta*; Figure 8-Figure 10) is common in ponds, lakes, marshes, and other forms of slow-moving water with a muddy bottom, it can also be found in fens and bogs (Rydin & Jeglum 2006) – habitats where bryophytes predominate. It has an interesting courtship in which the male uses his long claws, palms facing outward, to stroke the female on the cheeks and neck (Wikipedia 2011b). Females lay the eggs in several events in sandy soil exposed to the sun, preferably with open water within 200 m. The nest is shallow (5-11 cm deep), but doesn't need to protect the next generation over the winter. Instead, the eggs hatch in 72-80 days and the independent young dig their way out.



Figure 8. *Chrysemys picta* on moss-covered roots. Photo by John White, with permission.



Figure 9. *Chrysemys picta* sunning on a log. Photo © Gary Nafis, with permission.



Figure 10. *Chrysemys picta* on its back, revealing the decorated plastron. Photo © Gary Nafis, with permission.

Winter is a dangerous season for the young turtles. Although they tolerate freezing down to  $-6^{\circ}\text{C}$  (Churchill & Storey 1992), contact with soil causes ice crystals to penetrate their integument when the soil is just below freezing (Packard *et al.* 2000). At temperatures below  $-2.5^{\circ}\text{C}$ , apparently these hatchlings increase their ability to tolerate cold as the winter continues, extending an initial survival of 3 days at  $-2.5^{\circ}\text{C}$  to survival for 11 days at that temperature (Churchill & Storey 1992). It appears that ingestion of nesting soil raises their temperature of crystallization by increasing their ice-nucleating activity and hence decreases their survival at winter temperatures in the field (Costanzo *et al.* 2003). This effect can last for a month and can account for greater survival of laboratory-



reared turtles that are deprived of these soil-derived ice-nucleating proteins.

The muddy pond or lake bottom provides a place for the adult turtles to hibernate during the winter, using the calcium and magnesium in their bones and shell to buffer the lactic acid produced by their anaerobic respiration (Storey & Storey 1990; Storey 1996; Jackson 2002). At the same time 40-45% of the lactic acid is stored into the bone and shell and remains there until the turtle ceases hibernation and once again obtains fresh oxygen. Along with a severe depression in metabolism, this mechanism, known only from turtles, permits the turtle to remain in anoxic hibernation for months at a time.

Like snakes, the turtles must bask in the sun to gain enough heat to digest their food (Wikipedia 2009). On the other hand, too much heat will kill them within minutes.

### ***Glyptemys* (formerly *Clemmys*) *muhlenbergii* (Bog Turtle, Emydidae)**

The Bog Turtle, *Glyptemys* (= *Clemmys*) *muhlenbergii* (Figure 11), inhabits many of the same locations as the spotted turtle, so it is not surprising that hybrids exist (Ernst 1983). As the name implies, the Bog Turtle, also known as the cranberry turtle, lives largely in *Sphagnum* peatlands (Ashley 1948; Barton & Price 1955). (The term bog must be interpreted liberally because it is relatively recently that North Americans began using the narrower European definition of bog; previously, almost anything with *Sphagnum* was considered a bog.) The moist peat is most likely important in keeping the turtles hydrated. *Clemmys* (= *Glyptemys*) *muhlenbergii* (Figure 11) is the smallest of the turtles in North America (NRCS 2006). It has been diminishing in numbers due to over-collection and destruction of habitat. As early as 1918 Wright considered it to be disappearing due to destruction of peatlands. The northern population lives in the eastern United States from Massachusetts to Maryland; the southern population lives in southwestern Virginia, south to northern Georgia.

Their small size permits them to traverse peatlands through tunnels that at times afford them protection from predators – and human collectors. This secretive behavior makes them to be more rare than they really are. In a study of several *Sphagnum* peatlands in Pennsylvania and New Jersey, USA, Ernst *et al.* (1989) found that some Bog Turtle tunnels appeared to have been made by meadow voles (*Microtus pennsylvanicus*; Figure 12) and widened for use by the turtle. In fact, few of the tunnels appeared to be strictly the results of the labor of the turtles.

All things considered, one might think of these turtles as lazy inhabitants of peatlands. Carter *et al.* (2000) used threadpooling to determine their movements and found that 75% of their movements remained within 20 m. Only 2% of the movements took them more than 100 m. Hence, they seldom moved between wetlands, underscoring the importance of individual wetlands and the unlikelihood that restored wetlands will be easily recolonized by these turtles.

It appears that despite its common name of Bog Turtle, *Glyptemys muhlenbergii* (Figure 11) does not require peatlands. In Maryland, USA, turtles from two locations lived in wetlands dominated by low grasses and sedges in one area and by cattle and sheep pasture in the other

(Morrow *et al.* 2001). Almost no *Sphagnum* (Figure 13) peat was present.



Figure 11. *Glyptemys* (= *Clemmys*) *muhlenbergii*, the Bog Turtle. Photo by US Army Corps of Engineers, licensed under Wikimedia Commons.



Figure 12. The vole *Microtus pennsylvanicus* at entrance a tunnel. Photo by Daderot, through Creative Commons.



Figure 13. *Sphagnum magellanicum* hummock, a moist location for bog herps. Photo by James K. Lindsey, with permission.

Nevertheless, Bog Turtles do use *Sphagnum* (Figure 13) for basking and as a nesting site where eggs incubate for 42-56 days (NRCS 2006). Mating occurs in spring and nesting occurs from May to July (Smith 2006). These nests



generally are close to the hibernacula. Barton and Price (1955) describe a nest among *Sphagnum* (Figure 13) extending about 12 cm above the water surface with hatchlings emerging. Apparently the female had buried herself in the moss, deposited the eggs, and crawled out, allowing the mosses to close over behind her, camouflaging the eggs.

Although the turtles prefer to feed on slugs, worms, spiders, and insects, they will also eat mosses (NRCS 2006; Smith 2006). However, one must ask if this is an accidental consumption in an attempt to eat invertebrates.

### ***Glyptemys* (formerly *Clemmys*) *insculpta* (Wood Turtle, Emydidae)**

The Wood Turtle, *Glyptemys* (= *Clemmys*) *insculpta* (Figure 14-Figure 15) seems to prefer open areas and cornfields to hemlock swamp with mosses (Kaufmann 1992). In a study in central Pennsylvania, only one turtle chose the hemlock forest that had a thick carpet of *Sphagnum*. Was she the outcast, or did she have the sole privilege of staying in this damper habitat?



Figure 14. Wood Turtle, *Glyptemys* (= *Clemmys*) *insculpta*. Photo by USGS, licensed as public domain.



Figure 15. *Glyptemys insculpta* among vegetation. Photo by Steve Silluzio, with permission.

### ***Emydoidea blandingii* (Blanding's Turtle, Emydidae)**

In Nova Scotia, juveniles of Blanding's Turtle (*Emydoidea blandingii*; Figure 16) selected habitats with *Sphagnum* (Figure 13), sweet gale (*Myrica gale*), and leatherleaf (*Chamaedaphne calyculata*) (McMaster &

Herman 2000). Butler and Graham (1995) found that hatchlings often sought refuge under *Sphagnum* in dry vernal pools. After a literature and field study, the U. S. Fish and Wildlife Service (2007) concluded that the best place to release hatchlings might be in beds of *Sphagnum*.



Figure 16. Blanding's Turtle, *Emydoidea blandingii*. Photo by Phil Myers, through Creative Commons.

Power *et al.* (1994) provided a plausible explanation for the choice of sphagnum habitats, among others. In their study of the Kejimikujik National Park in Nova Scotia, Canada, they found that they could predict the occurrences of this turtle by the color of the water. Within the park, the turtles would seek out highly colored bodies of water, typically small streams and lakes draining peatlands. In addition to data from 1572 captures (60 turtles), three turtles that left one body of water migrated through more lightly colored waters to settle in another location that was highly colored. Graham (1992) made similar observations on the preference for highly colored water in Maine, USA. These highly colored waters typically drain peatlands that provided the source of the coloration. Kerekes and Freedman (1989) indicated that these colored areas were high in secondary productivity, especially aquatic invertebrates, that would serve as a food source for the turtles. It is the same colored organic material coming from the peatlands that provides the food for this greater invertebrate productivity.

I have to wonder if the colored water of vernal pools in peatlands might offer another advantage. Packard *et al.* (2000) found that these turtles do not overwinter in the nests where they were born. They can survive to -6°C, but that when they are in contact with frozen soil their integument is penetrated by ice crystals at temperatures barely below 0°C. The freezing is fatal at temperatures below -2.5°C. Since dark-colored water should absorb more heat than clear water, perhaps these colored ponds are a mechanism to keep them warm.

### ***Chelydra serpentina* (Snapping Turtle, Chelydridae)**

A snapping turtle is not one that would come to mind as a moss eater. Those powerful jaws that one must avoid when trying to capture this large freshwater turtle don't suggest a diet of bryophytes. But Ralph Pope provided me with a picture that may represent snapping turtle feeding on *Sphagnum capillifolium* (Figure 17) – or was it those beetles we can see? The wide swath suggests to me it was eaten by something larger than a beetle.





Figure 17. *Sphagnum capillifolium* with middle portion eaten, lacking its capitula. This may have been done by the snapping turtle that was found nearby (dead!), or was it the two beetles on the right side of the picture? Photo by Ralph Pope, with permission.

### Marine Turtles

At the risk of perpetuating a myth, I found an interesting reference to marine turtles that fed on mosses! Fritts (1981) reported that Dampier (1906) had found that the marine turtles on the Galapagos Islands and adjacent areas were "rank, fat, and fed on moss." Fritts considered it likely that these were Olive Ridley Turtles, based on their size and habits, but he also stated that Dampier had mentioned loggerhead turtles (*Caretta caretta*?, Cheloniidae; Figure 18) fed on moss and were rank. I doubt that the moss made them rank, and I have to wonder if it was true moss or another mosslike plant, like Spanish moss (a bromeliad) that also grows there.



Figure 18. *Caretta caretta* (Loggerhead Sea Turtle) swimming in a marine habitat. Photo by Ukanda, through Wikimedia Commons.

### *Testudo* (Spur-thighed Tortoise, Testudinidae)

Serhat Ursavaş wrote to me that he saw a turtle [*Testudo (graeca) iberica*, Spur-thighed Tortoise or Greek tortoise; Figure 19] in the Kirzil Mountain National Park near Beyşehir Lake, Turkey (1234 m asl). The overstory vegetation was *Pinus nigra* subsp. *pallasiana*, *Salix alba*, and *Populus tremula*. The turtle was eating a mixture of moss (*Calliergonella cuspidata*; Figure 20) and grass on very wet, muddy soil. When approached, it stopped eating.

This species is widespread in the Mediterranean, where it survives relatively dry conditions (Highfield 1992). It is a relatively large tortoise, with females reaching up to 30

cm. Typical food plants include vetches (*Vicia*), dandelions (*Taraxacum*), mallows (*Malva*), and numerous species of the legume family (Fabaceae).



Figure 19. *Testudo (graeca) iberica* eating the moss *Calliergonella cuspidata* and grass in a muddy field in Turkey. Photo by Serhat Ursavaş, with permission.



Figure 20. *Calliergonella cuspidata* in a wetland where the Spur-thighed Tortoise can eat it. Photo by Michael Lüth, with permission.

### Dispersers

The Snapping Turtle (*Chelydra serpentina*, Chelydridae; Figure 21-Figure 23) is not thought of as a moss dweller and spends much of its time in the water. But it has a different relationship with bryophytes. It contributes to dispersal, at least for *Riccia rhenana* (Figure 22), dragging fragments from one place to another (McGregor 1961). Apical segments of these liverworts can survive two months of desiccation and five weeks embedded in ice, despite the death of older parts. My own experience with dispersal involved a Box Turtle (*Terrapene carolina*, Emydidae). My *Conocephalum conicum* (Figure 24) spread in my garden room when I had a Box Turtle, but not at any other time.



Figure 21. *Chelydra serpentina* (Snapping Turtle) on land, showing the algae growing on its back. Photo by Todd Pierson, with permission.



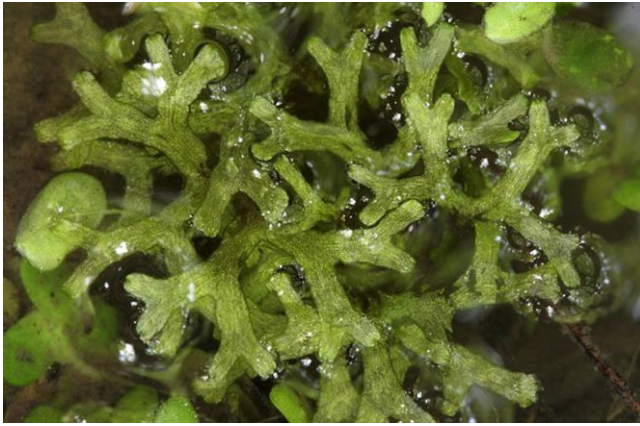


Figure 22. *Riccia rhenana*, a species that is dispersed by the Snapping Turtle (*Chelydra serpentina*). Photo by Štěpán Koval, with permission.

### Winter

Winter presents particular challenges for reptiles. Species in higher altitudes generally have better freezing survival than those of lower elevations (Storey 2006). Adults also are more freeze tolerant than juveniles. Live bearers have better long-term freezing survival than do egg bearers. And juveniles that hibernate in bogs go to greater depths than do adults. Thus, mosses help in the survival of at least some reptiles by providing insulation that keeps temperatures warmer than air temperatures in winter.



Figure 23. *Chelydra serpentina* (Snapping Turtle) on land, showing its huge feet and strong jaws. Photo by Todd Pierson, with permission.



Figure 24. *Conocephalum conicum*, a liverwort that may be eaten by the Box Turtle (*Terrapene carolina*). Note the circular cut from the thallus. Photo by Janice Glime.

## Order Squamata – Lizards

Lizards bring images of rocks, fence posts, and other dry habitats. But some include mosses as important habitat characteristics. Block and Morrison (1998) reported that *Sceloporus* (Figure 25) lizards in dry California oak woodlands were positively associated with mosses. Other lizards make rather unique uses of mosses.



Figure 25. *Sceloporus magister* in its typical rocky habitat where its disruptive coloration resembles rocks and lichens. Photo by Kalderi, through Wikimedia Commons.

### Adaptations

Lizards are predominately terrestrial. There is one marine species and a few aquatic ones, including the Jesus Lizard (*Basiliscus plumifrons*), a basilisk lizard. Hence, adaptations to the bryophyte habitat do not necessarily differ from those of lizards in general – they are terrestrial adaptations.

Among the more common bryophyte-associated lizards are some members of the genus *Anolis*. Whenever considering terrestrial adaptations, the life cycle is often a major factor, and *Anolis* seems to exemplify an extreme adaptation to its somewhat hazardous terrestrial life. Instead of the multiple-egg clutch size typical of other lizards, it has a clutch size of one! (Andrews & Rand 1974). This small number is, however, compensated by laying an egg at intervals of 1-2 weeks. This staggered and frequent production of eggs has several advantages: the female is able to produce larger eggs without a great increase in weight (light weight is important for escaping); the eggs each experience different weather conditions so that it is more likely that at least some will survive. With a generation time of only 4 months, this is a high reproductive potential.

The protection of the eggs is of paramount importance to reproductive success. Andrews and Sexton (1981) examined the water relations of eggs for *Anolis auratus* and *Anolis limifrons* (a bryophyte dweller; Figure 26). They found that rate of water loss from the egg surface had a linear relationship with egg mass in both species. *Anolis auratus* lost water more slowly, a factor related to its thicker calcium carbonate eggshell. These differences permitted *A. auratus* to live in the drier grasslands, whereas *A. limifrons* was confined to wetter habitats, i.e. the rainforest.





Figure 26. *Anolis limifrons* on a bed of mosses and liverworts. Photo by Peter Janzen, with permission.

The arboreal habitat poses its own hazards, *i.e.*, climbing and potentially falling. Adhesive toe pads facilitate climbing (Andrews & Rand 1974), but come at a price. Toe pad size increases by the square of the length. Body weight, on the other hand, increases by the cube of length. Hence, larger animals put more burden on the toe pads, causing a selection for smaller animals in arboreal habitats. Since many bryophytic habitats are arboreal, these adaptations can coincide with bryophyte dwellers.

Andrews and Rand (1974) suggest that this relationship of toe pad size to body weight and a foraging habit likewise put a limit on the egg weight at a given time. But another selection pressure on clutch size is the climate itself. In temperate and seasonal habitats of the tropics, clutch size is larger than in more moderated tropical climates. Hence, in those habitats with short-term fluctuations in rainfall, opportunistic reproducers are more likely to be successful. This strategy is likewise a safer approach in this habitat that likewise typically has high predation.

Predation can be an important factor in the strategy of a forager. The movement that permits these animals to chase or look for prey also makes them more conspicuous to their own predators. Anoles not only provide food for adult birds, but in Costa Rica birds such as the Bare-necked Umbrella Birds are known to capture the anole *Anolis capito* (syn.=*Norops capito*; Figure 27) from moss-covered tree trunks and feed them to their young (Losos 2011). These birds can detect the lizard from 10 m. Losos reports seeing a bird swipe a lizard from 2-3 m in front of him when the lizard had been invisible to him until the catch.



Figure 27. *Anolis capito* (= *Norops capito*), a cloud forest anole from Nicaragua. Photo by Josiah Townsend, with permission.

Both unpredictable weather conditions and opportunistic reproduction favor **r-selected life strategies** (high growth rate and many offspring with low probability of survival to adulthood, beneficial in less crowded niches and unpredictable habitats). Anoles exhibit the small body size, early maturity, short generation time, and high fecundity of an **r-strategist**. Arboreal anoles, in particular, are **iteroparous** (having multiple reproductive events), another r strategy.

Vitt and Congdon (1978) expanded on these ideas. They suggested that the "sit and wait" **ambush predators** were able to sustain a high clutch mass, whereas predator escape and foraging selected for small clutch size/mass. The anoles are foragers. They escape the problems of high egg mass by having only one egg at a time.

Even the **dewlap** (Figure 28, Figure 29), that often brightly colored flap of skin under the head that anoles (and others) flash to announce their aggressive defense of territory and attract females (Williams & Rand 1977), can relate to habitat/climate. Seasonally dry climates force reproduction into a short window of time annually. In these conditions, rapid choice of a mate is important, and males are selected for brightly colored, relatively large dewlaps (Fitch & Hillis 1984). In such seasonal environments, the males are typically larger than the females. In tropical rainforests and cloud forests, on the other hand, the breeding season is prolonged or even year-round, and dewlaps tend to be relatively small. In this case, some are brightly colored and others dull brown, tan, or white. Williams and Rand (1977) found that where populations of numerous species contact or overlap, the dewlap colors and patterns are sufficiently different to aid recognition. But Nicholson *et al.* (2007), in studying species of *Anolis*, failed to demonstrate any link between dewlap color and size with similar habitat specialization. They furthermore were unable to show that greater variation in dewlap morphology exists among sympatric (overlapping distribution) species, and suggested that the role of the dewlap in sexual selection still needs to be tested.



Figure 28. Brown Anole (*Anolis sagrei*) displaying its dewlap. Photo through Wikimedia Commons.

### **Anolis (Anole, Polychrotidae)**

The tropical cloud forests hide numerous species of lizards (Wilson & McCranie 1982, 2004; McCranie *et al.* 1993b), but finding specific relationships with bryophytes is a story of a needle in a haystack. Among these genera is the well-known genus *Anolis* (Figure 31).



This genus is best known for its use as a pet and laboratory organism, especially the Green Anole, also known as the American Chameleon, *Anolis carolinensis* (Figure 29), that is able to change color in response to temperature. This arboreal lizard parachutes to the ground when disturbed (Oliver 1951). *Anolis carolinensis* sometimes lays its eggs (Figure 30) among mosses (Greenberg & Noble (1944). In this case, the female uses her forelegs to part the branches, but the snout does most of the digging. Some individuals deposit their eggs deep in *Sphagnum* (Figure 13).



Figure 29. *Anolis carolinensis*, a species that sometimes uses mosses for nesting sites and oviposition. Note the red dewlap. Photo by Jeff Heard, through Creative Commons.



Figure 30. *Anolis carolinensis* and egg. Note the soil on the snout that was used to dig the hole for the egg. Photo by J. Cody Parmer, from <[www.discoverlife.org](http://www.discoverlife.org)>.

The adult *Anolis limifrons* (Figure 26) seems to prefer grass for its habitat, whereas the related *A. humilis* (syn.=*Norops humilis*; Figure 31) prefers leaf litter (Talbot 1977). But for laying eggs, *Anolis limifrons* (Figure 26) may use mats of moss at the base of bromeliads, as well as leaf litter or clumps of decaying vegetation in tree crotches 1-2 m above ground.

The cloud forest is home to a number of anole species (e.g. Wilson & McCranie 1982; McCranie *et al.* 1993a; Townsend & Wilson 2009). In the cloud forests of Honduras, there are 27 known species of lizards (Wilson & McCranie 2004). Since the cloud forest is also home to many bryophytes, the anoles must necessarily interact with the bryophytes daily in many of the niches. For example, the anole *Anolis morazani* in Figure 32 is running across

bryophytes on a branch. It is likely that bryophytes provide a means of moistening the ventral surface, as shown for salamanders, and can provide a collection substrate for drops of moisture collected from clouds, providing a suitable drinking location for the anoles and other arboreal lizards.



Figure 31. *Anolis humilis* (= *Norops humilis*). Photo by John D. Willson, with permission.



Figure 32. *Anolis morazani*, a cloud forest anole from Honduras. Photo by Josiah Townsend, with permission.

The montane ecotype of the Dominican Anole (*Anolis oculatus montanus*; Figure 33) lives in high elevation rainforests of central Dominica (Wikipedia 2012). This ecotype form lives on moss-covered tree trunks and has a deep green color to match. Occasional splotches and spots form a disruptive pattern, more closely resembling the non-uniform pattern of these bryophytes.



Figure 33. *Anolis oculatus montanus*, showing the green coloration with disruptive spots for this bryophyte-dwelling anole. Photo by Hans Hillewaert, through Creative Commons.



### ***Brookesia vadoni* (Mossy Pygmy Leaf Chameleon, Chamaeleonidae)**

This lizard doesn't cultivate bryophytes. It resembles them! A native of Madagascar, the rare Mossy Pygmy Leaf Chameleon looks like it has mosses and lichens growing on its back, enabling it to blend in with similar surroundings (Brygoo & Domergue (1968). Most members of this plant-mimic genus are slow-moving and hide under litter. ***Brookesia vadoni*** (Figure 34-Figure 35) lives in the northeastern part of Madagascar where more than 330 days have rain, and mosses and lichens abound.



Figure 34. The Mossy Pygmy Leaf Chameleon (*Brookesia vadoni*) exhibiting green patches that blend with these mosses and lichens. Photos from Flickr, through Creative Commons license.



Figure 35. The Mossy Pygmy Leaf Chameleon (*Brookesia vadoni*) exhibiting tubercles that give it the disruptive look that blends with mosses. Photos from Flickr, through Creative Commons license.

### ***Rhampholeon spectrum* (Spectral Pygmy Chameleon, Chamaeleonidae)**

***Rhampholeon spectrum*** (Figure 36) develops growths of liverworts on its body (Böhme & Fischer 2000). But this lizard does not restrict this to a head dress (Figure 36-Figure 37). Rather, it can have its entire body covered in liverworts! It is interesting that the only cryptogams inhabiting it are liverworts, and not mosses or lichens, but these liverworts are all in the family **Lejeuneaceae**, the family that is so common among the epiphyllous bryophytes.

These dwarf chameleons were collected in the montane cloud forest of Mt. Nlonako, Cameroon, at approximately 1200 m asl (Figure 38). Böhme and Fischer write that the "strikingly greenish coloration is not caused by a pigment, but by the overgrowth of otherwise epiphyllous liverworts." In all, they could identify four different species of liverworts, and claimed the first reported case of more than one species on the same individual.



Figure 36. This *Rhampholeon spectrum* appears to have liverworts on the eye socket, and there are enough to color the head green. Photo by Wolfgang Böhme, with permission.



Figure 37. These liverworts appear dangerously close to the eye of this *Rhampholeon spectrum*. Photo by Wolfgang Böhme, with permission.

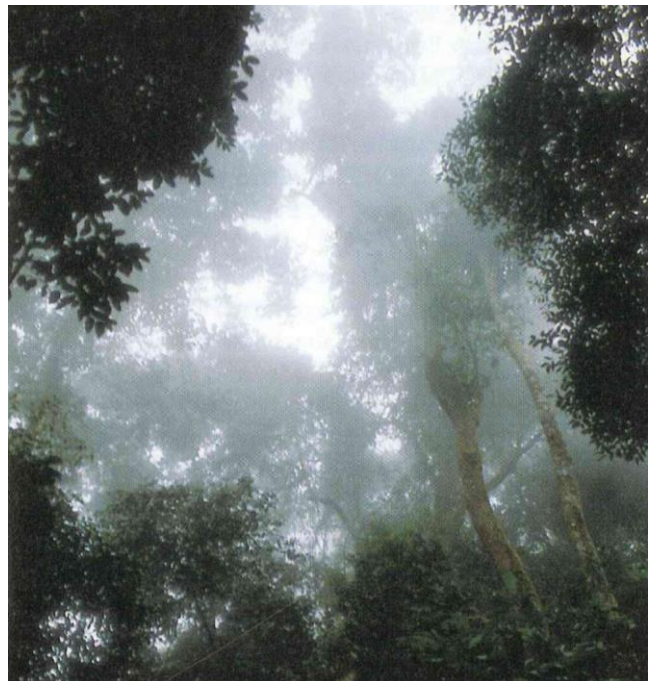


Figure 38. Cloud forest in Cameroon where *Rhampholeon spectrum* was collected, adorned with leafy liverworts. Photo by Wolfgang Böhme, with permission.





Figure 39. Green, liverwort-covered male and interested "naked" female Spectral Pygmy Lizard (*Rhampholeon spectrum*) in Cameroon. Photo by Wolfgang Böhme, with permission.

*Cololejeunea jovetastiana* (formerly *Aphanolejeunea jovetastiana*; see Figure 41) and *Colura digitalis* (see Figure 42) had the greatest abundance on the lizards, whereas Böhme and Fischer found only a few plants of *Cololejeunea* sp. and only two samples of *Lejeunea* (Figure 45-Figure 46). In addition to liverwort camouflage (Figure 40), this lizard is able to change color in the range

of dull shades of tan to gray (Wikipedia 2011c). The rough surface created by the scales gives sufficient topography for lodging of the spores and establishment of the liverworts (Figure 43).



Figure 40. This Spectral Pygmy Chameleon (*Rhampholeon spectrum*) seems to be in early stages of liverwort colonization, but it appears that soon they may impair its vision. Photo by Wolfgang Böhme, with permission.



Figure 41. *Cololejeunea minutissima*. *Cololejeunea jovetastiana* is a common member of the liverwort flora on the lizard *Rhampholeon spectrum*. Photo by David T. Holyoak, with permission.



Figure 42. *Colura calyptrifolia*. *Colura digitalis* is one of the two most abundant species of liverworts on *Rhampholeon spectrum*. Photo by David T. Holyoak, with permission.



Not only does the green covering of liverworts help to camouflage the lizard, but the researchers observed that one male so-adorned aroused the sexual interest of a nearby female! (Figure 39; translated from Böhme & Fischer by Rob Gradstein, pers. comm. 14 November 2011). Such a benefit must surely be considered a symbiosis.

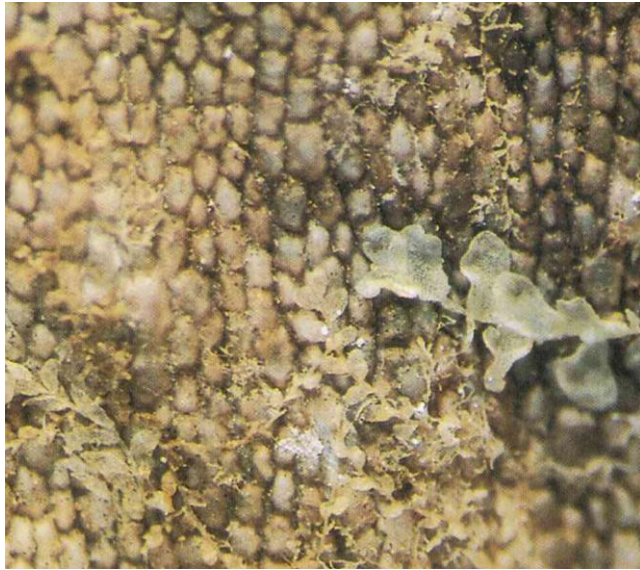


Figure 43. Close view of scales of *Rhampholeon spectrum* with several species of leafy liverworts attached. Photo by Wolfgang Böhme, with permission.

### ***Corytophanes cristatus* (Helmeted Iguana, Chorytophanidae)**

There is another lizard that reverses the relationship of habitat and inhabitant. It's hard to imagine walking around with a garden growing on your head. But for the Helmeted Iguana *Corytophanes cristatus* (Figure 44) in the lowland rainforest of the Chiapas, southern Mexico, not only algae, but also the leafy liverwort *Lejeunea obtusangula* (Figure 45-Figure 46), grow from their heads (Figure 47) (Gradstein & Equihua 1995).



Figure 44. The Helmeted Iguana/Basilisk, *Corytophanes cristatus*. Note the scoop-shaped head where bryophytes are able to grow. Photo © John Sullivan, Ribbit Photography, with permission.

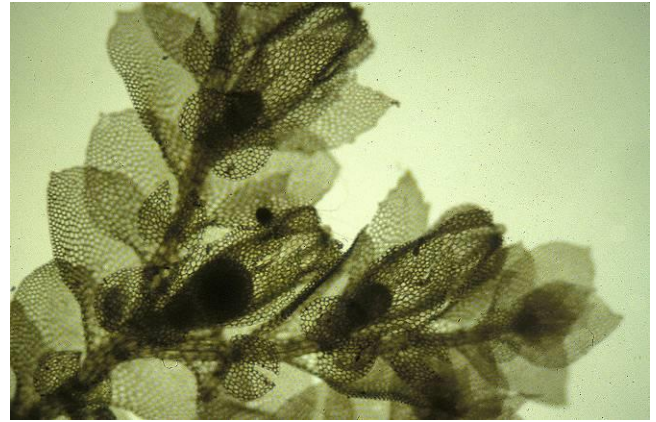


Figure 45. The leafy liverwort *Lejeunea obtusangula*. This liverwort has been identified from the head of the Helmeted Iguana, *Corytophanes cristatus*. Photo by Elena Reiner-Drehwald, with permission.

The liverwort in this story grew among a mat of algae comprised of four species in the Chlorophyta and Cyanobacteria. These included the common genera *Cladophora*, *Rhizoclonium*, and *Trentepohlia*. Together they resulted in a tear-drop shape of green on the head of the lizard. A picture by Twan Leenders from Costa Rica indicates that more than one species of liverwort can grow there as well (Figure 48).



Figure 46. Ventral view of *Lejeunea* such as that cultured on the head of the Helmeted Iguana. Members of this family are common as epiphyllous liverworts in the tropics. Photo by Michael Lüth, with permission.

The head seems to be especially adapted for green colonizers. The algae and liverworts reside in a depression in the head (the crest) that creates a catchment area where it could remain moist enough to support the growth of these photosynthetic organisms (Gradstein & Equihua 1995). The liverwort, *Lejeunea* (Figure 46), is a common epiphyte in the Neotropical rainforest, including living epiphyllous on tracheophyte leaves. Sporophytes of the liverwort were common in the forest and most likely represented its means of colonizing the lizard.

But what is the real function of this depression on the head? Although no one seems to have witnessed the act directly, it is likely that the head serves as a shovel to excavate a nest (Leenders 2002). Many lizards are known



to use their heads to excavate nests; their legs are weak and of little use for heavy digging (Twan Leenders, pers. comm. 20 February 2009). And, the one observation indicating nesting behavior was of a female with mud on her head standing over a hole in the ground that held two eggs. Since spores and fragments collect in the soil sporebank as they rain from the tree branches, the digging may also be at least one means of accomplishing the head gardening.



Figure 47. Head of the Helmeted Iguana *Corytophanes cristatus* showing the leafy liverwort *Lejeunea obtusangula* growing in the crest. Photo by Clementina Equihua, with permission.

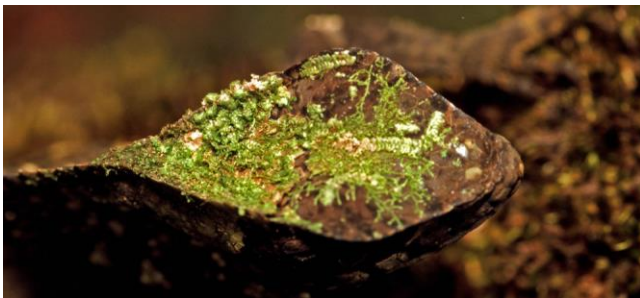


Figure 48. Head of Crested Basilisk/Helmeted Iguana, *Corytophanes cristatus*, or possibly a different species, in the Rara Avis Rainforest Preserve, Costa Rica, showing at least two different leafy liverworts. Rob Gradstein (pers. comm. 14 November 2011) has suggested these liverworts may be *Symbiezium transversale* and *Lejeunea flava* (Figure 49), two species that are locally common, but not typically as epiphylls. Photo by Twan Leenders, with permission.

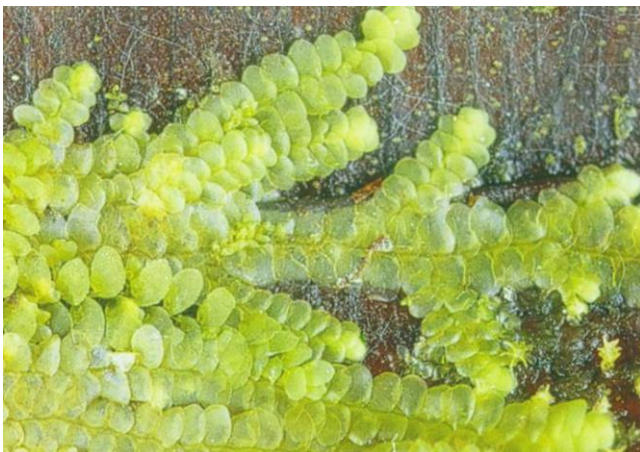


Figure 49. *Lejeunea flava*, a tiny liverwort that might colonize the head of *Corytophanes cristatus*. Photo by Jia-dong Yang, through Creative Commons.

One would assume that colonization of liverworts on the lizard's head would be challenging because the lizard most likely sheds its skin several times annually. Thus it's not surprising that the bryophytes are epiphyllous species of *Lejeunea* (Figure 45-Figure 46) that are already adapted to a transient habitat. The rainforest is moist and the lizard is able to move quickly if needed, but it spends many hours without moving (Figure 50) (Twan Leenders pers. comm. 31 January 2009), earning it the nickname of Old Man Lizard. Further supporting its name, its long life provides a combination that makes such colonization possible. It would be interesting to see what happens to the crown garden when the skin is shed. Perhaps fragments from the disposable garden are able to colonize the new crest immediately. The lizard may gain a camouflage advantage as it hangs out on trees with patches of epiphytes on the bark (Figure 51).



Figure 50. *Corytophanes cristatus*, looking a bit like its bryophyte habitat. Photo © 2007 Petrovan Silviu, with online permission for academic use.



Figure 51. Helmeted Iguana, *Corytophanes cristatus*, on a trunk covered with leafy liverworts. A crown of liverworts would have made it less conspicuous. Photo by John D. Willson, with permission.



Sasa and Monrós (2000) reported that both *Corytophanes cristatus* (Figure 47-Figure 51) and *C. hernandezii* (Figure 52) had remains of bryophytes in the guts of several individuals. It is possible these were consumed while targetting invertebrate food.



Figure 52. *Corytophanes hernandezii*, a species that occasionally eats mosses. Photo through Creative Commons.

### ***Ceratophora karu* (Agamidae)**

The name *Ceratophora* literally means horn-bearer, referring to the horn at the tip of the snout on the males. This genus is endemic to Sri Lanka (Bahir & Surasinghe 2005). *Ceratophora karu* (Figure 53) is rare and critically endangered, living in a 10 km<sup>2</sup> area at 900-1070 m asl in tropical moist montane forest. All the endangered agamid species in Sri Lanka are forest-dwellers. The genus *Ceratophora* is considered a geographical relict (de Silva 2006). In 2011, researchers Janzen & Bopage were unable to locate *Ceratophora karu* near its known Morningside Estate location. The lack of protection for this species forebodes its likely extinction.



Figure 53. *Ceratophora karu*, an endemic of Sri Lanka with mosses growing on its back and head. Photo by Friedrich Wilhelm Henkel, with permission.

Thanks to Wolfgang Böhme and Friedrich Wilhelm Henkel, we are able to document here the occurrence of

mosses growing on the back of at least one of these rare *Ceratophora karu* (Figure 53).

### ***Zootoca* (formerly *Lacerta*) *vivipara* (Viviparous Lizard, Lacertidae)**

Lizards are generally found in dry habitats where their scales help them to avoid desiccation. The common *Zootoca* (= *Lacerta*) *vivipara* (Viviparous Lizard; Figure 54-Figure 55) may be the only lizard to frequent peatlands in northern Europe, where it reproduces (H. Strijbosch in Desrochers & van Duinen 2006). It is one of a number of reptiles that have live birth instead of depositing eggs. In highland areas, this lizard is able to increase its ability to resist ice formation during its hibernation, which it spends under 2-4 cm of peatmoss or grass litter (Grenot *et al.* 2007). A contributing factor is that it can increase its blood glucose levels about 4-fold from September to March, followed by a rapid decline when it exits hibernation. The mosses act as insulation that reduces daytime temperatures and keeps nighttime temperatures warmer.

*Zootoca vivipara* (Figure 54-Figure 55) is most typical in raised bogs that transition into pine or pine-birch forests (Ėeirāns 2004). These areas are characterized by wet *Sphagnum* (Figure 2).



Figure 54. The Viviparous Lizard, *Zootoca* (formerly *Lacerta*) *vivipara*. Photo by Marek Szczpanek, from Wikipedia Commons.

The Viviparous Lizard, as its name implies, gives birth to live young. The courtship is a rather strange one in which the male grabs the female's head in his mouth (Peatlands 2009). Following copulation, the female must stay warm for the next three months, basking in the sun, so that the eggs can develop properly. In Northern Ireland they are legally protected not only from direct harm or capture, but also from disturbance.



Figure 55. The Viviparous Lizard, *Zootoca* (= *Lacerta*) *vivipara*. Photo by Marek Szczpanek, from Wikipedia Commons.



### ***Plestiodon* (formerly *Eumeces*) *anthracinus* (Coal Skink, Scincidae)**

The Coal Skink, *Plestiodon* (formerly *Eumeces*) *anthracinus* (Figure 56), can be found on the edge of swamps (Wright 1919), but it is more common among boulders on limestone cliffs, under ledges, sandstone slabs, and under rocks (Virginia Department of Game and Inland Fisheries 2009). It is rarely seen and has an interesting habit when pursued – it jumps into a shallow stream and hides under rocks or debris (ZipCode Zoo 2008). Females defend their eggs, which are usually placed under rocks or logs on land. The young can be recognized by their blue tails (Virginia Department of Game and Inland Fisheries 2009). In Tennessee it is considered very rare or imperiled (Atlas of Reptiles in Tennessee 2008). But information on its dependence on or use of bryophytes is lacking, aside from its occurrence on the edge of a swamp. The ability of bryophytes to ameliorate temperature and maintain moisture suggests that there are most likely many more reptiles that make use of bryophytes, but we have very little information on their use of this habitat.



Figure 56. Coal Skink, *Plestiodon* (formerly *Eumeces*) *anthracinus*. Photo through Creative Commons.

### ***Lobulia* (Scincidae)**

The genus *Lobulia* in the family Scincidae has several species that utilize mosses in the high altitude areas of New Guinea (Greer *et al.* 2005), where it is endemic. *Lobulia subalpina* is common in shrubby-grassy clearings of forests with dense moss cover, but may not actually use the mosses. *Lobulia alpina*, on the other hand, is common on fallen, decaying logs of tree ferns (*Cyathea* spp.) that are covered with mosses, their primary habitat. *Lobulia stellaris* sometimes occurs in mossy clumps. Greer *et al.* found one active at around 0900 hrs at the base of a moss mound. *Lobulia* species use mossy-grassy clumps in the alpine grassland for sunning themselves. The landscape is dotted with large mounds about 1 m high and 1-2 m in diameter, providing ideal sunning locations. They not only give good sun exposure, but serve as shelter sites. Nevertheless, none of the *Lobulia* were found in the dense moss forest.

### ***Cnemaspis spinicollis* (Geckonidae)**

*Cnemaspis spinicollis* (Figure 57) from Cameroon is poorly known, recorded only from the Takamanda Forest Reserve in the southwest province of Cameroon (LeBreton 2003). Its home is large rainforest trees that are covered with layers of mosses, stems of vines, and exfoliating bark.



Figure 57. *Cnemaspis* sp. *Cnemaspis spinicollis* lives among mosses on the rainforest trees of Cameroon. Photo by L. Shyamal through Creative Commons.

### ***Uroplatus sikorae* – Mossy Leaf-tailed Gecko**

*Ourá* means tail and *platys* means flat, referring to the flattened tail of the genus *Uroplatus* (Wikipedia 2015). It ranges 15-20 cm from its nose to the base of its tail as an adult. The Mossy Leaf-tailed Gecko is an endemic lizard in Madagascar, occurring in both primary and secondary forests.

*Uroplatus sikorae* (Figure 58) can change its skin color to match its surroundings and even has dermal flaps to break up its smooth appearance when at rest (Wikipedia 2015). But more to our interests, it looks like it has bryophytes growing on its scales, enough so that I thought from the picture that they were real bryophytes. It rests head down on tree trunks during the day, blending well with its surroundings. *Uroplatus sikorae* is a nocturnal tree dweller where it feeds on insects. These geckos die very quickly if the humidity is too low, requiring a range of 60-100% (Dunlop 2016).



Figure 58. *Uroplatus sikorae* (leaf-tailed gecko) in Madagascar, with bryophytes on scales. Photo by Paul Bertner, with permission.



## Order Squamata – Snakes

Like the lizards, the mention of snakes does not bring bryophytes to mind, but of course some make use of mosses in their habitat. The mosses can help provide moisture and may be suitable hiding places for smaller species.

### *Diadophis punctatus punctatus* (Ringneck Snake, Colubridae)

If one imagines snakes among mosses, it is small ones like *Diadophis punctatus* (Figure 59-Figure 60) that come to mind. This primarily nocturnal species is known from insect burrows under thick mosses of sunny slopes, although it might be more common in the soft tissues of decaying logs, under bark, or in beetle (*Passalus cornutus*) tunnels (Neill 1948).



Figure 59. *Diadophis punctatus* on a bed of the moss *Plagiomnium* sp. Photo by John White, with permission.

This nocturnal species is a native North American, occurring from southeastern Canada to Mexico. Although they are slightly venomous, they are no danger to humans. Their greater resource against predation seems to be their ability to roll up and expose the underside of the tail, displaying a bright red warning coloration (Figure 60).



Figure 60. *Diadophis punctatus* showing the warning coloration of the underbelly. Photo by William Flaxington.

In northern and western areas these snakes are typically located in open woodlands near rocky hillsides or in wetter environments that have good cover, including coarse woody debris (Stebbins 2003). But southern

populations live primarily in arid habitats within riparian and wet environments (Dundee & Miller 1968).

### *Pseustes poecilonotus* (Dos Cocorite, Colubridae)

*Pseustes poecilonotus* (Figure 61) lives in Amazonian South America (Boos 2001) where it is a species of IUCN least concern (Lee *et al.* 2007). It is known from sea level to 1200 m asl. This diurnal snake lives in humid lowland forest and savannas. It feeds on frogs, lizards, birds, and small mammals. These are all available in its arboreal habitat where it also encounters bryophytes. It is too large to live under bryophytes or hide in them, but they could provide moisture or egg-laying sites.



Figure 61. *Pseustes poecilonotus* on tree trunk in Tortuguero, Costa Rica. Photo by John D Willson.

### *Sibon longifrenis* (Stejneger's Snail Sucker, Colubridae)

*Sibon longifrenis* (Figure 62) is an egg-layer that lives in Costa Rica, Honduras, Nicaragua, and Panama (McCranie 2007; Lewis 2009; Hosek 2011). Kofron (1990) considered this and several other *Sibon* species to be synonyms of *S. dimidiata*, but later Savage and McDiarmid (1992) provided convincing argument that this species is distinct. *Sibon longifrenis* is a nocturnal moss mimic, with patches of white, green, and brown in a disruptive pattern that makes it blend well in its arboreal tropical habitat. Its diet consists of snails, slugs, and amphibian eggs, all of which can be found among the epiphytic bryophytes. Other members of the genus in Costa Rica have similar green coloration (Solórzano 2001).



Figure 62. *Sibon longifrenis* in a tropical tree among mosses and liverworts where it is almost invisible. Photo by Josiah Townsend.



Ryan and Lips (2004) found that the most common food for the related species *Sibon argus* (Figure 63) is slugs, but some eat eggs of anurans, gaining the species the common name of goo-eater. The researchers found a snake of this species in Panama with its head hidden in a moss clump. When the snake was pulled out, it was swallowing eggs of *Espadarana prosoblepon*. At night this species moves along branches, flicking its tongue at moss clumps and undersides of leaves, apparently searching for eggs.



Figure 63. *Sibon argus*, a species that eats amphibian eggs in moss clumps. Photo by Twan Leenders, with permission.

#### ***Virginia valeriae* (Smooth Earth Snake, Colubridae)**

*Virginia valeriae* (Figure 64) is not a snake one would probably associate with bryophytes, but Tobias Landberg found an unlikely connection. This is a snake that lives in the soil and leaf litter where it eats earthworms and soft-bodied arthropods. But just by chance, Landberg found this species dispersing moss spores!



Figure 64. Smooth Earth Snake, *Virginia valeriae*, sunning itself on a moss. Photo by Tony Gerard through Creative Commons.



Figure 65. Smooth Earth Snake, *Virginia valeriae*, wending its way among moss capsules. Photo by Tobias Landberg.



Figure 66. Smooth Earth Snake, *Virginia valeriae*, showing moss spores that have collected on its head. Photo by Tobias Landberg.

#### ***Natrix natrix* (Grass Snake, Colubridae)**

*Natrix natrix* (Figure 67) in Eastern Europe is frequent on poor *Sphagnum* and *Carex* peat in drained pine forests (Èeirâns 2004). They also occur around flooded peat mines in raised bogs, but they avoid pre-drained forest types and active raised bogs.



Figure 67. *Natrix natrix*, a *Sphagnum* inhabitant. Photo by Fafner, through Creative Commons.



### ***Sistrurus catenatus catenatus* (Eastern Massasauga Rattlesnake, Viperidae)**

Some moss inhabitants you would rather not meet. Such is most likely the case for the Eastern Massasauga Rattlesnake, *Sistrurus catenatus catenatus* (Figure 68). It inhabits low-lying areas including peatlands, where it uses temperature sense organs on its head to locate small prey such as mice, voles, and shrews (Johnson 1992, 1995). When winter approaches, these snakes seek places where the temperature does not drop below freezing, and at least in New York, USA, the raised hummocks of *Sphagnum* often provide a suitable place (Johnson & Breisch 1993, 2000; Johnson *et al.* 2000; Department of Environmental Conservation 2010). These hummocks typically overlie branching roots that provide spaces for the snakes.



Figure 68. The poisonous Eastern Massasauga Rattlesnake, *Sistrurus catenatus catenatus*. Photo by John White.

### ***Vipera berus* (European Viper, Viperidae)**

The common European Viper (*Vipera berus*; Figure 69-Figure 70) may easily be encountered in peatlands, where the presence of juveniles indicates that reproduction in the peatland is successful (H. Strijbosch in Desrochers & van Duinen 2006). Its bite can be dangerous or fatal to the very young and very old, but generally it is not fatal, the poison being mild.



Figure 69. The common European Viper (*Vipera berus*) amid the *Sphagnum* and cranberries. Photo by Twan Leenders, with permission.



Figure 70. The European Viper (*Vipera berus*) in a bed of *Sphagnum*. Photo from Wikipedia Commons.

North of the Arctic Circle in Sweden, *Vipera berus* (Figure 69-Figure 70) lives between 300 and 450 m asl (Andersson 2003). Its chosen hibernation sites are always within 1 km of peat bogs and marshlands where they fed on voles during their active season of mid-June to mid-August.

### ***Bothriechis schlegelii* (Eyelash Viper, Viperidae)**

The Eyelash Viper (Figure 71) derives its name from the superciliary scales above the eyes, believed to disrupt the contrast between the smooth body and its surroundings, making it less conspicuous to would-be predators and to its own prey (Wikipedia 2011a). This somewhat small (75 cm) species is characterized by a rainbow of color variants, some of which mimic the lichen and bryophyte encrusted bark of its arboreal habitat.



Figure 71. *Bothriechis schlegelii* (Eyelash Viper), demonstrating its color pattern that blends with bark, lichens, and bryophytes, where it waits quietly for its food. Note the upturned scales above the eyes. Photo by Josiah Townsend, through Creative Commons.

The Eyelash Viper is a pit viper, and thus is poisonous, sensing its prey through heat-sensitive glands between the eyes and nostrils. It lives in dense foliage of the mesic forests of Southern Mexico, south to Colombia and Venezuela at elevations from sea level to 2640 m asl (Wikipedia 2011a). The bryophyte collector must beware –



this venomous snake lies quietly in wait, an **ambush predator**. It is inconspicuous on branches, sometimes among mosses or tangled among vines, until it detects its prey. It is nocturnal and preys on other arboreal animals such as lizards, frogs, small rodents, and birds. As a likely adaptation to their arboreal habit, they are **ovoviviparous**, giving annual birth to 10-12 live young.

### Visitors

The common Eastern Garter Snake (*Thamnophis sirtalis*; Figure 72-Figure 73) (Stockwell & Hunter 1989) and Green Snake (*Opheodrys vernalis*; Figure 74-Figure 75) also appear in peatlands (Rocheffort in Desrochers & van Duinen 2006), but they are widespread elsewhere.



Figure 72. Eastern Garter Snake, *Thamnophis sirtalis*. Photo by Janice Glime.



Figure 73. *Thamnophis sirtalis tetrataenia* flicking its tongue. Photo by Brian Gratwicke, through Creative Commons.



Figure 74. Green Snake, *Opheodrys vernalis*, sunning on a rock near a patch of mosses. Photo © Gary Nafis, with permission.



Figure 75. Green Snakes, *Opheodrys vernalis*, hatching from eggs. Photo by John White, with permission.

The rough green snake (*Opheodrys aestivus*) lives in dense brush of lakeshores, streambanks, upland ravines, and forest edges, where they obtain their water by sucking droplets of dew from leaves (Goldsmith 1984). Bryophytes can provide droplets as well, especially early in the morning. Goldsmith observed this species two different times sucking water from piles of damp *Sphagnum* in its terrarium. Clark (1949) observed 5 eggs of the species in mosses beside a decaying log in Louisiana, USA. Nevertheless, it may be more of a visitor to bryophytes.



Figure 76. *Opheodrys aestivus*, a species that obtains water from mosses. Photo by James Harding, through Creative Commons.

## Order Crocodylia – Crocodiles (Family Crocodylidae)

In the Philippines, *Sphagnum* is used for nesting material in crocodile farms for incubating eggs (Tan 2003). At crocodile breeding stations, wild-collected eggs are cushioned or layered in *Sphagnum* for incubation. But information on natural uses of mosses by crocodylians is lacking.

### Reptiles in Captivity

Bryophytes are popular in terraria, albeit difficult to keep healthy. Even reptiles seem to benefit from bryophytes in their captive homes (Brough & Rearick 2011; Foster & Smith Inc 2012), and use of bryophytes in live sample containers is a common practice for collectors (LeBreton *et al.* 2011).



At Reptile and Supply Co Inc (2010), New Zealand *Sphagnum* is recommended as the best *Sphagnum* for reptiles due to its water-holding capacity. They also sell sheet moss (US\$13.99 per 6.75" circle) and cushion moss (US\$9.99 per sq ft) for lizard terrariums.

Kaplan (1997) recommends *Sphagnum* as a suitable substrate for reptiles, but admonishes that it can cause fungal infections to those who handle it. She recommends that it be dried thoroughly periodically and baked at 121°C for one hour to kill and fungal growth that may be occurring. The moss provides moisture and maintains air humidity.

One possible caution is that the lizard might eat the moss. One pet owner wrote to Just Answer.Reptile (2012) with concern that her Leopard Gecko had passed bits of "Fluker's" moss in her feces and had stopped eating. [It appears that Fluker's is a trade name and includes true moss and Spanish moss (a bromeliad)]. It is not clear that the moss played any role in the loss of appetite because the lizard had just shed and was also provided night temperatures that were too cool. The advice from Just Answer.Reptile was to provide moist towels instead of moss for the "moist pot." I would think a fine mesh or cloth over the moss might be a good alternative. On the other hand, the primary concern was that the moss might cause an obstruction, but X-ray indicated that did not seem to be the case.

## Summary

Peatlands are especially important for some of the reptiles, particularly turtles. *Chrysemys guttata* (Spotted Turtle) uses *Sphagnum* swamps for hibernation, being protected from freezing by the insulation. Later it uses *Sphagnum* and other mosses for nesting. *Glyptemys muhlenbergii* (Bog Turtle) lives primarily in peatlands, apparently using the mosses to maintain their hydration. They travel within the peatlands in small rodent tunnels. The *Sphagnum* is used for nesting. Turtles such as the Snapping Turtle may help in dispersal of bryophytes.

*Sistrurus catenatus* (Massasauga Rattlesnake) and *Vipera berus* (European Common Viper) live in low-lying areas such as peatlands and often hibernate in raised hummocks where the temperature is buffered. *Thamnophis sirtalis* (Eastern Garter Snake) and *Opheodrys vernalis* (Green Snake) also can live in peatlands.

In Europe, the Viviparous Lizard (*Zootoca vivipara*) frequents peatlands, hibernating under the moss. Coal Skinks (*Plestiodon anthracinus*) can occur on the edge of swamps.

The Helmeted Iguana (*Corytophanes cristatus*) can have leafy liverworts growing on the crest of its head, possibly providing camouflage, whereas species of *Brookesia* have color patterns that resemble bryophytes. Species of the arboreal snake genus *Sibon* also blend with the bryophytic epiphytes in their habitat.

Many reptilian caretakers use *Sphagnum* in the cages, and even crocodile eggs can be reared in *Sphagnum*.

Several snakes use bryophytes, some for sites of finding food, others to rehydrate, and some to modulate their temperature.

The only connection between bryophytes and crocodiles seems to be for breeders who use mosses for rearing the eggs.

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